Food and Agriculture Organization of the United Nations

Guidelines on urban and peri-urban forestry

FAO FORESTRY PAPER

178

ISSN 1999-2882

Guidelines on urban and peri-urban forestry

FAO
FORESTRY
PAPER
178

BY
FABIO SALBITANO
SIMONE BORELLI
MICHELA CONIGLIARO
YUJUAN CHEN

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
Rome, 2016

Recommended citation: FAO. 2016. *Guidelines on urban and peri-urban forestry*, by F. Salbitano, S. Borelli, M. Conigliaro and Y. Chen. FAO Forestry Paper No. 178. Rome, Food and Agriculture Organization of the United Nations.

ISBN 978-92-5-109442-6

Contents

TABLES

FIGURES

BOXES

List of contributors

Authors: Fabio Salbitano, Simone Borelli, Michela Conigliaro and Yujuan Chen
External reviewers: Clive Davies, Francisco Escobedo, Pepper Provenzano, Tomas Raundrup, Phillip Rodbell, Giovanni Sanesi, German Tovar, Pier Carlo Zingari
FAO reviewers: Eva Müller, Susan Braatz
Editor: Alastair Sarre
Designer: Roberto Cenciarelli

This book is based on an idea by Michelle Gauthier

Foreword

Although cities occupy only 2 percent of the planet's surface, their inhabitants use 75 percent of its natural resources. The world is urbanizing quickly, too: by 2050, 70 percent of the global population will live in cities and towns. Sustainable urban development is crucial, therefore, for ensuring the quality of life of the world's people.

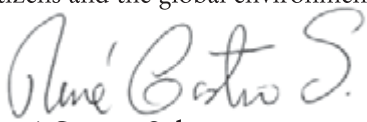
Forests and trees in urban and peri-urban environments, if properly managed, can make important contributions to the planning, design and management of sustainable, resilient landscapes. They can help make cities:

- safer – by reducing stormwater runoff and the impacts of wind and sand storms, mitigating the "heat island" effect, and contributing to the adaptation and mitigation of climate change;
- more pleasant – by providing space for recreation and venues for social and religious events, and ameliorating weather extremes;
- healthier – by improving air quality, providing space for physical exercise, and fostering psychological well-being;
- wealthier – by providing opportunities for the production of food, medicines and wood and generating economically valuable ecosystem services; and
- more diverse and attractive – by providing natural experiences for urban and peri-urban dwellers, increasing biodiversity, creating diverse landscapes, and maintaining cultural traditions.

To support the world's cities in reaping the benefits of urban and peri-urban forests, a few years ago FAO initiated a collaborative process to develop voluntary guidelines aimed at optimizing the contributions of forests and trees to sustainable urban development. Scientists, practitioners and public administrators from cities worldwide were brought together in a series of workshops to discuss the elements and key challenges of urban forestry, and a smaller team of experts was assembled to distil this vast knowledge.

This document is the ultimate result of that process. It is intended for a global audience, primarily comprising urban decision-makers, civil servants, policy advisors and other stakeholders to assist in developing urban and peri-urban forests as a way of meeting the present and future needs of cities for forest products and ecosystem services. The guidelines will also help increase community awareness of the contributions that trees and forests can make to improving quality of life, and of their essential role in global sustainability.

I thank all those involved in producing this document, which, I have no doubt, will help ensure that cities worldwide maintain and enhance the well-being of their citizens and the global environment.



René Castro-Salazar
Assistant Director-General, FAO Forestry Department

Acronyms and abbreviations

FAO	Food and Agriculture Organization of the United Nations
ha	hectare(s)
ICLEI	Local Governments for Sustainability
kg	kilogram(s)
m^3	cubic metre(s)
SDG	Sustainable Development Goal
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UPF	urban and peri-urban forestry
US$	United States dollars
WHO	World Health Organization
WISDOM	Woodfuel Integrated Supply/Demand Overview Mapping

1 Introduction

Recent decades have been characterized by increased migration from rural to urban areas. As a result, since 2008 and for the first time in history, more than half the world's population lives in towns and cities, and this percentage is expected to swell to 70 percent by 2050. Cities reshape and alter natural landscapes as they expand, creating microclimates in which temperatures, rainfall and winds differ from those of the surrounding countryside.

Urban development – as often practised – results in the depletion and degradation of natural ecosystems in and around urban areas, the drastic loss of vital ecosystem services[1] and, potentially, little resilience to disturbances, such as those caused by climate change.[2] As the world continues to urbanize, sustainable development challenges will increasingly concentrate in urban areas, particularly in lower- and middle-income countries, where urbanization has often taken place rapidly, spontaneously and with insufficient strategic planning, resulting in unsustainable patterns of land use.

Evidence of the unsustainability of urban growth is increasingly drawing public attention to the need for sustainable urban models capable of responding to increasing demands for food and basic ecosystem services. The United Nations General Assembly recently adopted the Sustainable Development Goals (SDGs), which include many targets directly related to cities.

Urban planners and city administrators face daily challenges in managing complex urban environments, such as maintaining sufficient healthy and safe food, clean water, clean air, energy, housing and green spaces and addressing conflicts of interest related to land use. More than ever, they must rise to the challenge of ensuring that their cities are economically, socially and environmentally sustainable, resilient and capable of providing the ecosystem services needed by their citizens for a good quality of life. Well-designed and managed urban and peri-urban forest and tree systems (hereafter referred to collectively as "urban forests" except where it is necessary to distinguish among such systems) are integral to meeting this challenge: urban forests can make significant contributions to the environmental sustainability, economic viability and liveability of urban settlements.

1 The ecosystem services framework – which became more prominent in the wake of the Millennium Ecosystem Assessment – is a systematic way of addressing the triple-bottom-line (economic, social and environmental) benefits of green spaces in urban areas. Rather than stressing the need to conserve nature and protect biodiversity *per se*, the discourse has shifted to stressing the links between ecosystems, biodiversity and the essential services these provide for humankind.

2 Urban resilience can be defined as the capacity of an urban system to absorb disturbance and reorganize while undergoing change.

WHAT IS AN URBAN FOREST?

All cities share a similar physical texture, comprising "grey" infrastructure (e.g. residential and industrial buildings, roads, utilities and parking lots), blue infrastructure (e.g. rivers, lakes, ponds and water channels) and green infrastructure[3] (e.g. trees, shrubs and grasses in parks, forests, gardens and streets). Optimizing the interactions among these elements is the key to reshaping or building cities capable of responding to urban challenges.

Urban forests can be defined as networks or systems comprising all woodlands, groups of trees, and individual trees located in urban and peri-urban areas; they include, therefore, forests, street trees, trees in parks and gardens, and trees in derelict corners. Urban forests are the backbone of the green infrastructure, bridging rural and urban areas and ameliorating a city's environmental footprint.

There are many ways to classify urban forests, but this document adopt five simplified reference types (Table 1).

In Chapter 3, these five types are ranked in importance for addressing specific issues in urban and peri-urban environments. In the provision of woodfuel, for example, peri-urban forests and woodlands play a very important role; for recreation, city parks and urban forests are of high importance.

Urban and peri-urban forestry (UPF) is the practice of managing urban forests to ensure their optimal contributions to the physiological, sociological and economic well-being of urban societies. UPF is an integrated, interdisciplinary, participatory and strategic approach to planning and managing forests and trees in and around cities. It involves the assessment, planning, planting, maintenance, preservation and monitoring of urban forests, and it can operate at scales ranging from single trees to landscapes. The scope of UPF encompasses the entire development spectrum – from sprawling, spontaneously growing metropolises to highly planned urban development projects. At the community scale, UPF emphasizes the engagement of urban citizens in the stewardship of private and public trees, including by educating them on the value and benefits of trees and forests and supporting their full ownership and responsibility for the environment around them.

WHY URBAN FORESTS?

Forests in and around cities face many threats, such as those posed by unregulated urban development and a lack of investment and management. Although it has been demonstrated that coherent investment in the establishment, protection and restoration of urban forests can help create a healthy environment, such forests are often appreciated more for their aesthetic value than for their ecosystem functions. Mayors, planners and other urban decision-makers are often unaware of the crucial economic, social and environmental benefits that urban forests can provide. They often place a low priority on urban forests, therefore, and budgetary resources are allocated to other civic areas seen as more important, such as health, welfare and

3 The "green infrastructure" of a city comprises the strategically planned network of high-quality natural, semi-natural and cultivated areas designed and managed to deliver a wide range of ecosystem services and protect biodiversity in urban and peri-urban settings.

TABLE 1.
Main urban forest types

	**Peri-urban forests and woodlands.** Forests and woodlands surrounding towns and cities that can provide goods and services such as wood, fibre, fruit, other non-wood forest products, clean water, recreation and tourism.
	**City parks and urban forests (>0.5 ha).** Large urban or district parks with a variety of land cover and at least partly equipped with facilities for leisure and recreation.
	**Pocket parks and gardens with trees (<0.5 ha).** Small district parks equipped with facilities for recreation/ leisure, and private gardens and green spaces.
	**Trees on streets or in public squares.** Linear tree populations, small groups of trees, and individual trees in squares and parking lots and on streets, etc.
	**Other green spaces with trees.** For example urban agricultural plots, sports grounds, vacant lands, lawns, river banks, open fields, cemeteries and botanical gardens.

Source: FAO (2016)

safety. The potential role of urban forests in improving the quality of life of urban and peri-urban dwellers is far from fully realized.

At first glance, the value of a square metre of land appears to be much higher if it can be used for "grey" infrastructure. It is increasingly recognized, however, that green infrastructure also has a high (tangible and intangible) value. Every urban planning decision should take into account the overall benefits and costs – the triple bottom line – of choosing one land use over another. Public administrators should view their urban forests as crucial infrastructure providing tangible benefits and values that enhance quality of life, safety, and public health. In fact, the return on investment in urban forests far exceeds the cost of installation and maintenance compared with grey infrastructure and should be considered a "smart deal" for decision-makers, administrators and citizens. The benefits of urban forests, detailed in Table 2, vary in nature and importance depending on the location and economic, social and environmental circumstances of a given community. For example, the sustainable production of woodfuel may be of considerable importance in a rapidly expanding urban area in a developing country, whereas the provision of recreational opportunities may be afforded higher priority in cities with developed economies (and therefore less reliance on woodfuel for energy).

For example, thanks to their water provisioning, regulating and filtering role, urban forests play key roles in supporting water management in and around urban settlements. Peri-urban forests increase the supply of good-quality water, thus helping cities address increasing water demands. New York City spent between US$1.4 billion and US$1.5 billion in watershed protection projects (including improved forest management) instead of building a filtration plant estimated to have cost US$6 billion to build and a further US$250 million per year to maintain. By helping store water in soil profiles, forests increase resilience to drought, the incidence and severity of which are projected to be exacerbated by climate change. Other studies in the United States of America have shown that the country's urban

TABLE 2.
Potential benefits of urban forests

Urban issue	Potential benefits of urban forests
Food security	Provide food, clean water and woodfuel
Urban poverty	Create jobs and increase income
Soil and landscape degradation	Improve soil conditions and prevent erosion
Reduced biodiversity	Preserve and increase biodiversity
Air and noise pollution	Remove air pollutants and buffer noise
Greenhouse gas emissions	Sequester carbon and mitigate climate change, improve local climate and build resilience
Extreme weather events	Mitigate local climate and build resilience
Energy shortage	Save energy through shading/cooling, and grow woodfuel
Heat island effect	Cool the built environment through shade and evapotranspiration
Limited accessible green space	Provide more accessible natural and green space
Public health	Improve the physical and mental health of residents
Flooding	Mitigate stormwater runoff and reduce flooding
Limited recreational opportunities	Provide opportunities for recreation and environmental education
Exposure	Provide shelter
Limited water resources	Enable infiltration and the reuse of wastewater
Lack of community and social cohesion	Provide distinctive places for formal and informal outdoor interaction

trees remove around 711 000 metric tonnes of pollution (at a value of US$3.8 billion) per year (Nowak, Crane and Stevens, 2006).

A recent valuation of urban forests carried out by the City of London showed that the 8 million trees growing in the urban area produce annual benefits of about £132 million, mostly related to the removal of air pollution, and they have an amenity value estimated at £43 billion (Rogers *et al.*, 2015).

Urban forest management incurs costs – such as for planting, maintenance and infrastructure repair (e.g. broken sidewalks and sewer pipes). Yet an assessment in five cities in the United States of America (McPherson *et al.*, 2005) showed that the benefits of urban trees outweighed the costs by ratios of between 1.37 and 3.09. Costs included in the analysis were: tree planting and maintenance, including pruning and the removal and disposal of damaged trees; infrastructure damage; inspection; litter clean-up; and trip-and-fall damage claims. The benefits included in the assessment were:

- energy savings based on computer modelling of the effects of shading on heating and cooling costs in buildings;
- the reduction in atmospheric carbon dioxide from both the sequestration of carbon in wood and the reduction in greenhouse gas emissions related to energy savings;

- air-quality improvements due to the collection of pollutants on leaves (but not counting the effect of reduced emissions);
- improvements in aesthetics, as measured by relative increases in property value; and
- reduced stormwater runoff, based on average precipitation levels.

Trees and forests in and around cities provide a wide range of goods and ecosystem services, and they make major contributions to the livelihoods and quality of life of urban dwellers. Well-maintained, healthy urban forests are one of the few municipal capital investments that appreciate in value over time – because the economic benefits increase as trees grow and require less maintenance.

UPF will make important contributions to the achievement of the SDGs, as summarized in Table 3.

ABOUT THIS PUBLICATION

These guidelines have four main chapters in addition to this introduction. Chapter 2 presents an overview of three key areas where attention is needed in developing an enabling environment for UPF: governance; policies; and the legal framework. Chapter 2 also provides guidance on planning, designing and managing urban forests to optimize the provision of goods and ecosystem services for local communities. Chapter 3 provides guidelines for maximizing the contributions of urban forests to local and global challenges, such as climate change, food security and human health and well-being, and it describes actions that can be taken at the policy and management levels. Chapter 4 provides an overview of the accompanying measures required for successful UPF programmes and how these can be implemented. Chapter 5 describes some of the actions to be taken to disseminate these guidelines and put them into effect.

TABLE 3.
Contribution of urban forests to Sustainable Development Goals

Sustainable Development Goal	Target	The role of urban forests	Relevant sections of Chapter 3
	1.5	Urban forests create employment, provide a resource for entrepreneurs, reduce the cost of urban infrastructure, provide ecosystem services for all citizens, improve the living environment and increase property values, ultimately boosting local green economies	Economic benefits and green economy (p. 65)
	2.1 2.2 2.3 2.4	Urban forests are direct sources of food (e.g. fruits, seeds, leaves, mushrooms, berries, bark extracts, saps and roots, herbs, wild meat and edible insects). Indirectly, they support healthy eating by providing affordable woodfuel, high-quality water and improved soil for sustainable agricultural production	Food and nutrition security (p. 85); water and watersheds (p. 80); wood security (p. 90); economic benefits and green economy (p. 65)
	3.4 3.9	Forests and other green spaces in and around cities provide ideal settings for many outdoor recreation and relaxation activities, thereby contributing to the prevention and treatment of non-communicable diseases and the maintenance of mental health. Urban forests filter and efficiently remove pollutants and particulates, which also helps reduce the incidence of non-communicable diseases	Human health and well-being (p. 50)
	6.3 6.6	Urban forests are efficient regulators of urban hydrological cycles. They filter drinking water by reducing biological and chemical pollutants, reduce the risk of floods and erosion, and reduce water losses by minimizing mesoclimatic extremes through evapotranspiration processes	Water and watersheds (p. 80)
	7.1	The sustainable management of urban forests can produce renewable energy for use by urban communities. This is a vital function for billions of urban and peri-urban dwellers worldwide, particularly in lower-income countries, where woodfuel is often the most affordable and sometimes only available source of energy	Wood security (p. 90); economic benefits and green economy (p. 65)
	8.4 8.9	Investments in urban forests and other green infrastructure add significantly to green economic growth by providing an attractive environment for tourism and business, improving home values and rental rates, creating job opportunities, providing materials for housing, and generating savings in the costs associated with energy and the maintenance of human health	Economic benefits and green economy (p. 65)
	11	Well-designed and managed urban forests make significant contributions to the environmental sustainability, economic viability and liveability of cities. They help mitigate climate change and natural disasters, reduce energy costs, poverty and malnutrition, and provide ecosystem services and public benefits	All
	13.1 13.2 13.3	Trees and forests in and around cities contribute to climate-change mitigation directly by sequestering carbon and reducing greenhouse gas emissions and indirectly by saving energy, reducing the urban heat island effect, and mitigating flooding	Climate change (p. 55)
	15.2 15.3 15.9	Urban forests help create and enhance habitats, constitute a pool of biodiversity, significantly improve soil quality, and contribute to land restoration	Biodiversity and landscapes (p. 60); mitigating land and soil degradation (p. 75)

2 The enabling environment

Establishing an enabling environment is the first step in optimizing the contribution of urban forests to sustainable development. A coherent policy and legal framework can help governments and communities successfully design, establish, protect and restore urban forests. This chapter presents an overview of three key areas where attention is needed in developing an enabling environment for UPF: 1) governance; 2) policies; and 3) the legal framework. It also provides guidance on planning, designing and managing urban forests to optimize the provision of goods and ecosystem services for local communities.

GOVERNANCE

Engaging stakeholders in the planning, design and management of urban forests is crucial for ensuring the effective governance of a city.

Governance comprises the efforts, means and tools involved in directing the actions of individuals and groups towards common goals; more specifically, it is the development, application and enforcement of generally agreed rules of the game. Whatever the definition, the sound governance of a modern city implies a fundamental transition from the concept of local government to that of local governance, in which all stakeholders have responsibility for policy development, planning and management.

In UPF, the rules of the game encompass both the governance of urban forests themselves, and the role of forests and trees in overall urban governance. Urban forest governance should aim to integrate the management of all green infrastructure in a city, which is often under the responsibility of several public authorities. It should encompass both public and private trees – that is, the urban tree canopy.[4]

The importance of an integrated approach to urban forest governance is widely recognized, but developing a framework of actions and providing an enabling environment for UPF is complex. An effective governance framework requires the development of the necessary policies, incentives, laws and regulations through multi-actor and multisectoral approaches that fully take into account all relevant economic, social and environmental dimensions. Such a framework must also be based on a strategic vision and the harmonization of planning, design and management of present and future urban forests. It has three distinct but interacting areas, summarized in Table 4.

4 "Urban tree canopy" is a measure of a municipality's tree canopy cover as a percentage of the total land area.

TABLE 4.
The interacting areas of urban forest governance within the urban governance framework

	Urban forest governance	Urban and peri-urban forestry (UPF) in overall urban governance
Policy	The governing style, measures, actions and processes adopted by a community to manage existing or planned urban forests	The governing style, measures, actions and processes of urban policies with direct or indirect relationships with UPF
Norms	Laws, regulations, by-laws, codes, ordinances, decisions and other formal deliberative documents that, at various levels (local to international), regulate use, define limits, indicate conditions, state opportunities, promote actions and identify incentives for publicly and privately owned urban forests	The legal framework (local to international) addressed to components of a society not directly concerning UPF but adopting or incorporating elements of UPF and green infrastructure as important aspects for the community – such as protected-area laws; building regulations; health ordinances; and road traffic acts
Planning	Assessments and plans of urban forests and other green infrastructure at the city-region level; the planning–design–management continuum of urban forests and other green infrastructure	The role of urban forests and other green infrastructure in the context of urban planning, such as urban strategic planning; master plans; and sectoral and operative planning. Urban forests and other green infrastructure are not the targets of the plan but have a direct or indirect role

Aspects of urban forest governance

Strategic governance. Although the governance of (publicly owned) woodlands, parks and natural areas is becoming more strategic, resulting in a rapidly growing body of visions, policies and strategies, urban forests are not always part of the discourse. Departments or units responsible for the management of green urban infrastructure should be involved directly in municipal decision-making processes to ensure that the strategic roles of urban forests are duly considered.

Strategic urban forest governance requires the recognition of the value of the ecosystem services delivered by urban forests and the adoption of nature-based solutions as strategic governance tools for improving urban places while reducing the cost of city management. Strategic urban forest governance also requires sound knowledge management and collaboration between the municipality and relevant knowledge institutions to ensure that urban forests are considered as integral parts of a city's infrastructure (Box 1).

BOX 1.

Elevating urban forests to the strategic level

The city of Arnhem, the Netherlands, employed the concept of urban and peri-urban forestry in a strategic interdepartmental effort to link the development of green infrastructure to overall city objectives. The city's "Green Agenda", formulated in an inclusive process involving many parts of the municipal government as well as experts and non-governmental organizations, now needs to be implemented.

Source: Gemeente Arnhem (2010)

Integration. The attention afforded UPF in urban governance is often limited by the fragmentation of responsibilities and technical and administrative services in policy and planning documents and across levels of government. "Integration" is a key issue in urban governance, and UPF both suffers from a lack of it and can play a central role in encouraging it. The effective governance of urban forests requires policies and laws aimed at harmonizing the range of interests in urban land by developing and strengthening a common vision and collaborative actions for green infrastructure in and around cities. In parallel, UPF governance requires integration for effective "scaling up", both geographically (e.g. local to national, and among cities) and in getting actors involved from different levels of government (Box 2).

BOX 2.

Uniting governance in a common vision

The City of Johannesburg re-organized park services that were previously fragmented across the city's five councils into a single agency called Johannesburg City Parks. The goal of the new agency, which has a managing director and a board of directors who report to the city manager, is to build and maintain more parks within the existing budget. In one stroke, this reorganization reduced confusion about who is responsible for what and ensured that common standards are applied across the city. The agency is being run on strictly business lines, which improves efficiency and has led to savings in governance costs.

Source: Johannesburg City Parks and Zoo (2015)

Inclusive governance. In UPF, as in other urban policy sectors, the approach of governance by government is increasingly being replaced by governance *with* government. Optimizing the contributions of urban forests and other green spaces to the quality of life of urban dwellers requires an ongoing robust dialogue between decision-makers and the public they serve (Box 3). Much is to be gained by increasing public involvement in decision-making on the urban living environment – such as increasing the legitimacy of decisions and public support for them, increasing awareness of the importance of urban forests, and improving the decisions themselves.

Achieving inclusive governance requires the assessment of:

- the types and roles of actors who can assume responsibilities in an inclusive UPF governance programme; and
- the attitude and willingness of the community and its stakeholders to be engaged in governance programmes.

Cities are complex socioecological systems (for example, biogeophysically, socially and institutionally), and the stakeholders who could be engaged in urban forest governance are many and heterogeneous (Figure 1). Some may be involved

BOX 3.

Inclusive neighbourhood green plans

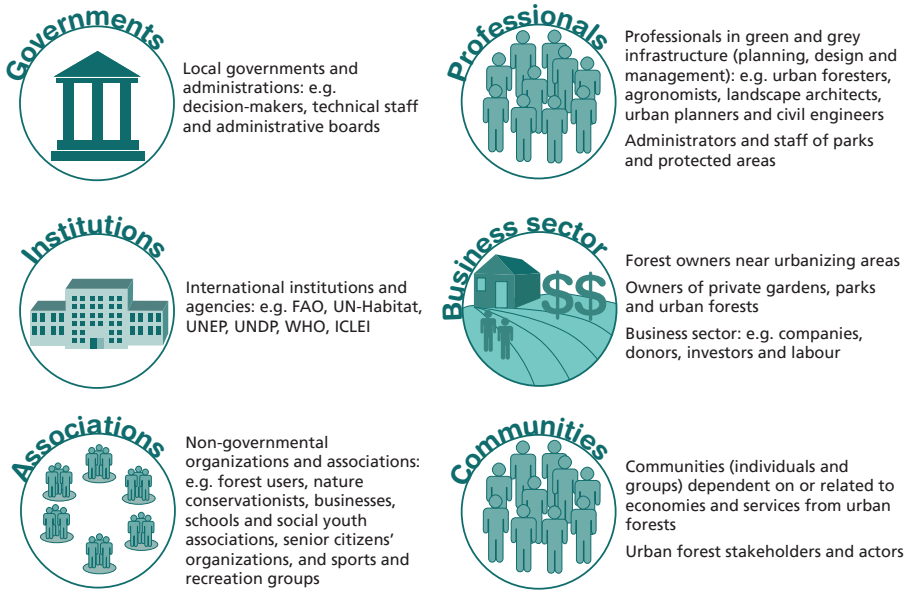
Established in 2010, Neighbourhood Green Planning was a municipal-level policy programme to facilitate citizen involvement in the development of green infrastructure in Utrecht, a city in the Netherlands. The initiative encompassed ten neighbourhoods – covering the entire municipality – in the green planning process, each with an allocated budget of 500 000 euros. In each neighbourhood, citizens were encouraged to share their ideas on projects that could improve both the quantity and quality of green spaces. The municipality screened these ideas for feasibility before selection and implementation through "neighbourhood green plans" in each neighbourhood. Each green plan was developed separately, and there are differences among them in the procedures, funding, content and involvement of actors. Each neighbourhood also has a different social and environmental character, which affected the range of opportunities and outcomes. The municipality is now actively seeking the participation of citizens in the continued care and maintenance of the projects and green spaces – that is, promoting self-management.

Source: Buizer *et al.* (2015)

directly in urban forest planning, design and management as professionals, technicians, users and decision-makers, and others may be more or less directly concerned with urban forest governance processes.

FIGURE 1.

Urban forest stakeholders and actors



Governance and knowledge. The governance of urban forests requires that planning departments have the necessary technical skills and knowledge to include UPF in the overall planning process (Box 4). It is also essential that the community has the capacity – for example with respect to time, resources, skills and knowledge – to act on the opportunities provided by the governance process. This may be the case in only some communities or for certain community members, and innovative urban forest governance, therefore, may require education and capacity building.

BOX 4.

Building capacity to manage urban forests

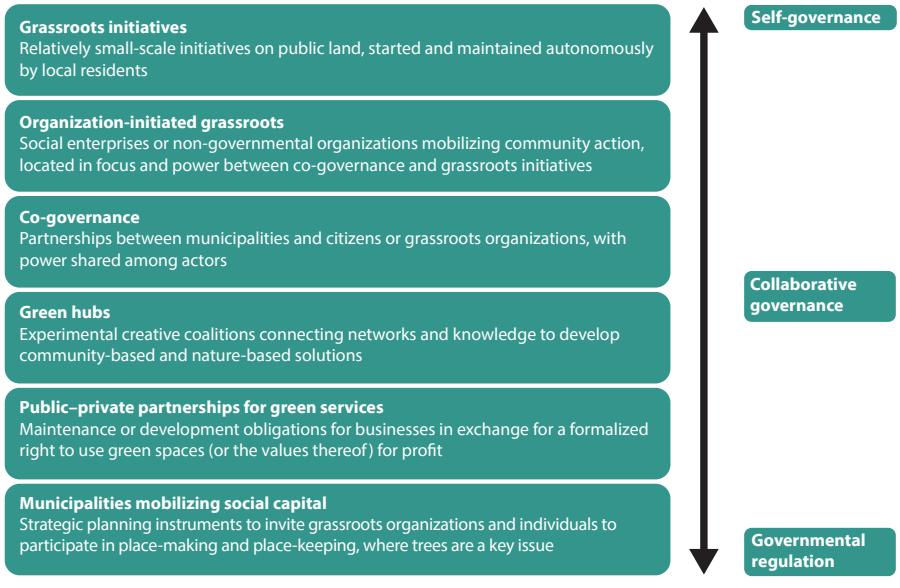
The urban forest strategy developed with the support of FAO for the city of Bangui in the Central African Republic has a strong capacity-building component. Project activities included the development of agreements between the University of Bangui and other international universities to offer seminars or conferences; the design of environmental education programmes for schools and rural communities; and an awareness-raising campaign directed at municipal authorities, technicians and farmer organizations.

Source: FAO (2009)

Urban forest governance arrangements. Figure 2 identifies a number of governance arrangements for urban forests based on their objectives and the functions of the various actors involved.

FIGURE 2.

Urban forest governance arrangement types

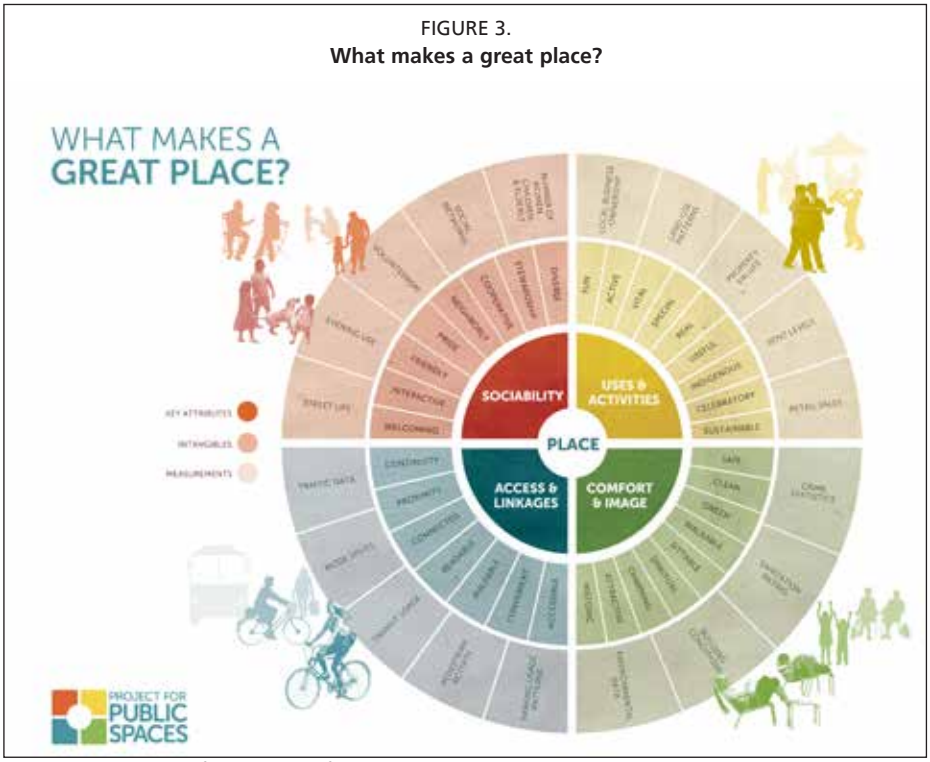


Place-making, place-keeping. To ensure that as many citizens as possible are engaged in, and are willing to take responsibility for, the governance of the public realm, it is essential that spaces become shared places; this has an important symbolic value and plays an essential role in the daily life of a community (Box 5). Place-making and place-keeping are complementary parts of a process of transforming spaces into places.

Place-making is the process of creating high-quality spaces (e.g. parks, squares and waterfronts) that people want to visit, experience and enjoy. Urban forests are fundamental elements in public spaces worldwide. In addition to providing users with many services and benefits, they contribute to the character and uniqueness of each place (Figure 3).

Place-keeping is the long-term management and maintenance of high-quality spaces to ensure that future generations will be able to enjoy their economic, social and environmental qualities and benefits. Large amounts of capital may be spent on the creation of green open spaces, but often little thought is given to, and insufficient resources made available for, their upkeep. Without such place-keeping, however, public spaces can fall into a downward spiral of disrepair and antisocial behaviour, with the net result that residents feel unsafe in those spaces and choose to avoid them. The economic and social costs of restoring neglected green spaces can be considerable.

FIGURE 3.
What makes a great place?



Source: www.pps.org/reference/grplacefeat

BOX 5.

Transforming spaces into places

Innovative governance approaches can sometimes be found in very poor places. People living in the Kibera slum in Kenya, for example, use public spaces very differently to people in New York City or Paris, where the term "public space" is normally associated with a park or a square. In Kibera, streets are the only public spaces, and people are on the streets all day, trying to earn a living by selling, bartering or begging. The community, however, perceived the almost complete lack of trees in the streets of Kibera as a serious problem, both culturally and physically. Having safe and adequate places in which people can earn their living was considered to be as vital as having access to water or electricity. In 2010, therefore, the community launched a campaign to plant 10 000 trees to improve slum conditions. Although tree-planting is not the solution to all the problems of slum-dwellers, it is a tangible action through which local people can start taking responsibility for the transformation of their spaces into places.

Source: Desgroppes and Taupin (2011)

POLICY

National and local policies and plans have the potential to rapidly expand or contract public access, stewardship, and the appreciation of natural resources in cities, towns and villages, with impacts on public health, safety and enjoyment of the urban environment.

A policy is a system of principles referring to a common vision, which aims to guide specific decisions or sets of decisions and to set out the actions required to implement those decisions.

There is an important distinction between policies addressed specifically at the implementation and management of urban forests, and broader urban policies (overall or sectoral) covering the multiple socioeconomic interests of a city-region[5], which have direct or indirect, and positive or negative, impacts on urban forests.

Each country has its own approach to urban policies; for some, it may be appropriate to develop such policies at the national or subnational scales, while others may be developed at the scale of individual cities. Even if there is a stringent national policy approach to urban issues (e.g. where there is a centralized ministry of urbanism or national urban policy, as is the case, for example, in Angola, the Central African Republic, Ghana, Morocco and Serbia, or there are binding programmes and centralized city policies, such as in China), cities differ in character and therefore in policy development and implementation.

5 The term "city-region" refers to megacities and their immediate, proximate rural and agricultural areas, as well as to small and medium-sized towns that link remote small-scale producers and their agricultural value chains to urban centres and markets in developing countries (cityregionfoodsystems.org).

UPF is inherently local, and policies on it can vary substantially, even within the same country, as well as between countries. In some cities (e.g. Ljubljana, Slovenia; Melbourne, Australia; Telford, the United Kingdom of Great Britain and Northern Ireland; and Vancouver, Canada), local administrations have designed and been successfully implementing UPF policies and strategies for many years. Other cities – especially in developing countries – lack specific UPF policies and do not actively manage their urban forests. A number of cities in Asia (e.g. Shanghai, China), Africa (e.g. Durban, South Africa) and Latin America (e.g. Curitiba, Brazil) have given high priority to UPF (particularly during some administrations), despite wide-ranging socioeconomic problems.

Policies on urban forests are often developed and implemented sectorally, leading to conflicts with the policies of other urban sectors over the use of open spaces. An effective UPF policy requires intersectoral dialogue to harmonize the range of interests and to develop and strengthen a common vision for green infrastructure in and around cities.

For an urban policy to be effective, it must address the entire municipality, and it must work to strengthen the economic, social and environmental links between urban and rural areas. UPF policies should pay particular attention to peri-urban areas, which can be considered as the bridge (both physically and socioeconomically) between urban and rural areas. Table 5 presents elements of the vision, principles and actions for UPF and other urban policies that may have impacts on the management of urban green spaces.

© FAO/SIMONE BORELLI

TABLE 5.
Vision, principles and means of implementation for urban and peri-urban forestry and green urban policies

	UPF policy	UPF in the context of broader urban policies
Vision	Healthy and resilient green cities and urban forests provide benefits to all and are managed with a shared commitment by all members of a community	Cities that are resilient to economic, social and environmental challenges and promote the sustainable, spatially integrated and orderly development of urban settlements with adequate housing, infrastructure and services, efficient institutions, and a sound living and working environment for all people
Principles	• Citizens, businesses, property owners and local agencies define the UPF goals and values and work with the community to achieve them • Residents are the most important and influential stewards of urban forests • Management is directed and coordinated to meet the overall intention to promote, conserve, protect and improve urban forests while flexibly accommodating diverse land ownership, uses and activities • Urban forests on both public and private land are protected and managed to provide the benefits of the "right tree in the right place" and support the integrity of natural features • Stable long-term financial support is available for UPF and other nature-based solutions	• All urban development is based on sound environmental criteria • Health in the broadest sense is a right of all citizens • Environmental education is accessible to all • Links exist between urban policies and other relevant policies at the local, subnational, national and regional levels • Strategic and programme documents at the local, subnational and national levels are intersectoral • Land use and land tenure are addressed equitably • Smart growth principles and actions are adapted to the local context • Urban–rural linkages are an opportunity for the socioeconomic development of both cities and surrounding rural areas
Implementation	• Develop urban forest targets • Develop municipal/national standards and guidelines for the sustainable design, management and maintenance of urban forests • Promote the inventory and monitoring of urban forests • Monitor the health of urban forests and adopt a risk management plan for addressing potential threats • Develop a business case for urban forests as green infrastructure to secure funding • Seek funding opportunities and partnerships and develop incentive schemes • Identify innovative technologies and techniques, and potential research partners • Promote and sustain initiatives and communication tools to engage the community in urban forest stewardship • Work collaboratively with schools and education and capacity-building institutions to increase knowledge • Promote or create UPF policy networks	• Develop a "green city" action plan, including measurable targets and goals • Establish sustainable development guidelines • Develop a "renewable city" strategy • Develop a sound healthcare strategy, including outdoor prescriptions • Develop a climate-change adaptation strategy • Prepare land-use and development guidelines • Update green zoning and re-zoning policies • Adopt green standards (e.g. the LEED ["Leadership in Energy and Environmental Design"] Gold standard developed by the US Green Building Council) for building and property development • Develop and manage smart infrastructure systems, adopting nature-based solutions • Protect open spaces, green belts, forest reserves, water bodies, wetlands, water catchment areas and other ecologically sensitive areas from physical development and urban encroachment • Develop and implement a systematic programme of flood control and establish adequate measures to protect against natural hazards in urban areas • Generate environmental awareness by increasing mass media public education, information technology and e-learning

Developing policies on urban and peri-urban forestry

UPF policies may be developed in many ways, depending on, for example, the local and national context and the prevailing socioeconomic and environmental conditions. UPF policies are often conceived without due consideration of other sectoral or overall urban policies. Conversely, overarching municipal policies often fail to sufficiently take urban forests and other green spaces into account.

Specific policies. Many cities in developed countries have sufficient technical capacity, budget and autonomy to develop UPF policies tailored to their specific needs, but such policies still vary in quality. They are generally developed by a relevant technical service – often supported by other institutions – and included as a "package" in municipal budgets, but they vary in the extent to which they are integrated with wider urban policies and other sectors and the community is engaged in their development; Box 6 presents a case in which stakeholder participation was key in the development of an urban forest policy.

BOX 6.

Participation in the Minneapolis urban forest policy

Until 2002, the city of Minneapolis in the United States of America lacked a comprehensive policy on urban forests. In late 2002, however, members of the municipal council convened a meeting of stakeholders, including public institutions, private companies and individual citizens, to identify the challenges facing the city's urban forests and to make recommendations for their protection and management. The stakeholders met several times in 2003, working collaboratively to identify problems and solutions. A new policy linked closely to the Minneapolis Plan (the city's overarching development plan) was adopted in 2004.

Source: City of Minneapolis (2004)

© FLICKR/DEEPROOT

UPF as part of overall "green city" policies. There are many possible ways in which to enhance dialogue and elevate UPF in wider municipal policies. A growing number of cities (e.g. Vancouver – Box 7), for example, are developing green strategies aimed at reducing environmental footprints while enhancing the quality of life of residents through the development and management of urban forests and other green spaces. In such cases, UPF may be addressed in several elements of the overall strategy.

BOX 7.

Green Vancouver

In 2010, Vancouver, Canada, promoted a city strategy associated with a comprehensive action plan called "Green Vancouver", a bold initiative to address Vancouver's environmental challenges. "While we live in what is widely recognized as one of the most liveable cities in the world," says the strategy, "our environmental footprint is currently three times larger than the Earth can sustain. The decisions we make every day about how we move around the city, what we buy, and how we deal with our waste means that we currently use far more than our share of the Earth's resources". The Green Vancouver policy consists of ten goals: 1) green economy; 2) climate leadership; 3) green buildings; 4) green transportation; 5) zero waste; 6) access to nature; 7) lighter footprint; 8) clean water; 9) clean air; and 10) local food. Target 1 of goal 6, "access to nature", aims to ensure that, by 2020, every person will live within a five-minute walk of a park, greenway or other green space. Target 2 challenges the municipality to plant 150 000 additional trees in the city between 2010 and 2020. By 2014, 37 000 trees had been planted.

Source: City of Vancouver (2012)

© FLICKR/RHIANNON BOYLE

The green infrastructure approach. The adoption of a green infrastructure approach is an important step in the integration of policies governing urban land use and particularly UPF, agriculture and public green spaces. Many cities worldwide are creating comprehensive townscape policies through integrated UPF strategies and adaptive management initiatives as part of regional and municipal plans (Box 8).

BOX 8.

The green infrastructure plan of Barcelona, Spain

In May 2013, the European Commission published a strategy to promote the use of green infrastructure in Europe. In Barcelona's Green Infrastructure and Biodiversity Plan, green infrastructure is described as "a network of spaces with public or private agricultural or landscaped natural vegetation, a multi-purpose resource providing ecological, environmental, social and economic services. These services are enhanced further when connectivity of green infrastructure is achieved". The plan aims to increase the connectivity between green spaces using green corridors and encourage multifunctionality (e.g. in the form of environmental and sociocultural services) in urban green spaces such as forests, parks and vegetable gardens. The plan also aims to integrate green infrastructure with other urban infrastructure.

Source: Metropolitan Area of Barcelona (2013)

© FLICKR/YU2031

The role of national urban policies. In some countries, the responsibility for urban planning is centralized at the national level, but national urban policies seldom address UPF or green infrastructure specifically; more commonly, they incorporate UPF development and management under the more general heading of "urban environment". Nevertheless, some countries are progressively integrating UPF into national and subnational policies, both within and beyond the forest sector (Box 9).

BOX 9.

Ghana's national urban policy

In 2012, Ghana's Ministry of Local Government and Rural Development launched the National Urban Policy Framework, which is a comprehensive urban policy formulated to promote the sustainable, spatially integrated and orderly development of urban settlements with adequate housing and services, efficient institutions, and a sound living and working environment for all people to support rapid socioeconomic development in the country. The framework addresses specific urban problems, such as land-use disorder and uncontrolled urban sprawl; increasing environmental deterioration; inadequate urban infrastructure and services; urban poverty, slums and squatter settlements; and weak rural–urban linkages. In particular, initiatives for the protection of forests, open spaces and green belts are promoted in Objective 4 ("improving environmental quality of urban life").

Source: Ministry of local government and rural development of Ghana (2012)

© FLICKR/JASON ARMSTRONG

National standards and targets in urban forest policy. In some countries, central governments have adopted nationwide "green" policy approaches and promoted the development of UPF schemes based on sets of national standards. Such standards are used, among other things, to certify the quality of living conditions in a given city. The financial resources for implementing UPF schemes are commonly made available to municipal governments from central funds, and their use is monitored to ensure that objectives are met (Box 10).

BOX 10.

National forest cities in China

China's State Forestry Administration officially launched the "National Forest City" programme in 2004 with the aim of advancing urban and rural ecological development. The programme represents a new model of urban forestry development, with both strong national policy support and successful local community involvement. Its main strategy is known as "one theme, two goals", in which the theme is "bringing forests into cities and letting cities embrace forests" and the two goals are planting trees and growing "green minds" among citizens. By 2015, more than 170 cities and 12 provinces were actively involved the National Forest City programme. Tree cover in these urban communities had increased to 40 percent or more, up from less than 10 percent in 1981. To acquire the status of a national forest city, a city must pass a screening process based on 38 standards and indicators referring to three domains: 1) administration and organization; 2) management system; and 3) forest development.

Source: www.forestry.gov.cn/xby/1277/content-126973.html

Key policy challenges

UPF policies face a number of common challenges, as described below.

Land tenure, access and rights. A crucial issue for the success of UPF policies is land tenure, defined as the complexity of norms, by-laws and customary behaviours that rule the ownership and possession (e.g. rental and leasehold) of, and access to (e.g. the rights to enter and use), land. Legal ownership may be insufficient for determining land tenure in urban and peri-urban settings, and this is particularly true with respect to open spaces. Whether statutory or customary (or, in many cases, both), clear land tenure is essential for determining the potential of UPF in a given location.

There may be differences in the perception of local people on land tenure based on customary laws and ownership as defined by the state. People are usually unwilling to plant and tend trees on land to which they lack tenure security; this is especially so in jurisdictions where tree-planting is perceived as a symbol of land ownership (and is therefore discouraged by legal owners).

There is no single blueprint for resolving conflicts over land tenure, but successful approaches usually build on existing tenure systems and involve robust platforms for conflict negotiation (Box 11).

BOX 11.

Two possible approaches to resolving land-tenure conflicts

Progressive approach. It is often better to build on and foster the progressive evolution of traditional land administration systems, subject to minimum requirements with respect to inclusiveness and the security of rights, rather than establish new formal systems. This is particularly important for communal and common-property lands, which may play important roles in local livelihoods. As suggested in the Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security (FAO, 2012), local governments may consider using customary and other local mechanisms that provide fair, reliable, gender-sensitive, accessible and non-discriminatory ways of promptly resolving disputes over tenure rights to land, fisheries and forests.
Source: FAO (2012)

Community approach. Creating platforms for conflict negotiation and facilitating legal advice and support can be important for resolving land-tenure problems as well as enhancing democracy and empowering communities. Developing a community approach to access to land may be a difficult path to walk, but the results can be surprisingly successful. In the Moravia slum in Medellín, Colombia, for example, negotiations between the local community and the municipality resulted in the upgrading and regularization of the neighbourhood, which, in addition to clearer tenure rights, included the plantation of ornamental shrubs and trees.
Source: Betancur (2007)

Urban growth and intensification: resilient cities and urban forests. The rapid pace of urbanization in the last decade has caused major changes in land use and landscapes in and around cities. Globally, the urban population is increasing rapidly, leading to further urban intensification in which green spaces are increasingly under threat.

Traditional models of urbanization lead to urban sprawl, which undermines the efficiency of urban living and can lead to the marginalization of poorer people in dense informal settlements or slums. On the other hand, the urbanization process – particularly in Africa and Asia, where much of the world's population growth is taking place – presents an enormous opportunity for sustainability, should adequate policies be put in place. If well planned, urbanization can increase the resilience of cities – that is, cities with the capacity to absorb future shocks and stresses to social, environmental, economic and technical systems and infrastructure so as to maintain the same functions, structures, systems and identity.

New urbanization models – such as the "compact city", "new town" and "polycentric city" models – are being developed to address concerns about urbanization and increase resilience (Box 12); UPF is an important component of any such urbanization model.

BOX 12.

Telford new town

When the new town of Telford ("the forest city") was created in the United Kingdom of Great Britain and Northern Ireland in the 1960s, its designers imagined a landscape veined with woodlands, parks and green spaces. This pioneering vision of a "green network" was made real through the planting of around 6 million trees and 10 million shrubs. In addition to natural regeneration on former mining and industrial areas, these plantings created an urban landscape in which people and wildlife could live together, and they linked the Wrekin and Ercall hills to the west and the thickly wooded River Severn valley to the south. The green network is under threat, however. Telford's population is expected to grow to 200 000 within a generation (larger than the cities of Oxford and Newcastle today), putting pressure on the town's wild places.

Source: Simson (2000)

© FLICKR/JEAN MOTTERSHEAD

Bridging the urban–rural divide. To ensure cohesive national development, policymakers need to address the growing divide (for example in terms of infrastructure and wealth) between urban and rural areas. Policies are needed to ensure adequate investment in infrastructure in peri-urban and rural areas, particularly for energy, transportation and information and communication technology, with the aim of increasing rural productivity and providing rural dwellers (both women and men) with adequate access to markets, jobs and public services.

Green infrastructure can provide the backbone of urban–rural linkages, in which interdependent landscape elements are managed cohesively to achieve long-term sustainability. UPF can play a crucial role in ensuring the continuity of natural environmental features through the development and management of ecological corridors linking cities with surrounding rural areas (Box 13).

BOX 13.

UN-Habitat guidelines on urban and territorial planning

UN Habitat is working to promote urban–rural linkages, including through the International Guidelines on Urban and Territorial Planning. These guidelines, which were published in 2015, constitute a global framework for improving policies, plans and designs for more compact, socially inclusive and better integrated and connected cities and territories that foster sustainable urban development and are resilient to climate change. The guidelines complement two sets of guidelines adopted by UN-Habitat's governing council: Guidelines on Decentralization (2007) and Guidelines on Access to Basic Services for All (2009), which have been used in several countries to catalyse policy and institutional reforms and leverage partnerships.

Source: UN-Habitat (2015)

© FABIO SALBITANO

Promoting multistakeholder processes. The increasingly multicultural character of urban societies creates challenges and opportunities for urban foresters and UPF policymakers. Relatively small areas of urban forests need to meet very high demand for ecosystem services and are often under pressure for conversion to other, more financially remunerative land uses. UPF strategies are most likely to be effective and to respond appropriately to contemporary social issues when they promote social inclusion and the involvement of disadvantaged ethnic communities as well as fringe groups such as deprived or homeless people (Box 14).

BOX 14.

Urban forestry project in Kumasi, Ghana

In launching the Kumasi urban forestry project in May 2014, the city's mayor said Kumasi residents must resolve to plant and tend at least one tree each. The tree-planting exercise, dubbed "Me and My Tree", with the slogan, "Let's Green Kumasi", aimed to engage school children and households in planting over 1 million trees by 2017 in driveways, on ceremonial routes and in open spaces. School children, chiefs and government officials planted trees together to mark the beginning of the project. The Kumasi Metropolitan Assembly, GIZ, the Bank of Africa and Melcom are providing financial support, seedlings and other planting facilities. A team of experts has been formed at the Kwame Nkrumah University of Science and Technology (KNUST) to monitor the project. Other partners, including the Forestry Research Institute of Ghana, the Institute of Renewable Natural Resources at KNUST, and the Ghana Education Service, are providing technical assistance. Social media – especially the Facebook profile of Kumasi Metropolitan Assembly – is ensuring ongoing communication and information, including encouraging stakeholder involvement.
Source: Kumasi Metropolitan Assembly (2014)

© FLICKR/BDODANE

Budgets and income generation. The funds allocated to the management of green urban spaces – although typically only a tiny part of total city budgets – are often under pressure; this is exacerbated by the difficulty in monetizing many of the benefits of urban forests. Policymakers and urban forest managers need to be inventive, therefore, in identifying funding mechanisms for UPF and policy instruments to increase the income generated by UPF. For example, they may need to explore external sources of funding, such as grants from central governments, foundations, associations and charitable organizations, and sponsorship by the private sector (Box 15).

BOX 15.

Public–private partnerships in urban forest management

Public–private partnerships in the management of urban forests are often restricted to green space plantings and maintenance, where private contractors carry out work for public authorities. In the United States of America, more strategic partnerships have developed in various cities, in which private conservancies or trusts co-manage large urban parks; examples are Central Park in New York and the Golden Gate Park in San Francisco. Such public–private partnerships are less common in Europe, although there are exceptions – such as the Woodland Trust in the United Kingdom of Great Britain and Northern Ireland and nature conservation organizations in the Netherlands, which own or manage woodland areas.

Sources: Drayson and Newey (2014); Buijs *et al.* (2016)

© FLICKR/M01229

LEGAL FRAMEWORK

A wide range of norms, laws and regulations exists pertaining to urban forests and other green spaces, and there is enormous variation in the legal status of trees, forests and other green infrastructure.

Whenever a city or other urban community decides to introduce or revise a set of norms regulating UPF, it is important to review existing laws and regulations at the various scales of governance.

The role of international institutions in legal frameworks

There is no legally binding global agreement dealing specifically with UPF, but numerous conventions and international programmes have some bearing on it. International organizations can play two main roles – facilitation and guidance – in the development of UPF legal frameworks.

1) **Facilitation.** FAO, UN-Habitat, the United Nations Environment Programme (UNEP), the UN Educational, Scientific and Cultural Organization, the United Nations Development Programme (UNDP) and the World Health Organization (WHO) all undertake actions and programmes to support local policies and laws related to the urban environment. Many international and regional partnerships involving cities – such as the Greener Cities partnership of UNEP and UN-Habitat; the Resilient Cities initiative of Local Governments for Sustainability (ICLEI); the Smart Cities initiative of the Institute of Electrical and Electronics Engineers; Sisters Cities International; and European Smart Cities and Communities – promote programmes, good practices and incentives for the smart governance of urban environments.
2) **Guidance.** A number of binding and non-binding international conventions, protocols and agreements exist that can guide the UPF-related actions of national governments and local administrations. The main binding conventions are the Convention on Biological Diversity and related protocols (including the Ramsar Convention), which pertain to land use, forest and tree management, urban biodiversity, habitat and genetic control (species selection); the UN Convention to Combat Desertification, related to actions to halt land degradation and drought; and the UN Framework Convention on Climate Change, which pertains to actions on the control of greenhouse gas emissions, urban and peri-urban afforestation, forest management and land-use change. To be effective, these conventions need to be ratified by countries and incorporated into national laws. Among non-binding instruments are the SDGs; the WHO health standards; the UN-Habitat resolution on sustainable urban development; and Chapter 11 of Agenda 21. International organizations have developed a range of relevant guidelines, such as those addressing tenure, landscapes, forests, urban settlements and climate change; these provide reference frameworks that can help in formulating laws pertaining to urban forests and other green infrastructure.

National laws

National-level laws may deal with, for example, forest ownership, exploitation rights and management norms, but there are few examples where they address urban forests specifically. Most often, national laws related to forestry and the environment set general standards and help shape the legal framework for forests and other green spaces at the urban level of governance. Legal frameworks pertaining to other sectors that may influence UPF laws at the national or subnational level include those referring to:

- forestry, agriculture, agroforestry and fisheries;
- mitigating forest loss;
- urban development;
- land use and land ownership;
- infrastructure and public works;
- nature and landscape protection;
- erosion control and watershed protection;
- decentralization; and
- incentives and supporting measures for local communities.

The extent to which national legal frameworks on UPF are binding at the subnational or municipal level varies, depending on context.

Municipal laws

Local laws on urban forests are often linked to the designation of green spaces for specific functions, such as urban parks, protected areas, street trees, green belts, historical and botanical gardens, school trees, gardens and forests, pocket landscapes and cemeteries. They may refer to – and regulate – the management of both public property and private estates that include UPF components. Policies, laws and regulations can provide authority, offer guidance to residents, specify rights, responsibilities and minimum standards, and regulate human activities affecting the resource. More specifically:

- Policies establish principles and guidelines for future decisions, actions, laws and regulations and provide an overview of the general approach to be taken in the establishment, management and use of urban forests.
- Tree ordinances and by-laws may provide authority, establish required conditions and actions, offer guidance, set standards, identify agents responsible for management activities, and provide incentives for maintaining healthy, vigorous and well-managed urban forests. Common types include street tree ordinances, tree protection ordinances (including compensatory measures for damage), tree preservation ordinances and by-laws, and view ordinances (i.e. protecting scenic views from trees on neighbouring properties that might block them).
- Permits are usually defined in tree ordinances and may encompass both publicly and privately owned trees. Permits commonly address issues related to tree removal, tree work, and the encroachment of construction into defined tree protection zones.

- Standards and specifications are guidelines for work performance, including tree-planting, tree maintenance and tree protection. Standards and specifications should be site-specific so as to best suit local circumstances.
- In many countries, regulation is constrained by private property rights, and municipalities have limited tools for regulating the behaviour of landowners. Municipalities can, however, use financial incentives like tax breaks and subsidies to encourage beneficial behaviour and subsidize landowners and tree owners to manage their properties for public benefit.

Usually, municipalities regulate urban forests through norms that have been created and amended over time; on occasion, however, subnational or national laws and regulations may supersede a local community's ability to control and manage trees on public and private lands. Ultimately, UPF-related laws should be developed to fit local conditions.

© FAO/SIMONE BORELLI

PLANNING, DESIGN AND MANAGEMENT

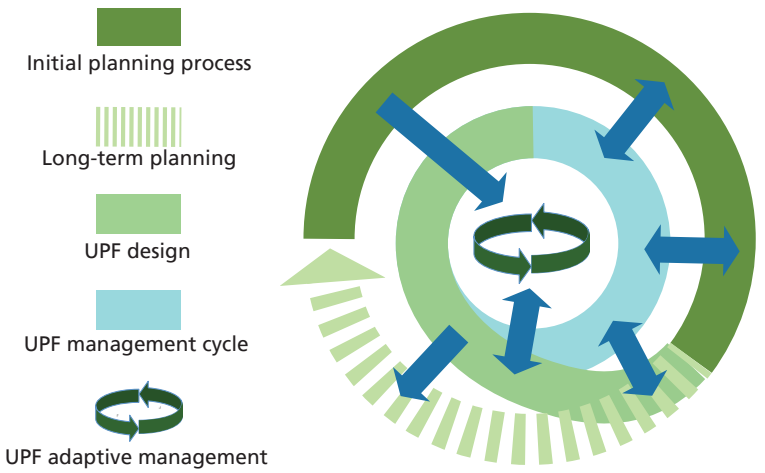
In the built environment, healthy and thriving trees and forests require careful planning, design and management to achieve their full economic, social and ecological potential.

The planning–design–management continuum

The green cities of the future will be the result of all the actions taken – or not taken – today. These actions (or non-actions) take place in a dynamic framework consisting of a planning process, a design phase and implementation (i.e. ongoing management). Thus, planning, design and management are three parts of a process in which continuous interaction and feedback can optimize the performance of decisions made and actions taken (Figure 4).

The boundaries between UPF planning, design and management are often nuanced. Cities are adaptive systems that change over time, as do urban forests; planning, therefore, needs to interact with design and management to maintain the adaptability of the city system. The enabling environment for UPF, therefore, should encourage integration and reciprocal learning in the planning, design and management continuum.

FIGURE 4.
The planning–design–management continuum



Planning

Contemporary urban planning starts from the viewpoint that the environment hosts the city, rather than the other way round. It is concerned with both the development of open spaces and the revitalization of existing areas in a city, and it involves goal-setting, data collection and analysis, forecasting, design, strategic thinking and public consultation.

Urban forests should be a priority in municipal planning strategies, with the objective of maximizing the benefits provided by trees and green infrastructure while reducing the cost of grey infrastructure (Box 16).

The various landscapes and open spaces in a city are assets that can reinforce a sense of place and identity, improve human health and well-being, and provide ecosystem services. Urban forest plans should provide a framework for actions, both active (i.e. what can be done) and passive (i.e. what is not permitted), and the norms regulating them.

The following are key steps for integrating urban forests in municipal planning processes:

- **Addressing UPF in urban plans.** A comprehensive urban plan should reflect local policies and provide a framework for implementing land-use regulations (e.g. zoning and functions), and it should specifically address all aspects of green infrastructure. Decision-makers and planners should ensure that green spaces receive equal attention in the urban planning process as elements of the built environment and are viewed as key components of infrastructure, providing the city with ecosystem services as well as (in many cases) both direct and indirect socioeconomic benefits. City master plans should earmark areas to become green spaces, specify the functions of such green spaces, and provide funding for their development, maintenance and conservation. Consideration should be given to the use, wherever possible, of green infrastructure rather than grey infrastructure, using nature-based approaches to (for example) deal with stormwater runoff, treat sewerage, save energy and improve human health.

BOX 16.

Green infrastructure in Philadelphia, United States of America

The city of Philadelphia is trying to institutionalize green infrastructure as a standard practice for improving local stormwater management and alleviating pressure on its sewer system. According to forecasts, addressing the sewerage problem using grey infrastructure would cost the city US$8 billion more over a decade than if green infrastructure (e.g. rain barrels, bioswales, pervious pavements, and wetland protection and restoration) were used. Moreover, the use of green infrastructure would generate additional benefits for the city through improved water quality, increased carbon sequestration, improved habitat for wildlife, and the increased availability of recreational open spaces. To support the green-infrastructure approach, the City revised its stormwater billing system, offering discounts for customers who reduced impervious cover on their land using green-infrastructure solutions.

Sources: EKO Asset Management Partners *et al.* (2013); EPA (2010)

- **Fostering dialogue between UPF and other planning components.** Wherever possible, urban plans should establish meaningful links between urban forests and other aspects of the plan. For example, street trees should be considered in the transportation component and urban parks in the economic development component (e.g. urban parks often host arts festivals and cultural events that draw tourists and strengthen local economies). Cross-referencing land-use elements in an urban plan can help in identifying risks, such as those posed to urban forests by planned developments, and actions should be specified to minimize such risks. For example, the presence of valuable forest resources in an area may require a review of the conditions specified in construction permits. Opportunities should be sought to bring together staff of relevant departments (such as public works, parks, and planning) and other stakeholders such as developers and environmentalists in the planning process to collaboratively draft strategic, sectoral and operational plans.
- **Including a UPF evaluation checklist or guidelines among the technical and legislative norms of city development strategies.** Incorporating UPF in urban planning and management requires an integrated approach that recognizes the multiple dimensions and scales of urban environmental problems and opportunities. Cities vary greatly in their environmental context, population size, physical and ecological features, social and economic challenges and priorities, and level of autonomy in decision-making. A checklist of indicators, actions and achievements can make it easier to discuss, evaluate and incorporate the services of urban forests in city development strategies (Box 17). The most successful systems for monitoring urban forest plans are those that can be incorporated into standard maintenance activities.

BOX 17.

Criteria and indicators for strategic urban forest planning and management in Canada

The municipalities of Oakville and Ajax, Canada, have incorporated a set of criteria and indicators for strategic urban forest planning and management in their long-term strategic urban forest management plans (in 2008 and 2010, respectively). The criteria and indicators provides a standardized set of 25 performance measures aimed at helping managers assess the effectiveness of their urban forest management approaches and guiding them in improving the conservation of urban forest resources. The criteria cover three main areas: 1) vegetation resources; 2) the community framework; and 3) overall management. This set of performance measures can be applied in all phases of urban forest management, from identifying objectives to communicating with stakeholders. In light of the successful experience, the tool has been taken as a model for the development of similar plans in other municipalities.

Sources: Kenney, van Wassenaer and Satel (2011); Clark *et al.* (1997)

- **Taking an adaptive management approach to urban forest resources.** Until recently, urban planning was mostly carried out in a top-down manner, leading to the development of rigid documents and norms. As a result, the actual application of plans required continuous exceptions, causing delays in implementation and creating conflicts. An adaptive management approach (see page 45), including regular monitoring and evaluation, will ensure that urban plans respond rapidly and appropriately to the evolving needs of urban communities.
- **Planning for the long-term maintenance of urban forests.** Time is a crucial aspect of planning. Urban plans generally span several years, but trees (and forests) may live for centuries. Integrating urban forests in city planning requires the adoption of a long-term perspective on their management, maintenance and conservation.

Design

Design should turn a "space" into a "place": designing urban forests and other green spaces is the art of creating sustainable living places that are good for both people and nature. A good urban forest or other green space will create a sense of well-being in a community and respond to its needs and demands while enhancing the sustainability and environmental quality of the space.

Urban forest design is not restricted to the creation of new forests: it may also involve the redesign of existing forests; interventions aimed at improving existing green spaces to provide new services and facilities and enhance their sustainability;

and even the rethinking and redesign of the wider urban landscape. By rethinking urban design, architecture, transport and planning, it is possible to turn cities and urban landscapes into "*urban ecosystems*" that, among other things, contribute to climate-change mitigation and adaptation.

The effective design of green spaces involves creating synergies among the social, biological and physical aspects of urban forests. Green spaces will attract local people most effectively when they are integrated with the wider urban landscape. Each green space, therefore, should be an integrated part of a city's green infrastructure, providing, in combination, a range of environments and experiences for the community and a complementary setting for its built elements. The design of quiet, safe, clean and green urban spaces can greatly improve the quality of life of a city's citizens.

Designing an urban forest: what and how? All urban forest design processes should start with the identification of suitable spaces. There are three main types of location for forests and trees in urban and peri-urban settings:

1) trees in streets, squares, parking areas and other "grey spaces" with sealed surfaces;
2) trees in parks and other green spaces such as continuous soil strips, yards, gardens and commercial areas; and
3) stands, patches and other groups of trees, which may be referred to as "woodlands", "woods" or "forests".

All potential constituencies in a community should be consulted in urban forest design so that it fully reflects their needs, requirements and demands; the design process should be sufficiently flexible to accommodate the outcomes of the consultation process. It is also crucial to ensure that any urban forest design:

- promotes the social comfort of users by meeting the needs of the community;
- is compatible with the specific characteristics of the site;

- creates places in which trees can thrive and deliver their full range of benefits without causing nuisance; and
- helps meet the SDGs.

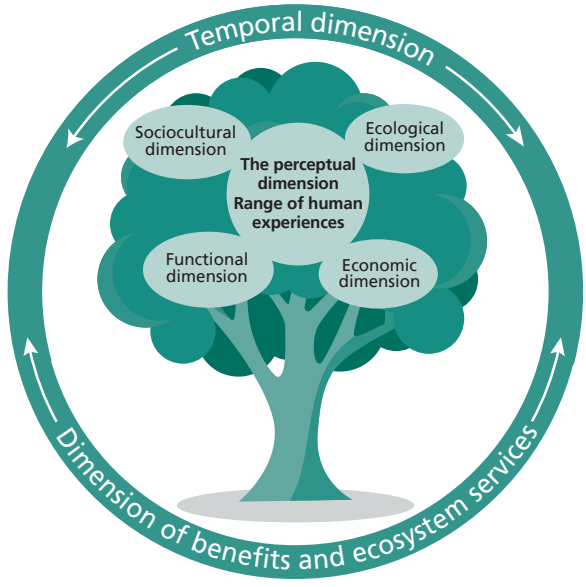
Be skilled, stay creative: the character of urban forest design. The right tree in the right place is a simple but effective rule for any urban forest design. A healthy urban forest begins with a clear understanding of the environmental (e.g. climate, soil, biology and ecology), infrastructural (e.g. relationships with natural and artificial infrastructure) and sociocultural (e.g. community preferences, perceptions, needs and attitudes) characteristics of the site.

A well-designed urban forest will cool homes in summer and mitigate winter winds; grow well in local conditions; and improve the aesthetics and health of the living environment. Moreover, it will not interact negatively with infrastructure such as power lines and buildings.

Designing urban forests and other green spaces requires injecting technical knowledge and skills (e.g. in applied ecology, landscape architecture, sociology and economics) into a creative process in which the main objects of design are living organisms that change over time. The creative process translates urban forest planning into reality and lays the groundwork for sustainable management over the long term.

The dimensions of urban forest design. The design of urban forests has six dimensions. The social, functional, ecological and economic dimensions interact with the perceptual dimension over time to provide ecosystem services and other benefits (Figure 5). Each of the six dimensions is discussed further below.

FIGURE 5.
Dimensions of urban forest design



1) **Perceptual dimension.** This dimension of urban forest design relates to how people perceive the environment and experience places. Comfort and image are keys to whether a place will be used. Perceptions about safety and cleanliness, the physical context, and a place's character or charm are often foremost in people's minds – along with more tangible issues, such as having a comfortable place to sit. A good urban forest design should:
   - emphasize the identity, structure and meaning of the location;
   - create differentiations and thematic spaces related to the specific needs of the community and their dreams and wishes; and
   - create or enhance a sense of place.

Urban forest design should take into account the way in which an environment appeals to the five senses – hearing, sight, smell, touch and taste. It should consider the physical and psychological needs and wishes of a community.

The "sense of place" pertains to the emotional bonds that people form with places over time. Crucial to the development of a sense of place is awareness of the cultural, historical and spatial context within which meanings, values and social interactions are formed.

Elements of the perceptual dimension: order and variety; unity; diversity; spirit of place (*genius loci*); all-round perception (e.g. visual, smell, taste, sound, touch and memory); psychological aspects; capacity to respond to needs and wishes (e.g. recreation, shade, wood and food).

2) **Sociocultural dimension.** Cultural, social, physical and ecological elements and processes determine the preferences, perceptions and uses of urban forests in a community. To meet the needs of users, landscapes should be designed in ways that allow people to become familiar with green spaces at their own pace. The location of an urban forest has a strong bearing on who enjoys it, how often, and at what times. Its size influences the kinds of experience the visitor has: small forests may be used as refuges for contemplation and represent an opportunity for children to engage in adventures, and larger forests can accommodate multiple uses and may offer a "wilderness experience". Vegetation structure can provide a sense of enclosure or protection, but an open structure is generally preferred in urban settings. The presence of water, broad views, lawns and other spaces for meeting, relaxing and playing sports can all help ensure the social success of an urban forest. All these elements are interconnected with local cultures and individual and community attitudes.

Designers of urban forests should conduct preference/perception analyses. Participatory and collaborative design represents a decisive step forward in developing the sociocultural dimension of urban forests.

Elements of the sociocultural dimension: use and user preferences; perception and/or preference analysis; interpretation; education; community engagement in design processes. Physical features that can enhance the social dimension include: distance; size; shape; paths; variety of forest structure; privacy; accessibility; water; lawns; broad views.

3) **Ecological dimension.** The design of urban forests should adopt ecological principles at various scales – the municipality (macro-scale), neighbourhood (meso-scale), and individual building (micro-scale) – encompassing structural, species and spatial diversity as well as habitat connectivity. For example, forest patches and corridors in urban and peri-urban landscapes may function as "stepping stones" for migratory species, linking urban forests with forests in adjacent landscapes. The age, size and species composition of urban forests also have important impacts on plant and animal communities. An understanding of variation in forest ecosystems is essential in the creation of urban forests with a "natural" character. There are three possible approaches to designing the ecological dimension of urban forests: 1) ecological succession approach (laissez-faire), in which natural ecosystems develop unassisted; 2) close-to-nature design, which involves a certain level of intervention and management as trees and forests develop, mimicking ecological processes; and 3) artificial construction, in which urban forest elements are designed with little relation to natural ecosystems.

Urban forest design that makes use of ecological principles will contribute to the resilience and sustainability of cities while providing a wide range of ecosystem services.

Elements of the ecological dimension: open space and dead or dying wood; tree species richness; canopy structure variability; age class of trees and retention of veteran trees; edge structure and vegetation; riparian zones and aquatic habitats; artificial resources such as nest boxes; mosaics of large and small spaces; clusters of forest patches; predominance of native trees and shrubs; a shrub layer, especially at forest edges; ecological corridors.

4) **Functional dimension.** Urban forests can perform many functions in city environments, producing a wide range of economic, social and environmental benefits. Balancing competing demands on urban forests and taking a multifunctional approach are crucial in the design process. For example, conflicts over urban forests between recreational users and conservationists are common and need to be managed and, where possible, resolved. The specific needs and concerns of local communities in urban forests can be determined and potential conflicts identified through, for example, multistakeholder dialogues, surveys, informal conversations and evidence of activities.

Urban forests can perform many functions, and users often have differing and sometimes conflicting interests. Stakeholder consultation is vital in urban forest design to reduce the potential for conflict.

Elements of the functional dimension: multifunctionality; carrying capacity; silvicultural and management aspects; balance of competing demands; interest groups; recreational aspects; historical aspects; human movement; comfort; needs and expectations; forest products (wood and non-wood, including food); active and passive engagement.

5) **Economic dimension.** The economic dimension of UPF design has four elements:
   a) the economic value (not always monetized) of the ecosystem services generated by UPF;
   b) perceived virtues – as indicated, for example, by the willingness to pay for microclimatic benefits (e.g. urban forests providing shade and acting as windbreaks) or noise reduction (urban forests as noise barriers);
   c) the role of UPF in providing income, employment and subsistence (this may be especially vital for impoverished people who lack income and who use urban forests to support their subsistence); and
   d) the means of financing the design and management of urban forests, including the opportunity cost of devoting an area of land to public green space.

Simply designed urban forests may be cheaper to establish and maintain than built infrastructure while performing similar functions and generating income through the products and ecosystem services they provide.

The economic efficiency of urban forest design is determined by comparing the benefits derived from the forest with the costs. For example, an economic argument for the creation of an urban forest using a naturalistic approach may be that it can provide certain ecosystem services at a lower cost than can conventional grey infrastructure.

Elements of the economic dimension: implementation costs; management and maintenance costs; economic values of benefits; available budget; savings; payments for ecosystem services; volunteers; simply designed planting schemes.

6) **Temporal dimension.** Taking into account the various time cycles of biological (e.g. humans, trees, shrubs, wildlife and microorganisms) and structural (e.g. buildings and roads) components of the landscape is crucial for successful urban forest design and management.

Given the short lifespans of policies, markets and social behaviours compared with the life cycles of trees and forests, urban foresters should aim to design forests that can meet current needs and address pressures and yet be resilient and adaptable to change over time.

Time is an important consideration in urban forest design. It can take years for new forests and trees to develop and fulfil their expected functions.

A key element of the resilience and adaptability of urban forests is structural diversity in terms of age, spatial profile and species distribution. Structural (and thus functional) diversity can be achieved quickly by planting appropriate fast-growing pioneer trees and shrubs in addition to slower-growing trees.

Elements of the temporal dimension: resilience; robustness; life-cycle assessment; continuity and dynamic stability of ecosystems; changing urban design projects and policies; continuity of cultural/natural heritage.

Design and management for goods and ecosystem services. Urban forest designs usually envisage the provision of a wide range of goods and ecosystem services. The framework of ecosystem services (supporting, provisioning, regulating and cultural – see Millennium Ecosystem Assessment, 2005) should be a guide as well as a checklist for designers in optimizing the benefits for nature and people.

Urban forest design can also be a tool for addressing urban poverty. The effective design of urban forests and other green spaces can address fundamental human rights, such as the right to land and access to resources such as food and wood, the right to avoid marginal or fragile environments that lack access to clean water or sanitation, and the right to access to places for socializing and recreation.

The designers of urban forests should aim to build constructive dialogues and find synergies with the managers of other natural resources and other land uses in urban and peri-urban areas. Effective design can help create smart cities by promoting the integration of, for example, green infrastructure, townscapes, sports areas, schoolyards, therapeutic gardens, horticulture, forestry, agroforestry and agriculture. Designers should be aware of increasing interest in "nature-based solutions" approaches, which hold that nature is a valuable tool for dealing with major challenges in urban environments.

Management

Urban forests are composed of a diversity of trees and other vegetation, perhaps dispersed as interconnected patches within the broader landscape and with differing structures, ages, levels of risk, ownership, infrastructure, uses, level of demand, histories, functions, and services delivered to the community. Some parts of the forest may need more intensive management than others, depending on the specific combination of such characteristics. The more informal the initial design and naturalness of the forests, the less intensive the management is likely to be.

In most cities, responsibility for the management of urban forests is divided

among several departments. For example, street trees may be under the care of the public works department, while the parks department may manage trees in parks and other open spaces. Planning departments may issue permits or approve plans that affect tree management on private properties, and planning and building inspectors may monitor compliance with tree protection measures during construction.

Municipal governments generally have responsibility for the management of publicly owned trees and forests, although they sometimes delegate the actual management to public or private agencies. In some cases, national (or subnational) public forest services may have responsibility for managing urban forests, either as a whole or for specific tasks. Outsourcing to multiservice companies or tree-care companies is increasingly used as a way of integrating the management of trees and forests with other city services.

The managers of urban forests may also deal with other aspects of the urban environment, such as utility line clearance; damage to sidewalks and other hardscapes due to tree roots; construction damage to tree roots; the invasion of natural areas by exotic species; and fire hazards at the urban–wildland interface.

Many homeowners, community associations, utility companies and businesses manage trees and forests in the private domain. This socially diverse management can greatly affect the distribution of tree-canopy cover in cities, and it can potentially create inequities in the distribution of ecosystem services. The issue of environmental justice should therefore be given due consideration in urban forest planning.

The management plan

There is no "one size fits all" urban forest management plan because each urban forest has a unique set of constantly evolving economic, social and environmental conditions. In general, however, the development of urban forest management plans follows five steps, as set out below (and illustrated in Figure 6).

1) **Assessing resources.** The first step in the preparation of an urban forest management plan is an assessment of the resource, including its history, status and existing issues. The type and scope of data will vary depending on management objectives (e.g. production, protection or recreation), which may differ within an urban landscape and between cities (and countries). The scope of the assessment will also depend on the availability of funds and technologies, such as remote sensing tools.

   There are several ways in which to conduct assessments. They may be simple "windshield surveys" in which tree data are collected from a slow-moving car, or statistical samples of an entire urban forest estate using digital imagery.

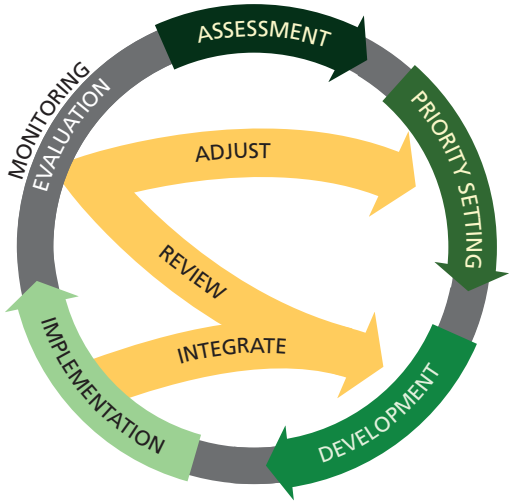
   In addition to tree species, size and condition (i.e. from a maintenance standpoint), urban forest inventories should include assessments of the risk to human health and safety, and of conflicts over management and use (such as utilities and sidewalks). Tree health is an important parameter because decayed and fallen trees can pose risks to people in densely populated areas as well as to urban infrastructure. Some tree pests, such as the processionary moth, may also be of concern for human health and safety. Information should be gathered on tree location, land availability and tenure, water resources, and existing tree nurseries.

2) **Identifying scope and needs and setting priorities.** Data from the forest inventory and other sources (e.g. urban plans and social-impact surveys) can help identify potential issues and future management needs, planting sites, tree-related risks, and the potential for the production of goods and ecosystem services. Such data provide the basis for priority-setting processes that aim to achieve an appropriate balance among legitimate competing interests.

   The success of urban forest management depends on public support and participation. The involvement of the community in priority-setting and other decision-making processes from an early stage, therefore, is essential. To be most effective, an urban forest management plan should be accepted, supported and "owned" by all those with a concern or interest in the urban forest. These may include:

   - *decision-makers* – the elected members or trustees responsible for higher-level strategic decisions (e.g. on annual budgets) that affect the forest;
   - *forest managers* – all those involved in the management and maintenance of the forest, including both public and private actors who operate in the forest and have an influence on access, visual amenity and local environmental quality;

FIGURE 6.
The urban forest management cycle



1. ASSESSING RESOURCES	• Assessing existing green spaces, trees and forests, ecosystem services, benefits and needs, risks, budget, natural and human capital • Inventory (complete, partial or sample) of existing trees, forest resources, parks and green spaces
2. IDENTIFYING SCOPE AND NEEDS AND SETTING PRIORITIES	• Sharing a vision; stakeholder mapping; problems/solutions analysis • Defining scope and needs • Setting the expected achievements and ranking priorities • Defining and sharing management responsibilities • Identifying sources of budget and support
3. DEVELOPING THE MANAGEMENT PLAN	• Defining the scale, duration and type of management plan • Detailing the political endorsement and decision-making process • Ensuring adequate baseline data, professional guidance, time, funding and the collaboration of multiple stakeholders • Setting the organization in time, space, capacities and priorities of management actions • Defining the administrative and legal framework • Performing a cost–benefit analysis and budget assessment • Preparing a framework for action and a general workplan with timeline, activities and responsible persons or positions • Programming outreach and public education activities, including safety • Consolidating the community involvement process
4. IMPLEMENTING THE MANAGEMENT PLAN	• Preparing and following detailed operational workplans • Clarifying and counter-checking agreements on the respective responsibilities • Testing and readjusting the outcomes of tree ordinances, regulations and policies • Making the necessary financial resources available • Hiring tree-care professionals and planning community management programmes • Developing public education programmes • Site and soil preparation; selection of regeneration processes; species selection; planting operations; tree and forest nurseries; and early care of tree plantings • Conducting actions on tree maintenance, silvicultural/arboricultural treatments (tending, thinning and pruning), tree and forest health management, risk management, and tree removal and forest harvesting
5. MONITORING AND EVALUATION	• Activating medium- to long-term monitoring programmes • Monitoring and evaluating the establishment, growth, composition, health and quality of forests and trees, the provision of ecosystem services, technical

- *local residents* – those people who use the forest or who live in or near it; and
- *non-resident beneficiaries* – individuals, groups and local businesses who may not have a direct relationship with the forest but who receive indirect benefits from the ecosystem services it provides.

3) **Developing the management plan.** Management plans for urban forests may vary in scale (e.g. local, city, national or regional), duration (short-term to long-term) and type (e.g. master or strategic). Their development requires adequate baseline data, professional guidance, time, funding and the collaboration of multiple stakeholders. Ideally, management plans will encompass an entire urban forest estate, even if (as is almost always the case) different segments of the estate are managed by different entities.

A standard urban forest management plan includes sections on the following:

- Background/history
- Current status and issues across all lands
- Analysis of potential for urban forest development
- Administrative and legal framework
- SMART (specific, measurable, achievable, relevant and time-bound) goals and objectives
- Cost–benefit analysis
- Budget
- Tree establishment, maintenance, protection, removal and use
- Maintenance of green spaces
- Outreach and public education activities, including safety
- Community involvement process
- Details on political endorsement and decision-making process
- Workplan with timeline and persons or positions responsible.

4) **Implementing the management plan.** Those responsible for implementation should undertake the actions specified in the management plan in a timely, effective and efficient manner. Detailed workplans should be developed with clearly delineated responsibilities and specified actions.

The approach taken to implementation will vary depending on the nature of the administrative system and laws, the stage of development of the urban environment, and the level of public involvement. Typically, however, it will include the following steps:

- clarifying and reaching agreement on the respective responsibilities of the entities managing the urban forest;
- passing tree ordinances, regulations and policies;
- making the necessary financial resources available;
- hiring tree-care professionals and planning community management programmes;
- developing public education programmes; and
- conducting activities according to the detailed workplan.

5) **Monitoring and evaluation**. Ensuring the sustainability of urban forests requires a long-term monitoring programme so that the effects of management interventions can be evaluated and the achievement (or otherwise) of management objectives can be assessed. An effective monitoring programme also generates information that can be used to adapt the management plan in light of experience and to inform the development of future management plans.

Adaptive management: a strategic framework for urban forest management

Urban foresters are increasingly adopting adaptive management approaches. Trees are a long-term investment, and successes and failures rarely happen overnight; for example, trees can take years to respond to stress factors or improvements designed to promote their health and longevity. Maintaining healthy urban forests, therefore, must be addressed from a long-term perspective. Active adaptive management[6] offers a suitable strategic framework for ensuring successful urban forests over time.

In UPF, adaptive management can reduce uncertainty by systematically monitoring management objectives and by gathering, analysing and making use of forest data to improve management actions.

Urban forests are complex, dynamic entities, and managers need to adapt their management in light of economic, social and environmental change while striving to achieve established (or evolving) goals. In active adaptive management, problems are assessed and strategies designed and implemented to address them. The materials and processes used and the results of interventions are monitored systematically and adjustments are made as experience is gained and new information becomes available from ongoing monitoring and assessment. In practice, active adaptive management is usually implemented on the basis of reviews of five-year to ten-year management plans towards the end of the planning horizon, and subsequent periodic management plans are based on the results of those reviews.

6 Active adaptive management is "a systematic process for continually improving management policies and practices by learning from the outcomes of previously employed policies and practices. In active adaptive management, management is treated as a deliberate experiment for learning" (Millennium Ecosystem Assessment, 2005).

© FLICKR/STEPH C

3 Addressing key issues

Urban forests can provide a wide range of products and ecosystem services to help meet the needs of urban and peri-urban dwellers. They can address many challenges of local to global importance, such as climate-change mitigation and adaptation, food and energy security, health and well-being, the need for employment and income, biodiversity conservation, watershed management and disaster risk reduction. This chapter presents guidelines for maximizing the contributions of urban forests to such challenges.

HUMAN HEALTH AND WELL-BEING

Well-designed and managed urban forests and other green spaces can play important roles in ensuring healthy lives and promoting well-being through disease prevention, therapy and recovery.

In many settings, the rate of urban growth has exceeded the capacity of health systems to serve growing populations, and urban and peri-urban dwellers face many health challenges. Sedentary urban lifestyles, high levels of air pollution, and peculiarities of the urban microclimate may lead to substantial increases in illness and disease, including mental stress; thermal discomfort and dehydration; cancers associated with air pollution or insufficient physical activity; diabetes and cardiovascular disease; and obesity. Moreover, rapid urban growth can result in the proliferation of slums and other impoverished settlements that create highly unhealthy conditions.

The balance between the natural and built environments is recognized as an influential factor in urban health. The WHO's Health Promotion Glossary (WHO, 1998), for example, defines a healthy city as "one that is continually creating and improving those physical and social environments and expanding those community resources which enable people to mutually support each other in performing all the functions of life and developing to their maximum potential".

Urban forests can perform three health-related functions: 1) disease prevention; 2) therapy; and 3) recovery from illness. They can reduce the direct and indirect causes of certain non-communicable diseases and urban stressors, such as ultraviolet radiation and air and noise pollution, and they can help in cooling the environment. The presence of, and access to, green spaces can promote active lifestyles and regular exercise, thereby reducing the risks posed by obesity, type 2 diabetes, coronary heart disease, respiratory disorders and some types of cancer.

© FAO/JOAN MANUEL BALIELLAS

Urban forests contribute indirectly to health in cities by sustaining the production of fresh and nutritious food and helping provide renewable energy for cooking. The presence of green spaces can also have a positive effect on psychological well-being by reducing stress and improving mental health. For example, it has been shown that surgery patients whose rooms faces groves of trees recuperate faster and require fewer painkillers than similar patients who view only brick walls (Ulrich, 1984). Also, sitting in a room with tree views has been proven to promote more rapid decline in diastolic blood pressure than sitting in a viewless room (Hartig *et al.*, 2003).

Urban forests are now being designed and managed to support convalescence programmes; for example, healing gardens are being installed alongside traditional healthcare structures. Designs to maximize the psychologically restorative potential of urban forests and other green spaces are now included in landscape architecture and UPF courses worldwide.

Poorly planned or managed urban forests have the potential to have direct and indirect negative impacts on human health. For example, they can induce allergies, host potential vectors of epidemic or non-communicable diseases, and cause injuries to pedestrians and vehicular passengers. These risks can be reduced and minimized through adequate risk management (see below).

Urban forests and the SDGs: human health and well-being

Key actions

Policy and legal framework

- Ensure that recommendations provided by WHO and other international bodies on the availability, accessibility, quality and security of public green spaces are incorporated and reflected in national and city policies and regulatory/legal documents.
- Promote and adopt strategies and financial and administrative mechanisms to maximize the potential for green spaces to deliver positive environmental and health benefits.
- Promote collaboration and information-sharing among the sectors involved in urban greening, urban planning and healthcare.
- Ensure the inclusion of health and well-being objectives in policies on urban forests and green spaces.
- Ensure that savings in healthcare costs generated by urban forest ecosystem services are taken into account in relevant policies and duly incorporated in the financial accounts of governments.

Planning, design and management

- Adopt sound standards for the design and management of urban forests with the aim of encouraging physical activities and improving mental health.
- Optimize the availability, accessibility, proximity, permeability and security of urban forests to promote the use of such resources by all citizens.
- Maximize the thermal comfort, pollution filtration and noise reduction functions of urban forests when planning and designing public spaces and streets.
- Consider including in the design and management of urban forests the production of fresh and nutritious food as well as natural and traditional remedies for use by local communities.
- Include urban forests in the planning and design of hospitals and schools for their proven therapeutic and psychological benefits for patients and children.
- Develop greenways/blueways to increase alternative mobility (e.g. bicycles) as a way of promoting physical and mental health and reducing pollution.
- Minimize the potential undesirable impacts of urban forests on human health and well-being in designing and managing urban forests.

Key monitoring criteria

- Availability, accessibility and proximity of green spaces
- Perceived attractiveness of urban forests to citizens
- Pollution levels in the city
- Suitability of urban forests to host sporting and other leisure activities
- Extent to which healthcare services promote the use of urban forests
- Number of "green" prescriptions
- Perceived thermal/physical/psychological comfort

Key competencies/skills to be developed

- Design and management of urban forests and other green spaces for restorativeness, illness prevention, therapy and rehabilitation
- Design and management of urban forests to maximize their capacity to remove traffic pollutants and optimize thermal comfort for pedestrians
- Planning and design of green spaces to encourage sporting and other leisure activities
- Management of potentially allergenic urban tree species

Main knowledge gaps to be addressed

- Indicators for monitoring and evaluating the effects of urban forests on human health and well-being
- Effectiveness of urban forests and other green spaces in therapies and recovery programmes related to mental health and non-communicable diseases
- Most effective urban forest structures and designs for filtering noise and atmospheric pollution caused by road traffic and industries, as well as for cooling the urban environment

Helpful facts for advocacy

- Outdoor walks in urban green spaces can lead to a reduction in clinical depression of more than 30 percent compared with indoor activities (Frühauf *et al.*, 2016).
- A 10 percent increase in urban green space in a community can postpone the average onset of health problems by up to five years.
- A study in London found that the number of medical prescriptions decreased by 1.18 per 1 000 people for every extra tree per km of street (Taylor *et al.*, 2014).
- Children living in areas with good access to green spaces have been shown to spend less time in front of television screens, computers and smart phones and to have an 11–19 percent lower prevalence of obesity compared with children with limited or no access to green spaces (Dadvand *et al.*, 2014).
- In the United States of America, trees help reduce or prevent more than 670 000 cases of severe respiratory diseases per year and thereby save more than 850 lives annually (Nowak *et al.*, 2014).
- Wide belts (30 m) of tall, dense trees combined with soft ground surfaces can reduce apparent loudness by 50 percent or more (6–10 decibels) (Cook, 1978).

Significance of urban forest type for human health and well-being

Urban forest type	Significance (on a scale of 1–5*)
Peri-urban forests and woodlands	
City parks and urban forests (>0.5 ha)	
Pocket parks and gardens with trees (<0.5 ha)	
Trees on streets or in public squares	
Other green spaces with trees	

* Where 1 = very low significance and 5 = very high significance.

Case studies

Green Rehab

Green Rehab ("Gröna Rehab") is intended for employees in Sweden's Västra Götaland Region who have or are at risk of suffering stress-related illnesses or mild depression. It is housed in the Gardener's Cottage in Lilla Änggården, just south of the botanical garden in Gothenburg, and the cottage is adjacent to the Änggårdsbergen Nature Reserve and surrounded by a rehabilitation garden. The programme is based on the insights gained from research on how gardens and nature can help humans recover. It combines these insights with established methods, and the staff includes a biologist, a gardener, an occupational therapist, a psychotherapist and a physiotherapist. Participants sow and harvest in the garden and take guided walks together in the surrounding forest or in the botanical garden. In winter, they prune trees and bushes and do handicrafts. Other activities include body awareness, stress management and art therapy.

Source: Västra Götalandsregionen (2015)

Chopwell Wood

Chopwell Wood is located close to the major urban settlements of Gateshead and Newcastle in a former coal-mining community in northeast England; it is owned by the Forestry Commission, and an active "Friends of Chopwell Wood" group is associated with it. Chopwell Wood has been the focus of well-being activities since a pilot health project took place there in 2004–2005, the aim of which was to raise awareness and develop the potential of woodlands as a resource for improving the health and well-being of local communities. The pilot included the employment of a health development worker to improve links with local health services and health promotion providers and also involved general medical practitioners and schools. Through the pilot project and the efforts of the Friends of Chopwell Wood, a range of activities and educational opportunities are now in place for all ages, such as walking trails and opportunities for cycling, mountain biking, horse-riding and orienteering.

Sources: Snowden (2006); C. Davies, personal communication (2016)

Designing spaces with low allergy impact

Spanish researchers have proposed guidelines for urban planting to reduce the effects of pollen on urban and peri-urban dwellers. They make nine recommendations that, if followed by local authorities, would reduce the allergenic effects of pollen on city inhabitants. The recommendations include increasing urban plant biodiversity; replacing male plants with female plants where possible; carefully controlling the planting of exotic species; using low-pollen-producing species; and consulting with botanists when selecting the most suitable species for a given green space. The researchers recommend other changes in the management of urban green spaces, such as improvement in the maintenance of derelict land and neglected green spaces to reduce the dominance of single species that produce large amounts of pollen.

Source: Cariñanos and Casares-Porcel (2011)

CLIMATE CHANGE

Urban forests can contribute to climate-change mitigation, both directly by sequestering carbon and indirectly by saving energy and reducing the urban heat island effect.

Urban areas are major contributors to climate change: although they cover only 2 percent of the earth's surface, they produce more than 70 percent of global carbon dioxide emissions as well as significant quantities of other greenhouse gases. Urban areas are also highly vulnerable to climate change. Rising sea levels, increased precipitation, inland floods, more frequent and stronger cyclones and storms, and increased extremes of heat and cold, all of which are projected under climate-change scenarios, are likely to affect hundreds of millions of urban and peri-urban dwellers worldwide in coming decades. Most affected are likely to be the urban poor, who tend to live in low-lying areas along waterfronts; on hillsides and slopes vulnerable to landslides; near polluted areas; on unplanned or desertified brownfields; or in unstable structures. Despite these risks, many cities are yet to plan adequately for climate change.

Urban forests can play key roles in making cities more resilient to the effects of climate change. For example, they can mitigate stormwater runoff, improve air quality, store carbon, decrease urban energy consumption by shading and cooling (potentially mitigating the urban heat island effect), and reduce the impacts of extreme weather and floods. The vegetation and soils of urban forests provide potentially very large carbon sinks. The potential for urban forests to reduce the vulnerability of cities to climate change has clear implications for policies that encourage urban infill, high housing densities and the consequent potential

reduction or loss of green spaces. As temperatures rise due to climate change, green spaces are likely to become increasingly important, especially for their direct ameliorating effects on urban microclimates.

Climate change will have implications for the management and cost of maintaining urban forests and other green spaces, which, for example, may require more watering during drought and be subject to excessive use. UPF must be properly planned so it can respond effectively to climate change.

Urban forests and the SDGs: climate change

Key actions

Policy and legal framework

- Carry out cost–benefit analyses to compare policies based on the use of nature-based climate-change mitigation and adaptation solutions with traditional "grey infrastructure" options.
- Adopt policies to increase urban tree cover to fulfil national and global carbon reduction requirements.
- In urban energy policies, adequately promote the contribution of UPF to climate-change adaptation and mitigation, particularly through energy saving (e.g. encourage tree-planting in energy-saving locations to shade homes and businesses).
- Design direct and indirect incentives (e.g. tax reductions) for the creation and sustainable management of urban forests and other green infrastructure aimed at climate-change adaptation and mitigation.

Planning, design and management

- Ensure that carbon sequestration and climate-change mitigation and adaptation are adequately considered in urban forest cost–benefit analyses.
- Adjust urban forest management plans and other planning tools to accommodate climate-change adaptation and mitigation measures and to incorporate the knowledge gained through assessments of climate-change vulnerability, risks and mitigation options.
- Actively manage urban forests to ensure structural heterogeneity and a range of age classes through diversified silvicultural interventions. Promote a diversity of native species to create multilayered canopies that can increase the carbon sequestration capacity of urban forests.
- Adopt an ecosystem approach to managing urban forests as a way of maximizing carbon sequestration while also increasing the complexity, resilience and adaptability of biological communities, including in the soil.

- Consider the likely impacts of climate change on tree and forest growth when determining sites and selecting species for the establishment of urban forests.
- Assess the risks that climate change poses to the achievement of urban forest management objectives (i.e. the delivery of desired forest products and ecosystem services).

Key monitoring criteria

- Heat island effect
- Energy needed for cooling/heating buildings
- Thermal comfort levels on pedestrian paths and in recreational areas
- Carbon storage

Key competencies/skills to be developed

- Design of nature-based solutions for maximizing the natural cooling and warming of buildings
- Implementation of inventories of carbon stocks at the municipal level
- Assessment and monitoring of the impacts of changing climatic conditions on tree health, including the spread of tree pests
- Assessment of the costs, benefits, trade-offs and feasibility of climate-change adaptation and mitigation measures

Main knowledge gaps to be addressed

- Tree species resistant to the urban heat island effect
- Best management practices for addressing the direct and indirect effects of climate change on urban forests
- Climate-change modelling at the local scale, including on ecological, genetic, meteorological and soil formation components
- Tree integration in urban and peri-urban agricultural systems to increase the adaptation capacity of local communities to climate change (including increasing temperatures)

Helpful facts for advocacy

- The net cooling effect of a young, healthy tree is equivalent to ten average-sized air-conditioners operating 20 hours per day (Wolf, 1998a).
- Shade from trees can reduce utility bills for air-conditioning in residential and commercial buildings by 15–50 percent (Parker, 1983; Huang *et al.*, 1987).
- Urban trees in the conterminous United States of America store 770 million tons of carbon, valued at US$14.3 billion (Nowak and Crane, 2002).
- Several countries and cities have established minimum green-cover standards for hospitals and convalescence homes.

Significance of urban forest type for climate change

Urban forest type	Significance (on a scale of 1–5*)	
	Climate-change mitigation	Climate-change adaptation
Peri-urban forests and woodlands	5	5
City parks and urban forests (>0.5 ha)	3	5
Pocket parks and gardens with trees (<0.5 ha)	1	4
Trees on streets or in public squares	1	4
Other green spaces with trees	2	4

* Where 1 = very low significance and 5 = very high significance.

Case studies

Urban climate-change adaptation strategy

The Bobo-Dioulasso municipality in Burkina Faso, supported by UN-Habitat's Cities and Climate Change Initiative under the coordination of the RUAF Foundation, committed to promoting urban and peri-urban agriculture and forestry as a climate-change adaptation strategy. The project aims to contribute to 1) the reduction of temperature and runoff by mitigating the urban heat island effect and serving as "green lungs" for the city; and 2) the increased resilience of residents by increasing and diversifying their sources of food and income. By 2012, eight greenways of around 60 hectares had been established, connecting the city with its peri-urban forests, with each greenway allotted specific functions and uses. In Phase 3 of the Cities and Climate Change Initiative, the municipality committed to promoting urban and peri-urban agriculture and forestry as a climate-change mitigation and adaptation strategy. This ongoing pilot project aims to showcase greenways as a development model in the face of climate change and to provide an example of good management governed by appropriate municipal regulation. Field implementation is complemented by advocacy targeting the adoption of regulations specifying the functions of urban and peri-urban agriculture and forestry in the greenways.

Source: UN-Habitat (2014)

London's climate-change adaptation strategy

The Mayor of London issued a draft climate-change adaptation strategy in 2007, developed through a participative and consultative process (for example, citizens were able to post their ideas on the strategy website). The strategy, which was revised and updated in 2010, has three aims: 1) identify who and what is most at risk today; 2) analyse how climate change will change the risk of floods, droughts and heat-waves through the twenty-first century; and 3) describe the actions needed to manage this change and who is responsible for them. A key action proposed in the strategy is an urban greening programme to increase the quality and quantity of green space and vegetation in London as a way of buffering the city from floods and hot weather. The goal is to increase green cover in central London by 5 percent by 2030 and by a further 5 percent by 2050 (an estimated 20 percent of London's land area is already under the canopy of individual trees and approximately one-quarter of the city's 7 million trees are in woodlands). The strategy was launched in 2010 with a plan to increase street tree cover in areas with few trees as well as in "hot spots" in the urban heat island. Other initiatives in the draft strategy include "The Right Place, Right Tree" approach, promoted by the London Tree and Woodland Framework, to maximize the benefits provided by urban trees.

Source: City of London Corporation (2010)

BIODIVERSITY AND LANDSCAPES

Cities should take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity and protect and prevent the extinction of threatened species.

Human well-being strongly depends on the ongoing provision of ecosystem services, which, for example, support food production, maintain soil fertility and stability, and provide water purification services. The expansion of cities, however, is causing the destruction, degradation and fragmentation of natural ecosystems in and around urban areas, with a consequent loss of biodiversity and ecosystem services and an exacerbation of human–wildlife conflicts. Such destruction, degradation and fragmentation is not limited to the physical boundaries of urban developments: cities can also be the indirect causes of landscape degradation and resource impoverishment in peri-urban and rural areas. Moreover, urbanization tends to favour opportunistic wildlife species at the expense of more specialized ones. Cities can be sources of exotic species, whose spread into peri-urban natural ecosystems can seriously threaten the conservation of native species.

Increasing and restoring the functionality and connectivity of urban and peri-urban natural landscapes can make a valuable contribution to the conservation of natural resources and biodiversity. Habitat fragmentation is the biggest challenge for the conservation of urban wildlife. The more heterogeneous, undisturbed and interconnected the green infrastructure, the more resilient will be the ecosystems

© SIMONE BORELLI

it hosts. Although all green spaces can contribute to biodiversity conservation, it is important to conserve as much of the original natural vegetation – grasslands, forests, wetlands and riparian corridors – as possible because these are unique habitats for native plants and animals and are also important for maintaining local "identity". Semi-natural areas such as roadside corridors and home gardens can help connect natural areas and thereby reduce fragmentation and increase the resilience of natural ecosystems to human pressures and disturbances. Cities with well-managed urban forests are able to maintain a surprisingly rich variety of habitats and native species while, at the same time, helping conserve natural landscapes beyond city boundaries. Nevertheless, a lack of financial resources, personnel and technical capacity can limit the attention paid to biodiversity and the environment in urban areas. Biodiversity conservation is intertwined with other management agendas, and, like all sustainability issues, it requires local knowledge, governance capacity, and an integrated, multiscalar approach.

Urban forests and the SDGs: biodiversity and landscapes

Key actions

Policy and legal framework

- Bring departments and agencies together to harmonize their policies and better coordinate the management of urban forests and other green infrastructure at the landscape level to improve biodiversity conservation outcomes.
- Develop local biodiversity strategies and action plans and incorporate these in overarching citywide plans. The Convention on Biological Diversity's Strategic Plan for Biodiversity and associated Aichi Biodiversity Targets can provide a basis for this alignment.
- Promote multistakeholder approaches for addressing the multiple drivers of biodiversity loss in urban and peri-urban environments and for aligning biodiversity conservation efforts with other formal and informal local processes that can have positive or negative effects on biodiversity.
- Promote the value of urban forests in conserving local biodiversity, including through the adoption of measures such as subsidies, by-laws, certification programmes and codes of conduct. For example, financial mechanisms can be established for compensating landowners who contribute to the conservation of urban forests.

Planning, design and management

- Include biodiversity conservation as a key objective in urban forest management plans and incorporate *landscape ecology* approaches in the planning and management of urban forests and other green infrastructure.
- To the extent possible, map the tree-based ecosystems originally present in an area, identify those that are threatened and the main threats to their conservation, address those threats, restore degraded threatened ecosystems, and protect threatened or rare native plant and animal species.
- In designing a city's green infrastructure, take into account the role of urban forests as biodiversity hotspots, as buffer zones protecting natural ecosystems (especially in peri-urban areas) from disruptive external influences and threats, and as green corridors increasing the connectivity and functionality of green infrastructure.
- Promote the planting of endangered native species, including those that provide habitats for birds and other local native species, and aim to create highly diverse forests.
- Collect seed from locally growing native plants and use these as a basis for local ecosystem restoration initiatives.
- Implement strategies aimed at eradicating non-native invasive plant and animal species or, where eradication is not feasible, minimizing the adverse impacts of such species.

Key monitoring criteria

- Natural ecosystem degradation
- Physical and ecological connectivity between natural spaces
- Native species richness
- Proportion of native/non-native species

Key competencies/skills to be developed

- Inventory/mapping of urban biodiversity
- Design and management of complex/diverse urban forest systems
- Landscape management, including the development of ecological networks and corridors
- Facilitation and support of environmental education in school curricula

Main knowledge gaps to be addressed

- Methodologies for valuing biodiversity conservation as an ecosystem service, and mechanisms to pay landowners for significant contributions
- Patterns and processes that affect urban and peri-urban biodiversity, such as the urban–rural gradient and biotic homogenization
- Urban ecology, taking into account the components of *landscape ecology* (e.g. ecological networks, fragmentation and connectivity, and resilience) and biodiversity at the landscape (habitat), population (species), and individual (genome) scales

Helpful facts for advocacy

- An estimated 20 percent of the world's bird species and 5 percent of the vascular plant species occur in cities (Aronson *et al.*, 2014).
- Urban forests provide habitat for many species of birds, insects and other wildlife. For example, there are approximately 200 000 trees in Amsterdam's open spaces, and the mosaic of interconnected landscapes provides homes for 140 bird species, 34 mammal species, 60 fish species and six frog and salamander species (UNEP and ICLEI, 2008).
- On average, 70 percent of the plant species and 94 percent of the bird species found in urban areas are native to the surrounding region (Secretariat of the Convention on Biological Diversity, 2012).

Significance of urban forest type for biodiversity and landscapes

Urban forest type	Significance (on a scale of 1–5*)
Peri-urban forests and woodlands	
City parks and urban forests (>0.5 ha)	
Pocket parks and gardens with trees (<0.5 ha)	
Trees on streets or in public squares	
Other green spaces with trees	

* Where 1 = very low significance and 5 = very high significance.

Case studies

Urban Forestry Biodiversity Programme

The Urban Forestry Biodiversity Programme in Adelaide, Australia, aims to redress the loss of biodiversity in the Adelaide metropolitan area by protecting remaining native flora and fauna and providing corridors for locally indigenous species. The conservation of local indigenous plants and animals is achieved in various ways, such as by identifying priority conservation areas for action and supporting the conservation efforts of individuals, communities, schools, industry, agencies and local government. The northern office of the Urban Biodiversity Unit, based in the City of Salisbury (an administrative unit within the Adelaide metropolitan area), works to protect areas of native habitat within the Salisbury, Tea Tree Gully, Playford, Mallala and Gawler council areas and at the metropolitan end of the Northern Adelaide and Barossa Catchment Water Management Board district. The Urban Biodiversity Unit's Million Trees Program restores vegetation communities by planting plants that are indigenous to each locality using local provenances – in other words, the programme uses plants that grew in the local area before European settlement. The Urban Biodiversity Unit also encourages local residents and communities to take part in the Backyards for Wildlife Program, which involves planting locally indigenous plants in their backyards.

Source: City of Salisbury (2015)

BioCity programme: integrating biodiversity in urban planning

The groundbreaking BioCity programme on urban biodiversity, run by the City of Curitiba, Brazil, is a leading example of urban planning that takes biodiversity-related issues into consideration. The programme aims to make a significant contribution to the recovery of biodiversity at the local and international levels through five main projects related to:

1) the reintroduction of ornamental indigenous plant species to the city, aimed at promoting knowledge of and familiarity with the region's indigenous flora;
2) the establishment of conservation units with the active participation of civil society;
3) the conservation of water resources through the Strategic Plan for Revitalizing the Barigui River Basin;
4) tree-planting in the city using indigenous species; and
5) the improvement of air quality, as well as mobility and transportation, through the Green Line Project, which aims to create a major transportation corridor with special lanes for bicycles and pedestrians as well as a linear park, taking into consideration important environmental concepts.

Source: UNEP (2008)

ECONOMIC BENEFITS AND GREEN ECONOMY

Urban forests provide many economic benefits that help cities build dynamic, energetic and prosperous green economies, including through green branding and marketing strategies.

Unplanned and mismanaged urban development can lead to poverty, unemployment, inequalities and social disintegration, especially in fast-urbanizing low-income countries. On one hand, cities generate more than 80 percent of global gross domestic product; on the other, about 1 billion urban and peri-urban dwellers live in slums with limited or no access to basic services.

For an individual landowner it is likely to be most profitable to build and sell residential properties, but decisions on land use at the municipal planning level should take into consideration the collective benefits of urban forests. According to UN-Habitat, the availability of common spaces is one of the main contributors to urban land values.

Urban forests and other green infrastructure provide many tangible and intangible ecosystem services and benefits that can help improve the living conditions and livelihoods of urban residents. For example, they increase property and land values and rental prices and attract investment, businesses and tourism. The shading and cooling effects of urban forests can cut energy bills significantly by reducing the need for artificial cooling, and further savings can be generated by the positive effects on the mental and physical health of citizens, decreasing the number of hospital stays and thereby lowering the cost of public health. The planning, design, management and use of urban forests can generate employment and business opportunities, for example in nurseries; gardening; the

© FLICKR/APOSTOLOS MALAMAKIS

production of foods (e.g. fruits, nuts, berries and mushrooms) and other non-timber forest products, such as woodfuel and medicines; the timber and bamboo industry; tree-care services; tourism; landscaping; and forest management. Thus, investment in urban forests is a promising strategy for sustainably creating jobs, increasing income, and boosting local green economies. Urban forests can also provide sustenance directly through the production of wood and non-wood forest products.

Despite a great deal of evidence, urban planners and developers often ignore or underestimate the economic value of urban forests and may use the argument that they are unaffordable to justify short-term choices that privilege the construction of grey infrastructure. Urban forests are not expensive "luxuries" requiring high levels of maintenance, however; on the contrary, they can make significant contributions to green economic growth. Studies have shown that an individual tree can provide net benefits of up to US$50 per year (based on energy savings and the reduction of carbon dioxide and stormwater runoff and ignoring other potential benefits); for every dollar invested in management, the estimated annual return is in the range of US$1.4 to US$3.0.

Municipal policymakers and decision-makers should be aware, therefore, of the economic potential of urban forests and make full use of this powerful green tool for generating urban prosperity and improving urban livelihoods.

Urban forests and the SDGs: economic benefits and green economy

Key actions

Policy and legal framework

- Develop policies and regulations to promote green businesses (e.g. in urban planning, arboriculture, urban forestry and landscape architecture) with the aim of creating green jobs, producing green products, improving green infrastructure, and stimulating green income, thereby balancing economic growth and sustainable development.
- Incorporate "turning grey to green" goals in urban growth strategies and implement them through multilevel governance, with an emphasis on local authorities (e.g. parks and recreation departments).
- Develop land-use regulations promoting the implementation of sustainable economic activities in urban green spaces and providing guidelines for managing conflicts over land use.
- Provide incentives (e.g. tax abatements) to promote the establishment and protection of urban green spaces by private landowners and entrepreneurs, recognizing the value of the ecosystem services provided by urban forests.

Planning, design and management

- Develop detailed short-term and long-term urban forest management plans and design urban green space networks in and around cities to implement green growth strategies:
  - at the site level – select low-maintenance, resilient native species to reduce management costs;
  - at the landscape level – increase the area of urban forests and other green spaces to attract homebuyers, retailers and investment, and increase the area of green space in public areas and business precincts (e.g. shopping malls, central business districts and parking lots) and the use of big-canopy tree species to attract visitors;
  - at the municipality level – ensure "clean, green" cities through long-term planning and design, and use branding and marketing to fully exploit the economic potential of green infrastructure.
- Apply "green roofs" to rooftops and increase tree canopy cover near buildings to save energy.
- Enhance the production–marketing–consumption chain for wood and non-wood products derived from urban forests.
- Make use of bioproducts and "urban waste" in the management of urban forests (e.g. use debris from pruning in organic mulches, and use biomass from thinnings and sawmilling in bioenergy production).

Key monitoring criteria

- Cost–benefit of the establishment and management of urban forests
- Number of new urban forest-related jobs and enterprises
- Energy savings for cooling and heating buildings
- Production and marketability of urban forest-related products
- Public and private-sector investment in urban forests
- Tourism and new business activities developed

Key competencies/skills to be developed

- Valuation of the economic benefits of urban forests
- Development of business plans that include green infrastructure
- Marketing and promotion of green businesses and products

Main knowledge gaps to be addressed

- Indicators of benefits derived from sustainable urban forest management
- Cost–benefit analyses comparing investments in urban green spaces with resultant revenues
- Sound decision-making tools for green investment based on cost–benefit analyses
- Urban forest management approaches that encourage investment and promote economic activity (e.g. tree shade on pedestrian paths to improve shopping experiences)

Helpful facts for advocacy

- UPF supports an estimated 15 500 jobs (1.2 percent of total employment) in Manchester City, United Kingdom of Great Britain and Northern Ireland, in areas such as the processing of forest products, tree-related tourism, and professional forestry-related services (Connor, 2013).
- In New York City, every dollar spent on tree-planting and care provides up to 5.6 dollars in benefits (Peper *et al.*, 2007).
- The establishment of 100 million mature trees around residences in the United States of America is said to save about US$2 billion annually in reduced energy costs (Akbari *et al.*, 1988; Donovan and Butry, 2009).
- Urban trees in the conterminous United States of America remove some 784 000 tons of air pollution annually, at a value of US$3.8 billion (Nowak, Crane and Stevens, 2006).
- In the United States of America, the appraised values of homes adjacent to naturalistic parks and open spaces are typically 8–20% higher than comparable properties without such amenities (Crompton, 2001).
- One study found that, on average, prices for goods purchased in Seattle (United States of America) were 11 percent higher in landscaped areas than in areas with no trees (Wolf, 1998b).

Significance of urban forest type for economic benefits and green economy

Urban forest type	Significance (on a scale of 1–5*)
Peri-urban forests and woodlands	
City parks and urban forests (>0.5 ha)	
Pocket parks and gardens with trees (<0.5 ha)	
Trees on streets or in public squares	
Other green spaces with trees	

* Where 1 = very low significance and 5 = very high significance.

Case studies

Municipal forest benefits and costs in five cities

Measuring the benefits that accrue from community forests is the first step in altering forest structure in ways that increase future benefits. The US Forest Service selected five cities (Fort Collins, Colorado; Cheyenne, Wyoming; Bismarck, North Dakota; Berkeley, California; and Glendale, Arizona) in the United States of America for the intensive sampling of public trees, the development of tree-growth curves, and the use of the numerical modelling programme STRATUM to estimate annual urban forest benefits and costs. A sample of 30–70 randomly selected trees from each of the most abundant species was surveyed in each city, and annual tree programme expenditures (as reported by community forestry divisions) for 2003–2005 were compiled. The study found that the five cities spent US$13–65 annually per tree, and the benefits returned per dollar invested were estimated at US$1.37–3.09 per year. Measuring the ecosystem services produced by city trees provides a sound basis for targeting management efforts to increase benefits and control costs. The analysis suggests that several measures of forest structure can be useful for urban forest planning and management; for example, knowledge of age structure and species composition can help in projecting whether future benefits are likely to diminish or increase.

Source: McPherson *et al.* (2005)

Discovery Green

Discovery Green is a 12-acre park in Houston, Texas (United States of America), created from a downtown parking lot. It features an outdoor concert pavilion, restaurants, a mist fountain on hot summer days, several distinct gardens featuring public art, and outdoor "reading rooms". For years, downtown Houston was an automobile-centric, placeless district without public spaces for residents to congregate. The task was to transform 12 acres of underused green space and concrete parking lots near the convention centre into an urban oasis that could serve as a village green. Through a public–private partnership between the City of Houston and the non-profit Discovery Green Conservancy, the site became one of the most beautiful and vibrant destinations in Houston in less than four years. The Discovery Green Conservancy works with hundreds of programming partners to present three dynamic seasons each year. In its first three years, the park welcomed more than 3 million visitors and hosted more than 800 public and private events. The partnership between the Park and Recreation Agency and the Discovery Green Conservancy has been successful, with the Conservancy raising all the funds needed for the programming while ensuring that the park remains an accessible and inviting public gathering space in the centre of the fourth-largest metropolitan area in the country. Discovery Green was conceived not only as a public park but also as a landmark to attract convention revenue to the city and as an anchor for downtown development. That goal has been achieved, with adjacent development comprising a residential high-rise, a commercial office tower, a hotel, and mixed-use development (amounting to a total investment of US$500 million)

coming to fruition. Since the park opened, the adjacent George R. Brown Convention Center has hosted major conventions, including those of Microsoft and the Society of American Travel Writers. The model has been so successful that new green spaces in Houston are being designed with Discovery Green in mind.

Source: National Recreation and Park Association (2012)

Urban forestry and poverty alleviation

Dhaka, the capital of Bangladesh, has a population of more than 14 million people and a poverty rate of 30.5 percent. A study conducted by FAO in 2006 analysed the contribution of urban forests to the livelihoods of poor people in the city. It found that urban forestry can increase the quality of life of poor people, for example through employment in nurseries and other forest-related industries. Most of the poor in Dhaka lack access to city services, such as the provision of electricity, safe drinking water and other benefits; urban forestry can help fill the needs gap by, for example, producing woodfuel and helping purify water. Most poor people in Dhaka work outdoors, where they face environmentally hazardous conditions from air pollution; urban forests can help in ameliorating such conditions. Trees provide shelter and security for the homeless and recreational places for street children. Finally, involving the poor in decision-making processes on urban forest resources can provide a certain level of empowerment.

Sources: Uddin (2006); Sohel, Mukul and Burkhard (2014)

RISK MANAGEMENT

To minimize the risks associated with urban forests and to maximize the benefits, urban forest risk management should be fully integrated into urban planning and management, emergency response protocols, and public education programmes.

The combination of climate change, rapid urbanization, growing urban populations and high population densities is increasing the vulnerability of cities. For example, urban sprawl leads to problems such as decreased tree canopy cover, increased impervious surfaces, high concentrations of atmospheric carbon dioxide, the urban heat island effect, and soil sealing. People living in urban and peri-urban areas, therefore, face many potential risks to their health, well-being and livelihoods. In general, the level of risk in a city is a combination of two factors: 1) location and exposure to hazards such as earthquakes, fire and storms; and 2) increased vulnerability due to poor governance, environmental degradation, pollution and the overstretching of resources.

As pointed out in other sections of this document, urban forests can play important roles in increasing the resilience of cities. If managed poorly, however, they can also pose direct and indirect risks. For example, urban green spaces may be host to crimes, and trees may be perceived as threats to human safety. Some tree species produce allergens (that is, substances such as pollen that cause allergic reactions in people); urban forests can provide habitat for fungi and insects that are potential vectors of epidemic or non-communicable diseases; and trees can drop limbs that may injure or even kill people and damage vehicles and infrastructure, especially during storms. Urban forests (especially those in peri-urban areas) may be susceptible to wildfire that could threaten people, homes and businesses.

It is important, therefore, to reduce the threats posed by urban forests to people, property and infrastructure. Policymakers, decision-makers, urban planners, urban foresters and private landowners should all be aware of the risks posed by urban forests, which can be greatly reduced with long-term planning and sound management practices. The perception of safety or acceptable risk is sometime more powerful than the reality of the condition of a tree or the situation in which it is growing, and decisions on urban forests may be made more on emotional

or political evaluations than on sound technical knowledge. For effective urban forest management and risk mitigation it is essential that the level of risk posed by individual trees, stands and forests is evaluated objectively on the basis of adequate information and knowledge.

Urban forests and the SDGs: risk mitigation

Key actions

Policy and legal framework

- Formulate, adopt and enforce a tree and forest risk management policy to complement urban management goals.
- Develop a normative framework for tree and forest risk management, including relevant ordinances, codes, rules and regulations.

Planning, design and management

- Select wind-resistant tree species for planting and optimize planting design, taking into account dominant winds.
- Develop an early-warning system for detecting forest fire, and design adequate forest fire prevention and response mechanisms.
- Implement proactive risk control and mitigation measures by conducting periodic tree risk assessments, using methods such as walk-by inspections (for individual trees) and drive-by (windshield) surveys (for stands).
- Correct hazardous tree defects such as decayed wood, cracks, problem roots, weak branch unions, cankers, poor tree architecture, and dead trees, tops and branches.
- Prioritize identified tree-related risks and initiate timely corrective treatment.
- Proactively transfer risk, for example by purchasing insurance.
- Be prepared for hazard management and emergency responses, for example to clean up urban forest debris and repair tree-caused damage in the wake of storms.
- Maintain older trees as important components of healthy and diverse urban landscapes.

Key monitoring criteria

- Number of tree failures
- Number of forest fires
- Number of accidents caused by trees
- Annual cost of property losses and infrastructure repairs (e.g. to sidewalks) caused by tree-related hazards

Key competencies/skills to be developed

- Communication skills to raise public awareness of tree-related risks, especially those associated with public safety (e.g. tree failure, tree–infrastructure conflicts, line-of-sight along streets, and fruit/seed litter) and steps people can take to minimize risks to their personal health and safety
- Tree risk management/arboriculture (e.g. tree pruning and tree removal)
- Natural disaster management (e.g. natural disaster and risk mapping, alerts, coordination, and management)

Main knowledge gaps to be addressed

- Urban planning and design approaches that reduce the risk of crimes associated with urban forests
- Tree-risk mapping using geographic information systems and remote sensing techniques as well as models for tree-risk assessment and prediction
- Locally appropriate species with a low propensity for dropping branches that are also wind-resistant, drought-resistant and insect-tolerant, and produce few or no allergenic materials

Helpful facts for advocacy

- Residents often mention tree loss as one of the greatest impacts of storms – including more than 30 percent of residents in the wake of Hurricane Hugo in 1989 (Miller, Hauer and Werner, 2015).
- Studies in the United Kingdom of Great Britain and Northern Ireland estimate that there is a one in ten million chance of an individual being killed by a falling tree (or part of a tree) in any given year (Watt and Ball, 2009).

Significance of urban forest type for economic benefits and green economy

Not applicable

Case studies

Firewise Communities USA/Recognition Program

The Firewise Communities USA/Recognition Program is a process that empowers neighbours to work together in reducing their wildfire risk. The programme has created a network of more than 1 000 recognized Firewise communities taking action and assuming ownership in the protection of their homes from the threat of wildfire. Using a five-step process, communities develop action plans that guide their residential risk reduction activities while engaging and encouraging residents to become active participants in building a safer place to live. Neighbourhoods throughout the United States of America are embracing the benefits of becoming a recognized Firewise Community.

Source: Firewise Communities (2015)

Survey and management of tree disease along the city walls of ancient Lucca

The phytosanitary conditions of all trees growing along and outside the city walls of Lucca, Italy, and in the city centre were assessed between 2004 and 2007 to develop a database – the "Informative System of Standing Trees" – for use in periodic maintenance. Each tree was assigned to one of four management classes: 1) class 0 – no damage present; 2) class 1 – low damage, with plants to be checked every year; 3) class 2 – medium damage, including trees requiring further analysis, such as with a resistograph; and 4) class 3 – trees with major damage, requiring removal or the pruning of dangerous portions. The database is a useful tool for evaluating the periodical operations required and also for the detection of emerging diseases, such as those caused by biological invasions.

Source: Luchi *et al.* (2008)

MITIGATING LAND AND SOIL DEGRADATION

By protecting soils and increasing their fertility, urban forests can help combat desertification, restore degraded soils and lands, and prevent drought and floods.

Land and soil degradation, and the consequent reduction of their capacity to provide goods and ecosystem services to local communities, including in urban and peri-urban areas, has become a worldwide problem costing an estimated US$40 billion annually. Increasing soil erosion, salinization, desertification and soil pollution are reducing the fertility, water filtration ability and carbon storage capacity of soils on urban and peri-urban land, decreasing food production capacity and thereby threatening the livelihoods and well-being of millions of people worldwide. Urban development often involves the complete removal of pre-existing vegetation as well as the depletion and stockpiling of topsoil, with consequent soil compaction. In highly modified urban landscapes, a large proportion of natural soils may also be covered and replaced by impervious surfaces (e.g. pavements, roads and buildings), increasing the susceptibility of urban environments to flooding and extreme climatic events. Soil contamination, sealing and erosion can irreversibly impair the health and resilience of urban and peri-urban ecosystems, thus decreasing their capacity to contribute to the sustenance and livelihoods of urban and peri-urban communities.

Many cities have embraced UPF as a way of both preventing and ameliorating land degradation and soil erosion. By decreasing wind speeds and stabilizing soils, trees can reduce soil erosion and compaction. UPF also offers opportunities for restoring degraded, neglected and abandoned lands and remediating degraded soils.

© FAO/ROSETTA MESSORI

Trees can support soil formation processes and increase soil productivity and permeability; UPF can be a cost-effective tool for remediating soil contamination.

Strategies for the effective use of forests and trees in restoring degraded lands are likely to differ between urban and peri-urban areas. In peri-urban areas, the main goals may be to combat desertification, decrease soil erosion, increase soil fertility and protect homes and arable lands from the damaging effects of winds; to achieve such goals, agroforestry and the construction of "green belts" and other vegetation barrier systems may be the best options. In inner urban areas, the main goals may be to mitigate stormwater runoff and ameliorate contaminated soils while providing environmental amenity at the local scale; tree species and systems can be selected to best meet such goals.

Urban forests and the SDGs: land and soil degradation

Key actions

Policy and legal framework

- Develop policies targeting soil threats and functions to ensure that these are addressed through sustainable soil management practices.
- Develop policies and regulations for the treatment and disposal of industrial waste, recognizing the positive role that urban forests can play in this regard.
- Implement regulations defining minimum tree protection zones (including of the roots, trunks and crowns of trees) to minimize damage to trees on construction sites.
- Develop regulations to ensure that, if trees are removed, the parties responsible plant replacement trees elsewhere, pay compensation, or both.

Planning, design and management

Preventing land degradation and soil erosion:

- Retain native trees and vegetation to increase land and soil protection, especially in peri-urban areas.
- Develop greenbelts to protect peri-urban and urban soils from winds and adverse climatic events, especially in arid and semi-arid environments.
- Implement sustainable tree-based agricultural practices (i.e. agroforestry) to maintain soil fertility and productivity over the time, especially in peri-urban areas.
- Maintain natural vegetation cover to limit environmental damage and soil degradation in construction and urban development interventions.

Addressing land restoration and soil remediation:

- Assess and monitor the extent and severity of land and soil degradation processes such as desertification, salinization, compaction, contamination and erosion in urban and peri-urban environments.
- Assess opportunities for forest- or tree-based landscape restoration interventions in degraded urban and peri-urban degraded lands.
- Select the most suitable species for a given site and implement UPF interventions to restore degraded land in urban and peri-urban areas.
- Strip, stockpile, conserve and re-use existing topsoil on-site in urban and peri-urban developments.
- Focus interventions on: depleted peri-urban forest areas (afforestation); impoverished peri-urban rural lands (agroforestry); degraded and eroded peri-urban slopes (afforestation/tree planting); contaminated urban and peri-urban soils (selected trees/vegetation planting); and urban and peri-urban brownfields (trees/vegetation planting).

Key monitoring criteria

- Land stability
- Land cover
- Soil structure and dynamics
- Soil quality and extent of contamination

Key competencies/skills to be developed

- Landscape management and the restoration of brownfields, degraded lands and vacant lots
- Design and development of green infrastructure, maximizing land stability
- Implementation of low-impact development and environmentally sustainable construction techniques
- Use of soil remediation, conservation and improvement techniques through UPF-related technologies

Main knowledge gaps to be addressed

- Most suitable UPF and agroforestry systems for soil rehabilitation
- Sound techniques for reducing and reversing soil loss, land degradation and desertification through UPF interventions
- Most appropriate native/naturalized tree species for remediating soil contamination in urban and peri-urban areas and colonizing highly degraded soils, especially in arid environments

Helpful facts for advocacy

- In a medium-sized city, tree cover can save more than 10 000 tonnes of soil from degradation and erosion annually (Coder, 1996).
- Properly designed shelterbelts have been estimated to reduce the erosive force of winds by up to 75 percent (Agriculture Victoria, 2003).

- The City of Toronto recently published "Tree Protection Policy and Specifications for Construction Near Trees", regulating the protection of trees at construction sites (Toronto Parks, Forestry and Recreation, 2016).

Significance of urban forest type for land and soil degradation

Urban forest type	Significance (on a scale of 1–5*)
Peri-urban forests and woodlands	5
City parks and urban forests (>0.5 ha)	3
Pocket parks and gardens with trees (<0.5 ha)	2
Trees on streets or in public squares	1
Other green spaces with trees	4

* Where 1 = very low significance and 5 = very high significance.

Case studies

Moroccan city creates greenbelt using treated wastewater

Dubbed "the door of the desert", the Moroccan city of Ouarzazate is combating land degradation, biodiversity loss and desertification by building a greenbelt of trees that is irrigated with treated wastewater. Inhabited by 60 000 people, Ouarzazate is one of southern Morocco's major tourism hubs. Its location on a bare plateau in the High Atlas Mountains makes it vulnerable, however, to desertification and desert storms, which deteriorate the living conditions of local communities and accelerate land degradation and the loss of biodiversity. To mitigate these environmental challenges, Morocco, with support from UNEP and the Korean Forest Service, created a 400-hectare greenbelt of trees around Ouarzazate and "greened" surrounding drylands using treated wastewater (pumped using solar energy) for irrigation. The aim is to stop desertification, decrease land degradation and protect the city from strong winds and dust clouds. The project used an innovative approach to the involvement of local people by creating job opportunities and making use of local traditional knowledge and experience; this resulted in a high level of local support and community engagement in looking after the trees. The greenbelt also provides the urban community with a recreational space, helps raise community awareness in an innovative way, and stimulates public participation in the prevention of land degradation and biodiversity loss. The success of this pilot project has encouraged local and national authorities to scale it up; the second phase will focus on awareness-raising, partnerships and sharing experiences with other communities in Morocco and beyond.

Source: UNEP (2015)

Brownfield remediation

Green brownfield remediation methods are gaining popularity and interest in Detroit, Michigan, in the United States of America, for the reuse and redevelopment of previously industrialized vacant land. Detroit has more than 6 000 vacant properties, many of which have high levels of contaminants. In 2010 and 2012, the non-profit resource agency, "The Greening of Detroit", received funds for dendro-remediation interventions in a number of urban industrial brownfields. The primary objective of the project was to reduce soil toxicity by introducing green infrastructure to selected former industrial and commercial sites. Secondary objectives included improving stormwater management and air quality and beautifying vacant lots in a way that reduced maintenance costs for the city. Hybrid poplar and willow trees were planted on brownfield properties to measure their ability to remediate heavy metals and polycyclic aromatic hydrocarbons, as well as their survivability on contaminated soils.

Sources: Hay (undated); Arbor Day Foundation (2012)

WATER AND WATERSHEDS

By protecting watersheds, filtering water and increasing soil permeability, urban forests can make substantial contributions to sustainable urban and peri-urban water and watershed management.

Sustainable watershed management is a key aspect of sustainable urban development. Although they occupy only 2 percent of the global terrestrial surface, cities account for 75 percent of residential and industrial water use. Healthy urban and peri-urban watersheds can supply high-quality water for residential, industrial and agricultural uses, ameliorate extreme weather, and provide a range of other ecosystem services. Many are degraded, however, due to natural phenomena, human activities, or a combination of these. Many human settlements face three important, interdependent water-related challenges: 1) a lack of access to safe water and sanitation; 2) an increase in water-related natural disasters such as floods and droughts, exacerbated by climate change; and 3) growing water demand from increasing urban populations and a corresponding loss of water quality. Access to clean water in particular is a fundamental human right, but more than 1 billion city dwellers lack it.

Well-managed and healthy urban forests can contribute greatly to the sustainable management of water and water resources; they can help clean, save and store water, as well as reduce the risk of water-related disasters (e.g. flooding). By protecting soils, reducing erosion, mitigating the climate and supporting natural ecosystem processes, forests are often crucial for protecting and conserving watersheds serving urban communities. Urban forests can play key roles in increasing not only the availability but also the quality of water by intercepting air pollutants, reducing sediment and filtering rainwater. They can help minimize damaging runoff in urban and peri-urban environments and, by

© FLICKR/PAUL GODARD

increasing soil infiltration, they can reduce the severity of flooding events. To be effective, however, the contributions of urban forests to the protection of water resources must be recognized and integrated in watershed and water management plans. Special attention should be paid to fragile areas and steep slopes and to the watersheds of municipal reservoirs.

Urban forests and the SDGs: water and watersheds

Key actions

Policy and legal framework

- Ensure that the role of UPF is adequately addressed in policies and laws directed at the minimization and remediation of water contamination and pollution.
- Adopt policies to protect and conserve watersheds using green infrastructure approaches such as forest conservation and the retention of riparian vegetation along rivers and streams.
- Protect forests in watersheds from urban development and damage through adequate land-use planning.
- Establish policies and regulations recognizing the positive role that urban forests can play in the treatment and disposal of industrial wastewater.

Planning, design and management

Protecting watersheds for water supply and water quality:

- Use proactive planning approaches to reduce soil erosion and control sediment flows. For example, consider the effects of upstream urban and agricultural development on the flow of water and sediments into reservoirs, irrigation systems, floodplains and urban areas.
- Conduct field assessments of existing forests in watersheds, including forest fragments and protected and unprotected forests, and identify potential restoration opportunities.
- Adopt silvicultural approaches aimed at maintaining and improving water quality, especially for drinking.
- Restore degraded watersheds – especially degraded peri-urban slopes – through tree-planting, agroforestry and natural regeneration to improve watershed functioning.
- Establish riparian forest buffer zones to protect streams, lakes and other wetlands from disturbances and encroachment.
- Use innovative tree-based approaches to help reduce water consumption, improve water quality, and recycle wastewater in urban and peri-urban environments.

Increasing resilience to flooding events/stormwater runoff:

- Assess and monitor flooding and stormwater runoff (e.g. the frequency, volume and damage caused) in urban and peri-urban areas.
- Increase the percentage of permeable surfaces and tree cover, especially in urban areas most affected by flooding and stormwater runoff events.
- Apply, as appropriate, green infrastructure approaches such as forested bioswales, permeable pavements, green roofs, green streets, wooded wetlands, rain gardens, bioretention, bioinfiltration, forested filter strips, and linear stormwater tree pits to mitigate the impacts of stormwater runoff.

Key monitoring criteria

- Land cover
- Water quality
- Water flow
- Soil permeability
- Frequency of flooding events

Key competencies/skills to be developed

- Assessment, planning, management and monitoring of watersheds
- Management of water supply
- Development of nature-based solutions for water purification
- Design and implementation of nature-based solutions to increase or maintain the permeability of urban and peri-urban soils

Main knowledge gaps to be addressed

- Locally adapted watershed management models integrating green, blue and grey infrastructure
- Innovative nature-based solutions for water harvesting, water saving and water recycling
- Role of forest management systems and different urban forest types in increasing water quality and supply

Helpful facts for advocacy

- In New York City, street trees intercept 890.6 million gallons (3.37 billion litres) of stormwater annually – an average of 1 525 gallons per tree. The total value of this benefit to the city is estimated at more than US$35 million per year (Peper *et al.*, 2007).
- Ninety percent of sediments and nutrients can be prevented from entering waterways by maintaining strips of riparian vegetation (Schultz, Isenhart and Colletti, 2005).
- In 50 years, one tree can recycle water to the value of US$35 000 (Bucur, 2006).
- Since 2006, the City of Philadelphia has reduced combined sewer overflow and improved water quality through green infrastructure policies and pilot projects, savings approximately US$170 million (Boyle *et al.*, 2014).

Significance of urban forest type for water and watersheds

Urban forest type	Significance (on a scale of 1–5*)	
	Watershed protection	Resilience to flooding events
Peri-urban forests and woodlands	🌳🌳🌳🌳🌳	🌳🌳🌳
City parks and urban forests (>0.5 ha)	🌳🌳	🌳🌳🌳🌳🌳
Pocket parks and gardens with trees (<0.5 ha)	*Not applicable*	🌳🌳🌳
Trees on streets or in public squares	🌳	🌳🌳🌳
Other urban green spaces with trees	🌳🌳🌳🌳	🌳🌳🌳🌳

* Where 1 = very low significance and 5 = very high significance.

Case studies

Framework for integrated management of watershed health

Portland, Oregon, in the United States of America is often cited as a prime example of green stormwater management, with good reason. Portland has one of the country's most mature and comprehensive green infrastructure programmes, with multiple overlapping policies and programmes that have evolved over time. Portland's city administration took the initiative – and, to some extent, the risk – to implement a citywide programme to improve stormwater management. It estimates that its US$9 million investment in green infrastructure will save ratepayers US$224 million in costs associated with the maintenance and repair of combined sewer outflow infrastructure. The city administration expects many other benefits as well, such as the recovery of Chinook salmon and steelhead trout populations.

Source: City of Portland (2005)

The Marikina Forest Watershed Integrated Resource Development

In 2010, the mayors of seven towns in metropolitan Manila in the Philippines signed a memorandum of agreement committing themselves to working together to rehabilitate and reforest the Marikina watershed, a 28 000-hectare peri-urban forest area. The decision to work together to protect and restore the watershed was made in the wake of the devastating effects of tropical storm Ondoy, which battered the Philippines in 2009. The intensity of the floods in metropolitan Manila was attributed to the high level of degradation in the upper Marikina watershed. The memorandum of agreement built on the Marikina Watershed Initiative, which began the year before to support the rehabilitation of the watershed. The initiative, led by the Philippine Disaster Recovery Foundation (a broad alliance of business organizations and non-governmental organizations), aims to rehabilitate the Marikina watershed by: reforesting 34 percent of the watershed's degraded areas; establishing a framework and system of cooperation among the various sectors of society to rehabilitate, protect and restore the Marikina watershed; and reducing human pressure on the watershed by providing villagers with alternative sources of livelihood. As a result of the memorandum of agreement, the Government of the Philippines made investments to implement actions such as a review of existing policies and the development of harmonized mechanisms within a sustainable, climate-sensitive plan for the Marikina watershed. In 2011, the government also declared the upper Marikina watershed a protected landscape through Presidential Proclamation 296.

Source: Tuaño (2013)

FOOD AND NUTRITION SECURITY

By producing woodfuel for cooking and food and non-food products to be sold on the market, urban forests can contribute significantly to food security and nutrition in urban and peri-urban environments.

Feeding a rapidly growing urban population worldwide is one of the greatest challenges of the twenty-first century. Hunger and poverty affect an increasing number of cities and urban dwellers. Urbanization and poverty often go hand-in-hand, and many cities – especially in developing countries – are struggling to provide their residents with access to sufficient safe, nutritious and affordable food. The urban and peri-urban poor are especially vulnerable to food insecurity and malnutrition due to the low quality of available food, the limited availability or affordability of energy for cooking, and limited access to safe drinking water. Nutrient-dense foods such as fruits and vegetables are often more expensive than energy-dense foods produced at the industrial scale. As a result, "hidden hunger", including micronutrient deficiencies and diabetes, is projected to become a greater cause of death than "visible hunger" in low-income communities. Immediate actions and long-term strategies are needed to achieve food and nutrition security as the world becomes more urbanized in coming decades and to reach the goal of "ending hunger, achieving food security and improving the nutrition of the increasing global urban population" (SDG 2).

Urban forests can be sources of highly nutritious foods. Trees produce hundreds of food products (e.g. fruits, seeds, leaves and berries) and food additives (e.g. for ice cream and chewing gum), and they are a source of fodder (e.g. leaves, sprouts, young shoots and seeds) for animal husbandry. Forests are also sources

of wild meat and edible insects and have beneficial impacts on human nutrition: it has been shown, for example, that children in Africa who live in areas with greater tree cover have more nutritious diets. Moreover, forests can directly provide easily accessible and low-cost woodfuel and help ensure the supply of safe water for drinking and cooking. Urban forests are often distributed widely in municipalities on both public and private lands, ranging from large municipal parks, community gardens and orchards to home gardens, green roofs and street trees. Along with other green spaces, they can potentially produce significant quantities of fresh, low-cost food for local consumption. Urban forests can also boost the productivity of urban and peri-urban agriculture by improving soil fertility and water infiltration, reducing wind speeds and ameliorating pollution and climatic extremes (i.e. agroforestry). The products provided by urban forests can be sold on local markets, thus indirectly increasing local food security. Although UPF cannot – on its own – ensure food and nutrition security in cities, well planned, designed and managed urban forests can make valuable contributions to local food production and the provision of ecosystem services that benefit local agriculture. The demand for and supply of urban food varies greatly by municipality, and policy and management approaches should be developed for each based on local needs (e.g. food preferences) and contexts (e.g. land ownership, environment and culture).

Urban forests and the SDGs: food and nutrition security

Key actions

Policy and legal framework

- Eliminate policy and regulatory barriers to the development of urban "food forestry" and promote coordination among municipal authorities and civil-society actors on food production in urban forests.
- Address land tenure and land access with a view to making it easier for citizens to engage in productive UPF, urban and peri-urban agroforestry, and urban and peri-urban agriculture to increase their food and nutrition security.
- Develop policies, laws and regulations to facilitate the development of sustainable, equitable food production in urban forests (particularly urban food forests) and from urban and peri-urban agriculture and agroforestry, and associated food processing and distribution systems.
- Encourage entrepreneurial activities and support start-up companies engaging in UPF and urban and peri-urban agriculture and agroforestry, for example through microcredit schemes and financial support.

- Provide incentives for the adoption of agroforestry in peri-urban areas as a practice that enables farmers to increase their incomes and support their livelihoods through the production, sale and consumption of food and non-food forest products (e.g. fodder, leaves, fruits, timber and woodfuel).

Planning, design and management

- Assess the "environmental footprint" and social impact of urban forest food production.
- Promote the potential contribution of urban forests and other green infrastructure to the food and nutrition security of residents, and incorporate urban food forestry and agroforestry (e.g. in community gardens and orchards) into municipal plans.
- Encourage the use of public lands such as parks, schools, vacant lots and streets for the production of urban food through the creation of food forests and community gardens, including the use of tree species that produce edible fruits, nuts, syrups, honey and edible leaves.
- Adopt silvicultural treatments (e.g. tending, thinning, selective felling and enrichment planting) in ways that create suitable conditions for the growth and productivity of edible tree species and other non-wood forest products (e.g. mushrooms, berries and wild meat).
- Promote the branding and marketing of local food products obtained through UPF and urban and peri-urban agriculture and agroforestry.

Key monitoring criteria

- Availability, stability and accessibility of quality food from urban and peri-urban areas
- Variations in the consumption of urban food products
- Marketability of products derived from UPF and urban and peri-urban agriculture and agroforestry

Key competencies/skills to be developed

- Local food production from UPF and urban and peri-urban agriculture and agroforestry
- Food demand and supply analysis
- Value adding to food-forest products

Main knowledge gaps to be addressed

- Tools for mapping food production from urban forests and other green infrastructure
- Selection of suitable food tree species for specific urban and peri-urban environments
- Production techniques for minimizing negative impacts on food safety due to air pollution and soil contamination in urban areas
- Increasing the efficiency and productivity of UPF and urban and peri-urban agriculture and agroforestry

Helpful facts for advocacy

- An 80-square-metre urban backyard demonstration food forest in Melbourne, Australia, included more than 30 fruit trees, 16 types of berries, and over 70 types of medicinal herbs (Zainuddin, 2014).
- In Indonesia, homegardens can contribute 7–56 percent of the total income of owners (Soemarwoto, 1987).
- City Fruit harvested 12 700 kg of unused fruit from Seattle's urban fruit trees in 2014 and donated 10 000 kg to 39 local groups, including food banks, schools and community organizations. The value of fruit donated to meal programmes and food banks is estimated at US$44 112 (City Fruit, undated).
- The value of shelterbelts in raising agricultural productivity has been demonstrated in many countries, suggesting potential improvements in crop yields (25 percent), pasture yields (20–30 percent) and dairy milk production (10–20 percent) (Tisdell, 1985).

Significance of urban forest type for food and nutrition security

Urban forest type	Significance
Peri-urban forests and woodlands	5
City parks and urban forests (>0.5 ha)	3
Pocket parks and gardens with trees (<0.5 ha)	2
Trees on streets or in public squares	2
Other green spaces with trees	4

* Where 1 = very low significance and 5 = very high significance.

© FLICKR/CIFOR

Case studies

The Beacon Food Forest

The Beacon Food Forest in Seattle in the United States of America is a community-driven community garden project. It started in 2009 as a final design project for a permaculture design course, and it is now a project in the Seattle Department of Neighborhoods's P-Patch Community Gardening Program, combining aspects of native habitat rehabilitation and edible forest gardening. The Beacon Food Forest uses a gardening technique that mimics a woodland ecosystem and involves edible trees, shrubs, perennials and annuals. Fruit and nut trees make up the upper level, and berry shrubs, edible perennials and annuals make up the lower levels. The land is owned by Seattle Public Utilities, which has made 1.75 acres available for the initial phase of the project. A group of friends and neighbours initiated the idea of a food forest in this location. With funds from the Seattle Department of Neighborhoods, the group launched a community design process and invited neighbours and permaculture enthusiasts from around the area to participate. Hundreds of people have participated in all aspects of the project's vision, design and construction, and hundreds more participated in work parties to build the food forest, with tasks ranging from spreading woodchips to installing a water system. Community volunteers are responsible for the ongoing stewardship and maintenance of the garden. As the garden matures, on-site signs will provide guidelines for harvesting, and volunteers will work together in organized ways to harvest and share the food with the broader community. Gleaning and grazing are free and open to all and are to be ruled by "ethical harvesting" – you take only what you need, without damaging the plant.

Source: Seattle Department of Neighborhoods (2016)

Combining avenue beautification with fruit production

While planning the development of India's new capital, Delhi, the British planted fruit trees, primarily jamun (*Syzhigum cumini*), along avenues of what is now commonly called Lutyen's Delhi. Jamun is a tree with a wide canopy that is excellent for shading urban roads and other spaces. Today, Delhi's roadside jamun trees yield about 500 tonnes of fruit per year, which is harvested and sold to passing pedestrians and motorists in the monsoon season, when the fruits are ripe. The jamun trees serve multiple functions. They improve the aesthetics and microclimate of the bustling city, and they produce a highly nutritious food inside the city itself, saving on the cost of, and reducing the environmental impacts associated with, transportation, packing and handling. This fruit production also generates considerable employment and livelihood opportunities for the labour force associated with harvesting, preparing and selling the fruits. Jamun fruit is used in the treatment of sore throat, bronchitis, asthma, thirst, biliousness, dysentery and ulcers, and it is a good blood purifier.

Source: Nagre (2013)

WOOD SECURITY

By providing additional sources of wood and woodfuel, urban forests can play key roles in responding to urban needs for wood products while helping reduce pressure on natural forests and woodlands due to overexploitation.

Wood and woodfuel demand is still high in developing countries and one of the main causes of urban forest depletion. Woodfuel – fuelwood and charcoal – is the oldest source of energy in human societies. Even today, it represents 60–80 percent of wood consumption in developing countries and can account for 50–90 percent of national energy use (FAO, 2014). Woodfuel is vital, therefore, for the well-being and health of billions of urban and peri-urban dwellers worldwide. For example, its use in cooking food and boiling water enables the prevention of gastrointestinal and other related diseases. Fuelwood and charcoal[7] are common sources of energy for urban commercial and manufacturing sectors, such as bakeries, metal forges, breweries, restaurants, food stalls and brickmakers. In slums and poor households, woodfuel may be the only available source of domestic lighting. The production, transportation and retailing of woodfuel can be an important source of income in urban areas. Wood is frequently harvested in urban forests for use in house construction, the manufacture of tools, and other uses.

Long considered to be environmentally destructive, woodfuel has recently been "rediscovered" as a renewable energy source that, if properly managed, can provide cost-effective and high-quality energy services. Urban forests can provide sustainable sources of bio-based fuels for power and heat generation, thereby

7 Urban consumers generally prefer charcoal to fuelwood because it produces less smoke, does not affect the taste of food, leaves cooking pots relatively clean, and is easier to transport and store.

reducing fossil fuel consumption, waste disposal costs and pressure on natural forests, and they can also contribute to the urban supply of other wood products. The unsustainable harvesting of some urban forests, however, has caused their depletion.

Assessing and monitoring the wood and woodfuel supply and demand (the "woodshed") of a municipality is crucial for ensuring the sustainable management of the wood and woodfuel resource and the development of an efficient and sustainable supply system. Involving all concerned stakeholders and practitioners – such as urban planners and policymakers, urban and peri-urban dwellers, wood producers, non-governmental organizations and associations of wood buyers and sellers – is essential in developing such a system. Due attention should also be given to the production, sale and use of clean, efficient woodfuel stoves in urban and peri-urban areas.

Urban forests and the SDGs: wood security

Key actions

Policy and legal framework

- Address land tenure and land access to encourage stakeholders to make long-term investments in urban forests and agroforestry systems to increase wood security.
- Develop comprehensive bioenergy policy frameworks to promote efficient and sustainable production and use (e.g. improved wood stoves, biofuels) that do not require the expansion of monoculture plantations or threaten biodiversity.
- Provide incentives for the development and adoption of "green energy" technological innovations.

Planning, design and management

- Map and monitor the woodshed to assist in developing strategies for municipal-scale wood security. The appropriate application of the WISDOM methodology (see case study below), which combines aspects of forestry and energy, may support effective urban wood-energy planning.
- When planning urban forests for the supply of wood and woodfuel, choose suitable, fast-growing tree species (e.g. reaching their economically optimum size in 8–20 years).
- Where appropriate, use the coppicing ability of certain tree species for the rapid production of woodfuel.
- Use urban forest prunings and thinnings as woodfuel.

- Develop efficient value chains for the production and distribution of woodfuel and other wood products.

Key monitoring criteria

- Availability and accessibility of woodfuel and other wood products
- Market prices for woodfuel and other wood products
- Local demand for woodfuel and other wood products

Key competencies/skills to be developed

- Assessment and sustainable management of forests in woodsheds for energy production
- Dissemination of appropriate technologies and best practices in woodfuel use
- Design and implementation of participatory processes to monitor changes in woodfuel-related preferences and behaviours

Main knowledge gaps to be addressed

- The economic, social and environmental factors that influence the consumption of woodfuel and other wood products in a municipality, including differences between socioeconomic groups
- Urban forest biomass production modelling
- Sustainable management approaches for the production of woodfuel and other wood products in urban forests
- The efficiency and sustainability of short-rotation coppicing or equivalent management models
- Best-performing, locally appropriate species for the production of woodfuel and other wood products
- Research and development into second-generation biofuels

Helpful facts for advocacy

- Meeting the wood-energy needs of a city of 1 million inhabitants in Central Africa requires the annual harvesting of 10 000 hectares of productive plantation and up to 100 000 hectares of degraded natural forests, depending on the natural productivity of stands and prevailing land-use patterns (Marien, 2009).
- The estimated demand for woodfuel in Dhaka, Bangladesh, in 2013 was 11.6 million m^3 but the supply was only 7.74 million m^3, meaning a shortage of 3.81 million m^3. The shortfall had grown significantly from 1993, when it was 2.14 million m^3 (Uddin, 2006).
- In Kinshasa, the Democratic Republic of the Congo, the total charcoal market value was estimated at US$143 million in 2010, which was 3.1 times the value of the country's timber exports (Schure *et al.*, 2011).

Significance of urban forest type for wood security

Urban forest type	Significance
Peri-urban forests and woodlands	🌳🌳🌳🌳🌳
City parks and urban forests (>0.5 ha)	🌳🌳
Pocket parks and gardens with trees (<0.5 ha)	🌳
Trees on streets or in public squares	🌳
Other green spaces with trees	🌳🌳

* Where 1 = very low significance and 5 = very high significance.

Case studies

Woodfuel Integrated Supply/Demand Overview Mapping methodology

In 2008, FAO's Woodfuel Integrated Supply/Demand Overview Mapping methodology (WISDOM) was adapted to generate thematic maps describing the areas of influence of urban woodfuel demand. "WISDOM for Cities" has proved a useful tool for the mapping of sustainable resource potential and of woodfuel consumption areas, identifying deficit and surplus areas, and pragmatically defining and visualizing areas influenced by the urban and peri-urban consumption of woodfuel and priority areas for intervention. The WISDOM methodology and its urban woodshed module were applied to selected cities in East Africa (Arusha-Moshi, Dar-es-Salaam, Kampala and Khartoum) and Southeast Asia (Battambang, Luang Prabang, Phnom Penh and Vientiane), using as references WISDOM analyses carried out recently for these subregions. The studies revealed how deeply supply zones extend into rural areas and forests, with woodfuel often transported hundreds of kilometres to reach urban consumers. The studies also highlighted the essential contribution of wall-to-wall analysis in defining the zones of influence of individual cities.

Source: Drigo and Salbitano (2008)

Producing woodfuel for urban centres in the Democratic Republic of the Congo

Woodfuel is a source of renewable energy with good potential for climate-change mitigation. In the Democratic Republic of the Congo, the sector employs more than 300 000 people in supplying Kinshasa alone, but the benefits for the poor are often unclear. A 2014 study found that woodfuel production contributes substantially to the household incomes of producers in the country, ranging from 12 percent of total income for fuelwood producers near Kisangani to 75 percent for charcoal producers around Kinshasa. In addition, woodfuel supports basic needs and investments in other livelihood activities (for 82 percent of charcoal producers and 65 percent of fuelwood producers), which helps reduce poverty. These data show the importance of including the contributions of woodfuel commercialization to poverty reduction in energy and forestry policies.

Source: Schure, Levang and Wierzum (2014)

Woodfuel use in cities in developing countries

A number of studies of traditional fuel supply and demand in rural areas in developing countries have been undertaken, but few comparable studies have been conducted in urban populations. A paper by Alam, Dunkerley and Reddy (2009) reported on two studies undertaken on woodfuel supplies and their transportation, distribution and use in the Indian cities of Bangalore and Hyderabad. Substantial quantities of woodfuel – 200 000 tonnes in Hyderabad and 450 000 tonnes in Bangalore – are consumed each year. Households account for 78 percent of this volume, and woodfuel is a major source of energy for cooking and heating for low-income families. Although the researchers did not visit the forest areas from

which the woodfuel was extracted, the quantity consumed is sufficiently large to suggest that the resultant deforestation is severe. Recommendations are made to deal with the problem.

Source: Alam, Dunkerley and Reddy (2009)

SOCIOCULTURAL VALUES

Urban forests can help communities maintain cultural identities across generations, provide residents with community spaces in which to socialize, and decrease the gap between rich and poor neighbourhoods.

Urban forests and parks, gardens, pocket parks and tree alleys deliver important social services. Urban dwellers use green spaces – commonly free-of-charge – for relaxation, both individually and in groups, and for social events and cultural performances. Urban green spaces are also preferred venues for informal and formal sporting activities and for the establishment of playgrounds.

In addition, strong social, cultural and religious values are often associated with urban forests; many urban communities express strong support for tree-planting and the conservation of existing trees and forests in both rich and poor areas of cities. Ancient trees and forests often have especially strong cultural and social values; their persistence over decades and centuries provides connections between old and young generations and helps people feel more attached to their cities. Although the moral, spiritual, aesthetic and ethical values associated with urban forests vary greatly between cities and cultures, they usually play crucial roles in the protection and conservation of urban forests. In India, for example, the values and religious practices associated with sacred trees commonly found in cities often afford the only protection for urban forests. The availability of urban forests and other green spaces also provide natural or close-to-natural spaces for education (especially of children and youth) on environmental-related issues.

© FLICKR/SAVIO SEBASTIAN

Unplanned urban growth is usually accompanied by increasing social inequity between rich and poor and between centres and peripheries. There is often a "luxury" gradient in cities between wealthier and poorer neighbourhoods, which can affect the availability of green spaces – access to such spaces is often very limited for the urban poor, who mostly live in marginal, neglected or fragile areas. The luxury gradient can also influence the choice of species planted in urban forests, ranging from purely aesthetic considerations to the more pragmatic provision of goods and services.

Well designed and distributed, urban forests can play key roles in increasing social equity, promoting a sense of community among residents, and ensuring the maintenance of local cultural values. By beautifying all areas in a city equally, for example, urban forests can help reduce social, environmental and housing inequities. By providing residents with settings for local activities and events, green spaces can increase social cohesion and help build stronger, more stable communities. The existence of street trees can improve public safety by increasing the sense of privacy and reducing crime.

Maintaining the sociocultural values of forests in urban planning can have other benefits, such as promoting local forest products and tourism, increasing the quality of life of local people, and ensuring that current and future generations benefit from a diversity of cultural landscapes. Sociocultural values, therefore, should be fully integrated in urban forest management planning and policies, thereby helping achieve SDG target 11.4 –"protecting and safeguarding the world's cultural and natural heritage".

Urban forests and the SDGs: sociocultural values

Key actions

Policy and legal framework

- Develop a legal framework for the designation and inventory of trees and forests of sociocultural significance in and around cities.
- Ensure the equitable distribution of quality green spaces in both "rich" and "poor" neighbourhoods.

Planning, design and management

- Ensure that urban greening projects are designed (including through tree species selection) according to the architectural and aesthetic standards of local communities, considering geographical, cultural and socioeconomic gradients. This is particularly important in cities with a high influx of migrants with differing ethnic or religious backgrounds.

- Design multifunctional green spaces for use by the entire community, with suitable amenities and sociocultural services to make them attractive and to improve social interaction and inclusion.
- Support the transition and cultural continuity of migrants moving from rural areas to urban neighbourhoods by promoting the collaborative design and management of green spaces and related infrastructure (e.g. barbecues, secluded areas for families, benches and iconic trees).
- Create green spaces around public buildings (e.g. schools, hospitals and municipal buildings), religious buildings (e.g. churches, mosques, synagogues and temples) and cemeteries.
- Catalogue and conserve sacred forests and forests with historical value, as well as heritage trees.
- Manage urban forests to maximize their educational value for local communities (especially youth).
- Develop schemes for city "branding/identity" around the availability of urban forests.

Key monitoring criteria

- Discrepancy in the availability of green spaces between poor and rich neighbourhoods
- Availability and accessibility of green spaces
- Satisfaction of local communities
- Health status of important heritage trees

Key competencies/skills to be developed

- Design and implementation of participatory processes
- Assessment of local sociocultural values and needs
- Planning and design of public green open spaces
- Development of environmental education courses
- Tree conservation/arboriculture practices

Main knowledge gaps to be addressed

- Integration of rural values into urban environments and the implications for the management of urban forests
- Community expectations for sociocultural services provided by urban forests and other green spaces
- Valuation of sociocultural services compared with the other functions of urban forests

Helpful facts for advocacy

- A study conducted in Baltimore, United States of America, showed that a 10 percent increase in canopy cover was linked to a 12 percent decrease in crime (Troy, Grove and O'Neil-Dunne, 2012).

- In China, buildings were undermining the roots of a 4 700-year-old, 50-metre tall tree. The government spent more than US$300 000 to relocate nearby residents in order to preserve the tree (Xinhua, 2015).
- An individual cotton tree (*Ceiba pentandra*) is the historic symbol of Freetown, Sierra Leone. It is older than the city itself, which was established in 1787 (Kaushik, 2014).
- In Ida B. Well, a large public housing estate in Chicago, United States of America, apartment buildings with high levels of greenery had 52 percent fewer crimes than those without any trees (Kuo and Sullivan, 2001).

Significance of urban forest type for sociocultural values

Urban forest type	Significance			
	Recreation	Education	Social cohesion	Social security and equity
Peri-urban forests and woodlands	4	5	2	1
City parks and urban forests (>0.5 ha)	5	4	5	4
Pocket parks and gardens with trees (<0.5 ha)	3	1	3	4
Trees on streets or in public squares	1	1	1	5
Other green spaces with trees	3	3	2	3

* Where 1 = very low significance and 5 = very high significance.

Case studies

Healthy and Ecological School, Lomas de Zapallal

Lomas de Zapallal is a slum community in northern Lima, Peru, with a growing population of about 27 000 residents. The community is part of a mega-slum of more than 1.5 million inhabitants, of whom many live in makeshift homes of plywood and corrugated metal and lack water, sanitation and reliable electricity. With more than 1 600 primary and secondary students, the community's Pitágoras school is said to be the third-poorest in Lima. Until 2012, the school sat on a giant sand dune, with no walkways – just dry, sandy ground. The Puente Piedra Project: Healthy Schools, Healthy Communities, developed jointly by the University of Washington, the National University of Marcos in Lima, and other partners, created a 600-square-metre park on the site. The park is constructed with local stone, nurtures more than 200 shrubs, trees and other plants, and incorporates an innovative grey-water irrigation system to reuse hand-washing water for irrigation. It now provides a vital green space in an otherwise barren desert landscape – and areas for students to relax and play. The project relied on community investment, with students, parents and teachers involved directly in its development through participatory design workshops. More than 300 parents graded the site with shovels and wheelbarrows, laid stone to form pathways, and planted trees. The park was constructed in two weeks.

Source: Informal Urban Communities Initiative (2011)

"Heritage hunt" in Namibia: a participatory inventory

In 2005, the National Heritage Council of Namibia instituted the Heritage Hunt Campaign, a project through which Namibians are encouraged to nominate heritage properties for consideration for national heritage status. The Heritage Hunt Campaign has broadened the scope of heritage sites to include intangible heritage considerations. One such site is the Omwandi gwontala, a tree that served as a meeting place for traditional leaders of different tribes in northern Namibia. Men walking to join the contract labour system also made use of this tree, taking refuge in its branches to protect themselves from the lions that prowled the area. The fact that communities, local authorities and regional governments are responsible for identifying their own heritage creates a sense of responsibility towards the maintenance of heritage properties.

Source: Barillet, Joffroy and Longuet (undated)

Urban green space, street tree and heritage large tree assessment

In 1999, the Bangkok Metropolitan Authority in Thailand ran a competition asking the public to nominate the largest trees of heritage value on public or private property growing in their neighbourhoods. In 2001, the Silviculture Department at Kasetsart University was contracted to survey the 53 selected trees, as well as any adjacent large trees on the same properties. Many of the surveyed trees were on the grounds of Buddhist temples, where they have been relatively undisturbed compared with other trees because of religious traditions prohibitingthe cutting of

certain species. According to Buddhist scripture, the Buddha found enlightenment under *Ficus religiosa*, and the species is widely planted, therefore, at Buddhist temples. Several other heritage species were found to be associated with Buddhist temples in Bangkok, including *Crudia chrysantha* and *Couroupita guianensis*. The Buddha is said to have been born under a *Shorea robusta* tree, a species native to south Asia; its common name and that of *C. guianensis* are very similar in the Thai language, and *C. guianensis* has been misidentified and planted as *S. robusta*.

Source: Thaiutsaa *et al.* (2008)

4 Supporting the process

The successful implementation of UPF requires the following accompanying measures: communication and awareness-raising; community engagement; the development of alliances and partnerships; and the identification of research needs and perspectives. This chapter provides guidance for planning and supporting the implementation of such accompanying measures. It also presents case studies showing actions for creating the necessary conditions for the effective implementation of UPF.

COMMUNICATION AND AWARENESS-RAISING

Good communication improves public understanding of decisions related to the development of green infrastructure and helps minimize conflicts on the use and functions of urban forests.

Urbanization has implications far beyond the demographic and physical structures of cities, with profound effects on sociocultural values, norms and processes as well as on the environment (both within and well beyond cities), physical and mental health, behaviours, policies, the economy, equity and aspirations. Urban populations are usually at the forefront of change processes and "hot spots" for innovation.

Due to the urbanization process, however, many urban and peri-urban dwellers have become less familiar with natural processes and may lack understanding of their dependence on forests and green spaces for (for example) clean air and water, recreation and mental health and as sources of food and energy.

There is a clear need, therefore, to increase awareness among urban and peri-urban dwellers, other stakeholders and policymakers of the roles and benefits of urban forests and other green spaces. Although UPF is an established profession, it is often undervalued in cities and at the national level. The relatively new concept of green infrastructure requires wide and deep acceptance by the public, a strong commitment at the political and technical levels, and new expertise and education. Effective communication that meets the criteria of "completeness, conciseness, consideration (reciprocity between issuer and receiver), concreteness, courtesy, clearness and correctness" is crucial for developing solid roots in this strategic domain.

The numbers and types of partners with an interest and stake in urban forests have increased dramatically in recent years. In many places, however, urban forests still have a negative image; for example, they may be thought of as places where

© FLICKR/ANNE RUTHMANN

crimes are committed with impunity. Public education and involvement is needed to reverse this negative image. Communication and awareness-raising processes are also powerful tools for attracting investments in urban forests.

How to achieve communication goals

The first step in achieving communication goals is to identify the target audience. In general, three audiences can be distinguished:

1) internal stakeholders – the individuals and organizations who need to be worked with directly to achieve UPF objectives;
2) external stakeholders – individuals and organizations who can provide political and financial support for meeting objectives; and
3) the public – segments in the broader community who could be more aware of urban forests and more involved in UPF activities.

When the audiences have been identified, communication strategies and community engagement processes can be developed in line with municipal planning frameworks. For example, new norms and regulations on urban forests should be communicated widely: doing so through collaborative processes will help in avoiding misunderstandings and potential future conflicts on the roles and uses of urban forests.

Communication styles and collaborative tools should be designed to incorporate local and individual knowledge. Communication based on reciprocal learning can be effective in the success of urban forest design, implementation and management.

Practical action can also be an effective communication tool. For example, providing free trees to citizens to plant in their gardens is an inexpensive and effective way of bringing attention to urban forests and other green spaces. Involving volunteers and formal and informal community groups in tree-planting in public spaces can help raise awareness of the importance of urban forests while also increasing community capacity in urban forest management (potentially reducing the cost of forest management in the longer term). Certification schemes can be effective means for communicating the environmental credentials of products derived from well-managed urban forests.

Forest institutions can play an important role by building the capacity of urban foresters to communicate the costs and benefits of UPF, thereby helping strengthen the position of urban forests in city governance and also facilitating the acceptance of UPF in the wider community. More research on effective communication approaches in UPF is needed, however.

Case studies

The urban forest in Celje: from space to place

Awareness of the value of change can be obtained by transforming a "space" (that is, a contiguous area that is free, available and unoccupied) into a "place" (that is, a particular area on a larger surface – a person's "home"), thereby increasing the sense of belonging within a community. The communication process for the urban forest in Celije, Slovenia, is a good example of how structured communication and branding can help transform a (forest) "space" into one of the city's core "places". The development of the forest started in the city in the early 1990s. The city council approved the initiative of the local forest service and commissioned the preparation of a strategic urban forest plan, which was issued in 1996. More than 150 articles on Celje's urban forests were published in newspapers and electronic media between 1997 and 2010, mostly in local newspapers and on television and radio. Starting in 2000, a network of multipurpose, recreational and educational forest paths was constructed and equipped. In 2005, the forest service, in cooperation with the local municipality, launched the non-commercial brand "Mestni gozd Celje" (City Forest Celje) to promote the values of urban forests and to raise awareness. In 2009, an educational initiative – "The Wisdom of Forests" – was launched to foster systematic cooperation between the forest service and local primary schools.

Source: Hostnik (undated)

MillionTreesNYC

MillionTreesNYC is one of the 132 initiatives included in PlaNYC, the sustainability and resiliency blueprint of New York City in the United States of America. PlaNYC is a joint programme of the offices of Long-Term Planning and Sustainability and Recovery and Resiliency, which are part of the New York City Mayor's office. MillionTreesNYC is a citywide public–private partnership with an ambitious goal: to plant and care for 1 million new trees across the City's five boroughs over the next decade. MillionTreesNYC communicates the many environmental, health, social and economic benefits that trees provide in all facets of city life by using adaptive awareness-raising. The action framework of the programme comprises experiential learning ("learning by doing", for example by tree-planting), a "strong commitments" basis, a continuous multisource and multiscalar communications system, and the smart application of information technology (the Twitter hashtag @MillionTreesNYC has proved popular among New Yorkers). MillionTreesNYC has become a citywide movement that is engaging and energizing citizens from all backgrounds and interests, not only in planting trees and fostering greater respect for the city's urban forests but in volunteerism, environmental education and public policies that will lead to a more beautiful, healthy and sustainable city.

Source: MIllionTreesNYC (2015)

COMMUNITY ENGAGEMENT

Urban forests and other green spaces are key elements of urban landscapes. Their full value is only realized, however, with the active participation of the local community.

The European Landscape Convention states that the value of a landscape – that is, an area the character of which is the result of the action and interaction of natural or human factors – is only fully realized with the active participation of the local community. Urban landscapes – built or open, public or private – interact continuously with urban communities, both directly and indirectly. Therefore, community involvement should not an option but a paradigm in the governance of cities and urban landscapes.

Community engagement can be defined as the process of working collaboratively with and through groups of people affiliated by geographic proximity, special interests or similar conditions to address issues affecting their well-being and quality of life. It is a powerful way of bringing about environmental and behavioural changes to improve the health and well-being of communities and their members.

Community engagement is also a prerequisite for empowering people in decision-making processes and helps increase the capacity of communities to share responsibility and act personally on common and negotiated interests. In cities, "community engagement" refers to a series of actions and initiatives aimed at deepening democratic participation so that citizens have a direct voice in public decisions concerning the landscapes in which they live.

In successful citizen engagement programmes, the disparity between the expectations of planners and participants should be minimal. Conflict is probable if they differ, potentially affecting the planning process and damaging the planning agency's reputation and its relationship with stakeholders.

Urban foresters and planners should bear in mind that, while public participation is often a requirement for decision-makers, it is always voluntary for citizens, who are most likely to participate if they anticipate a rewarding experience or hope to influence planning, design and management processes. Many agencies choose to exclude or minimize community involvement in planning, design and management, claiming that it is too expensive, time-consuming, conjectural or conflictual, or it is impractical. Many tangible benefits can be derived from effective community involvement, however, such as:

- information and ideas on public issues;
- public support for planning decisions;
- avoidance of protracted conflicts and costly delays;
- the creation of a reservoir of goodwill that can carry over to future decisions;
- the collaborative management of public goods, thereby reducing the cost of administration interventions;
- the enhancement of the spirit of cooperation and trust among institutions, agencies and the public;
- lifelong learning benefits via capacity building and awareness-raising;
- the valuing of local knowledge; and
- the strengthening of a sense of volunteerism in the care of public goods.

UPF and community involvement

Urban forests and other green spaces – from the small open area at the end of the street, to the large-scale forest on the urban fringe – are resources in which many actors have shared interests. When public parks and other accessible open spaces really "work", they are invariably at the centre of people's lives – they are places where people meet, walk, play and enjoy nature. The contribution that attractive urban forests and other green spaces can make to localities and, more broadly, to the quality of life in cities is increasingly seen as dependent on the level of engagement among decision-makers, professionals (e.g. planners, managers, designers, researchers and educators) and the communities they serve. Among the many reasons for involving people in the planning, design and management of urban forests are the following:

- *Quality* – the key reason to facilitate the participation of people in an initiative is to improve the decision-making process and the quality of outcomes. In UPF, the ultimate aim of socially inclusive planning and design is to enable people to fully tap into the benefits of urban forests.
- *Sense of ownership* – an increased sense of ownership is a strong reason to involve the community. When people contribute to the shaping of their living environment they are more likely to consider an area to be "theirs".

- *Conflict management* – stakeholder involvement is an important tool for managing conflicts. Social conflicts occur frequently in urban forests because relatively small forest resources must cater to high and diverse demands for forest products and services and might be under threat of conversion to other, more immediately profitable land uses. Proposals for new developments, for example, frequently include the removal of mature trees in order to maximize the space available for grey infrastructure. Local planning authorities must put in place robust policies and procedures to ensure that urban development does not cause a permanent loss of amenity. They must also rigorously monitor and enforce those conditions, but bringing stakeholders together to build understanding and develop common goals is perhaps the most effective way of reducing conflicts over time.
- *Mutual learning* – people are interested in what happens in their living environment. They are curious about the ideas of others, they like to learn from "professionals", and they want to demonstrate their own ideas and knowledge. In participatory processes, the knowledge and skills of participants come to the fore, contributing significant knowledge and intellectual capital to projects and putting in place mutual learning processes between lay people and experts.

Involving stakeholders and the public at large is not easy because there are many interests and backgrounds to consider. Public involvement is often approached as something technical and concerned with substantive ends, but policymaking and planning for urban forests inevitably involves a very wide range of actors. UPF can be viewed as one of many means to obtain increased community involvement in municipal-level decision-making and to strengthen social cohesion.

How to make the process work

A wide range of tools has been developed to help stakeholders contribute to urban forest planning, design and management. Each situation is unique, however, and will evolve in its own way, perhaps unpredictably.

In any participatory process it is essential to carry out a community assessment to map the various actors and stakeholder groups and assess limitations and opportunities. Identifying, reaching and engaging the "right" stakeholders is crucial. Questions about the legitimacy and representativeness of participants are likely to arise. The process must not be restricted to those with a direct interest in UPF, and a wide scope of interests should be encouraged.

Actors in the process may be insiders, outsiders or newcomers. Insiders might be landowners, land users, people living in the community, and professionals responsible for planning, creating, managing and maintaining urban forests. Outsiders may be people, organizations, agencies and decision-makers acting from beyond the immediate area (or using the resource only periodically), experts not living in the area, and developers and elected officials not specifically engaged in planning, designing or managing the resource. Newcomers may include young people and new cultural, ethnic, social or interest groups.

The establishment of support mechanisms to promote and sustain the active participation of the various actors is crucial, and strategies should be put in place to achieve a balance of empowerment, involvement, education, consultation and practical participation. Overall, space should be found to enable the participatory process to grow and develop and to find its optimum level in a given context, be it a plan for new urban forests, a street tree-planting programme, or a city-wide tree strategy.

Local non-governmental organizations and research teams with proven track records of collaboration with governments and local communities can be helpful in providing tools for guiding change and ensuring adequate communication, information and consultation. The information produced in participatory discussions and diagnoses complements local-government data, and a collaborative relationship among stakeholders can increase understanding of problems and lead to innovative solutions.

Including all stakeholders in open and collective dialogue creates transparency, which helps build trust. Setting norms and rules for participatory processes, and using appropriate tools, will help in avoiding conflicts when selecting projects, making decisions on budget allocations, and using resources.

It is important to ensure that cultural sensitivities are accommodated. The increasingly multicultural character of contemporary urban societies creates both challenges and opportunities for the management of urban forests and other green spaces. The educational, consultative and participatory elements of community strategies should be delivered through diverse events and activities designed to promote social inclusion and encourage the engagement of marginalized communities.

In many aspects of community involvement, quality is more important than quantity. As a participatory process develops, measures of success should increasingly feature qualitative assessments. Local governments can be inspired by the example set by participatory approaches to urban forest management to the extent they adopt similar methods in other processes.

© SIMONE BORELLI

Case studies

City of Toronto

The City of Toronto, in Canada, in close collaboration with the Toronto and Region Conservation Authority (and many other partners), coordinates a wide range of stewardship activities across the city. These are largely under the umbrella of two programmes: the Parkland Naturalization Program and the Community Stewardship Program. The Parkland Naturalization Program is centred on an annual event called "Trees across Toronto", which involves planting thousands of native trees and shrubs at various locations with the support of corporate partners, targeting small areas in need of enhancement. The Community Stewardship Program is more unusual in that it is designed to fully engage volunteers in a sustained way. Volunteers are trained by skilled City staff and take part in tree-care activities ranging from maintenance to monitoring (e.g. removing invasive plant species, collecting litter, planting native vegetation and monitoring vegetation health). The programme has succeeded in creating a sustained base of trained volunteers.

Source: Ursic, Satel and van Wassenaer (undated)

Participatory development of an urban forestry community engagement model

In 2009, Cornell University, in the United States of America, embarked on a three-year social science research and education project that supports practitioners and groups working in urban forestry. Partners included the New York City (NYC) Parks Department, the United States Forest Service, the Alliance for Community Trees, the Council on the Environment of NYC, and Trees NY. The effort involved working in collaboration with residents and community organizations in ongoing interactive educational and engagement activities. The goal of the project was to develop, implement and evaluate an urban forestry community engagement model and toolkit that would help organizations across the country reach and empower people to be active stewards of their community's trees and natural resources. The project took place in two NYC neighbourhoods where trees had been planted recently by the MillionTreesNYC initiative: Canarsie (Brooklyn) and Jamaica (Queens). In Canarsie, the project focused on engaging stakeholders in the stewardship of trees planted in the natural areas of Canarsie Park. In Jamaica, the project engaged members of the community in taking care of street trees. Interactive presentations and activities were developed for learning about topics in each theme. As a result of involvement in the workshops, participants in Canarsie gained a significant increase in five of 14 "knowledge" items. Sixty-five percent of Canarsie participants reported that their attitudes toward urban trees had changed after attending the programme. Participants in Jamaica reported an increase in seven of 13 "future intentions" to engage in urban forest stewardship behaviour; 83 percent of participants reported that their attitudes toward urban trees had changed as a result of attending the programme. The Program Model/Education Toolkit was also developed, comprising best practices in community

engagement, templates for eliciting community views toward urban forests, best practices for building social capital and urban tree stewardship, and tools for tree stewardship awareness, knowledge and skills development.

Source: Cornell University (undated)

ALLIANCES AND PARTNERSHIPS

Building alliances and partnerships in an essential component of urban greening programmes. It can help mobilize resources and improve collaboration among stakeholders.

Building partnerships and alliances among stakeholder groups is essential in urban greening – not only as a way of mobilizing resources but also because it creates goodwill, community spirit and a greater understanding of the benefits and costs of urban forests.

The term "alliances and partnerships" traditionally refers to approaches involving the private sector, which may contribute finance or other assistance in return for a range of benefits (e.g. in public relations or the development of commercial assets). More recently, however, collaboration and cooperation among actors in aspects of UPF has come to be seen as a way of strengthening governance and as a crucial aspect of urban management.

Another relatively recent phenomenon is the creation of networks of municipal governments at the subnational, national and global scales. Participation in such networks provides a useful institutional framework for exchanging information and sharing successful experiences between cities, including on urban forests. Intercity networks can facilitate the exchange of technical expertise and help in attracting international financial assistance, thereby increasing the quality of public management. The participation of cities in associations and networks contributes to defining and presenting local perspectives in regional and global arenas, and it allows the coordination of efforts to deal with global issues that have local impacts.

© FLICKR/PROVINCE OF BRITISH COLUMBIA

Strong alliances and partnerships are crucial, therefore, for the success of UPF management and development. Cities will be greener, cleaner and healthier when all actors and stakeholders work together, benefiting from the exchange of ideas, the sharing of knowledge and responsibility, and the mobilization of resources.

The best municipalities continually seek better ways to solve problems, and they can make progress more quickly by interacting with and learning from other municipal governments. "Sister cities" alliances (or "twinning cities"), for example, provide opportunities for cities with comparable issues to learn from and help each other. Twinning can help boost the reputations and self-pride of both participating cities. Networking and calls for tender are potential tools for finding partners and collaborators. The important thing is to foster creative interactions among partners for mutual benefit.

How to make the process work

Of particular relevance for UPF are networks that focus on skills, tools and approaches for improving the design and management of urban forests and other green spaces. Working groups of various partners – such as state and municipal agencies, local and regional organizations, mayors and professional associations – can serve as forums for sharing strategies on integrating ecosystem approaches and green infrastructure development into programmes, identifying and coordinating appropriate professional resources and local knowledge, and attracting interest in UPF initiatives. Career-track training programmes in partnership governance and accountability focused on urban forests and other green infrastructure can be developed.

Measures to encourage public–private partnerships on UPF could be adopted with the aim of attracting private-sector investments and other inputs. Such partnerships have been gaining attention as an innovative way of mobilizing resources to supplement municipal forestry programmes, and they are becoming instrumental in the conservation and expansion of green infrastructure.

The private sector can obtain many benefits from partnerships with the public sector. Stewardship and greening efforts boost employee morale and help companies achieve corporate social responsibility objectives. As government resources decline, the private sector will need to become more involved, not only in supporting UPF but also in taking on leadership roles in developing and implementing the strategic approaches necessary to make UPF a success.

It is important to engage networks to educate and inform people about issues related to urban forests, develop resources and create partnerships in support of UPF.

Finally, action research and education-based alliances on urban forests and other green infrastructure can play important roles in developing innovative approaches to UPF and sharing these among stakeholders.

Case studies

São Paolo's public–private partnerships for tree-planting

In this programme in São Paolo, Brazil, companies are contracted – through public bids – to plant trees along roadways. The contract assigns a quota of trees that should be planted on a monthly basis and sets technical specifications that must be complied with. In exchange for planting the trees, the company receives a permit to sell small advertising spots placed on seedling-protection rails, with the prices for such spots varying according to market demand. If prices are too high, few spots are sold and the permittee may be unable to meet contractual tree-planting obligations; if they are too low, on the other hand, the company may go bankrupt. This is quite an advanced system of partnership, in which private companies bear the risks and the municipality obtains a final product – trees planted along roadways – at no cost other than those associated with ensuring that the terms of the contract are met.

Sources: Zulauf (1996); Coleman *et al.* (2013)

National Urban Forest Alliance

Australia's National Urban Forest Alliance is a coalition of councils, research bodies, industry and not-for-profit associations involved in the future planning, management and development of Australian urban forests. Its vision is to promote thriving, sustainable and diverse Australian urban forests that support healthy ecosystems that are valued and cared for by all Australians as essential environmental, economic and community assets. Alliance partners represent a vast array of stakeholders and are united in taking the lead in urban forest issues in Australia. The Alliance is committed to a "2020 vision" in which green infrastructure is prioritized as an essential community asset that contributes to resilient, healthy and liveable communities across Australia.

Source: National Urban Forest Alliance (2015)

The global cities network

ICLEI – Local Governments for Sustainability – is the world's leading network of over 1 000 cities, towns and metropolises committed to building a sustainable future. By helping members make their cities sustainable, low-carbon, resilient, biodiverse, resource-efficient, healthy and happy, with a green economy and smart infrastructure, the network supports over 20 percent of the world's urban population. ICLEI's mission is to build and serve a worldwide movement of local governments to achieve tangible improvements in global sustainability, with a specific focus on environmental conditions through cumulative local actions.

Source: ICLEI (2015)

RESEARCH NEEDS AND PERSPECTIVES

Human decisions and activities can significantly influence urban forests, and science-based guidance is needed at both the policy and management levels.

Urban landscapes are becoming increasingly complex, and research will continue to be crucial in the identification and development of adaptive solutions to urban challenges and for effective community-wide planning and management. UPF is a relatively new field that needs strong research support for its long-term development.

Strategic framework

Urban forest research priorities should be determined based on society's needs. As a first step, a framework should be established for UPF research, focusing on three major components: 1) biological aspects; 2) links between urban forests and other natural and human-made attributes of urban and peri-urban environments; and 3) interactions between people and urban forest ecosystems.

Simply conducting research is insufficient. Local stakeholders, including authorities, the private sector and community groups, may not have direct responsibility for setting the urban forest research agenda, but they are all likely to be keenly interested in the outcomes because of their implications for the planning, development and management of urban forests and other green spaces. It is essential, therefore, that research priorities are set in consultation with stakeholders.

© FLICKR/FERNANDO DA VEIGA PESSOA

To ensure this, it is important to build in feedback loops between researchers and urban forest stakeholders and to promote collaboration and partnerships to ensure that research meets ongoing needs. The ultimate goal of urban forest research is to provide stakeholders with the knowledge and data they need to plan and manage the resource effectively.

Action research – the process of progressive problem-solving led by individuals working with others in teams or as part of a "community of practice" to improve the way they address issues and solve problems – is a promising approach for UPF. It can be used to solve immediate problems, or as part of a research process aimed at identifying concrete actions with defined goals. Box 18 describes some of the key elements of effective research on urban forests.

BOX 18

Key elements of effective research on urban forests and other green infrastructure

- Be innovative. There is a general assumption that innovation is a matter of technology. This is reductive, however, especially when referring to urban and peri-urban environments and UPF. Broadly, innovation is the development of new ideas. In environments such as cities, innovation is crucial for improving processes and developing new methods for solving applied problems.
- Promote integrative and collaborative research. Urban forests are common goods, and their effective governance requires ongoing research that cuts across sectors and stakeholders.
- Seek solutions to conflicts. Urban forests are often "battlefields" of conflicting interests. Research can help develop the knowledge, information and communication, and the methods and styles, for negotiating and resolving conflicts and empowering communities.

Main research needs

1) **Biological aspects.** At the scale of individual trees, recommended research areas include species selection, urban forest health (i.e. the management of pests and abiotic stresses), and the relationship between tree growth and site factors (e.g. soils). The identification and management of the direct and indirect impacts of human activities, including the interconnections between urban environments and human health and well-being, are ongoing research challenges, as is the need to improve predictive models for the growth and development of urban forests under differing management regimes.
2) **Links between urban forests and other natural and human-made attributes of urban and peri-urban environments.** At the scales of an urban or peri-urban ecosystem, the benefits of forests are related directly to the spatial configuration of vegetation and its location with respect to

other natural and human-made attributes of the urban environment. Thus, research on urban forest structure, functions and management is needed. Applied research on environmental design will be crucial for the restoration and improvement of urban and peri-urban environments. As interest increases in ecological restoration in urban and peri-urban areas, identifying the most appropriate cost-effective approaches for such restoration would be helpful.

3) **Interactions between people and urban forest ecosystems.** Performance indicators for ecosystem services and payment schemes for the delivery of such services need more development. Ecosystem services are often forgotten in economic debates, yet they are essential for healthy, vibrant cities. Developing ways of measuring their value will help increase public awareness about them. Mapping the potential ecosystem services provided by urban forests and other green spaces is one way of developing estimates of benefits to urban communities. Such maps can assist in municipal planning with medium-term to long-term time horizons and provide transparent information on the economic, social and environmental values of ecosystem services. Reliable information on the economic costs and benefits of urban forests, and the trade-offs (e.g. in water use, allergy concerns and maintenance costs) they involve, is needed to support informed decision-making and maximize investment returns.

Further insights are needed on the potential of urban forests and other green spaces to create opportunities for integrating youth, elderly people, immigrants, unemployed and other social groups into urban life.

Long-term vision

While there is increasing attention on urban forests and other green spaces in developed countries, research needs to be supported and improved in other parts of the world. Many countries in Africa, Latin America and the Caribbean, and southern and western Asia have huge knowledge gaps in almost all research areas related to urban forests and other green spaces. There is a need for greater technology transfer and information-sharing within and between countries and regions. Research networking, the creation of centres of research excellence, and the establishment of demonstration urban forests and landscape laboratories are all potential tools for increasing applied research in urban forests and other green spaces.

As urban forest management scales up, urban–rural research linkages will need strengthening in recognition that physical, biological and social processes that influence forests span the urban–rural continuum. Future UPF research efforts will require the involvement of researchers from a wide range of disciplines at multiple scales across urban and peri-urban landscapes. The integration of landscape, ecosystem and tree-care research in UPF will enable comprehensive and adaptive management to sustain urban forest structure, health and benefits over the long term.

Research institutions continuously generate new information, tools and technologies, which must be disseminated in useful forms and a timely manner. Research institutions can help in developing effective dissemination and feedback mechanisms to ensure that research benefits, and benefits from, its users.

© FLICKR/SHORTMEGAN

5 The way forward

In 2015, the global community adopted a set of goals – the SDGs – designed to end poverty, protect the planet, and ensure prosperity for all as part of a new sustainable development agenda, thus reaffirming sustainable development as the means for achieving a better future. Urban growth threatens to undermine the achievement of the SDGs, however, with cities responsible for an increasing proportion of carbon emissions as well as resource depletion, increases in income inequality, and other negative trends.

Urban forests have a vital frontline role to play in the achievement of the SDGs. UPF provides essential ecosystem services to urban and peri-urban communities; it is a cost-effective measure for improving human health and quality of life, an innovative, nature-based solution to many social and cultural needs, and a smart way to deal with the negative effects of urbanization. It can ameliorate the direct impacts of climate change on people and provide them with places in which to achieve physical and mental well-being.

These guidelines should serve both as a source of inspiration and as a guide in the preparation of policies, plans and actions to create and sustainably

© FLICKR/HUGUES

manage urban green spaces and improve the quality of life of urban and peri-urban residents. The guidelines provide a global reference framework for the development of environmentally sound, socially inclusive, properly integrated and connected urban green infrastructure that addresses the challenges of global change while responding to people's needs at the local level.

The guidelines should be viewed as the first of a series of actions to support the adaptation and application of the concepts and practical tools contained herein by governments, decision-makers, professionals, civil-society organizations and individual citizens wanting to invest in urban forests. Networking, collaboration, dissemination, communication, local adaptation, knowledge, capacity building, integration, resource mobilization, action research, monitoring and community engagement are the "road signs" for the journey that starts with the publication of these guidelines.

NETWORKING AND REGIONAL AND INTERNATIONAL COLLABORATION

Existing UPF-related networks are key to supporting the dissemination and implementation phases of the guidelines. In addition to the European Forum of Urban Forestry (a transnational network that has been working beyond Europe for the last 20 years), a regional networking event on UPF was held recently in the Asia-Pacific region and another is planned for Latin America and Caribbean. The UPF working group of Silva Mediterranea (the FAO statutory body dealing with Mediterranean forests) has become a permanent means for facilitating the sharing of knowledge and supporting the implementation of UPF in the Mediterranean subregion. It is expected that the implementation of the guidelines will also lead to additional networking activities.

DISSEMINATION, COMMUNICATION AND LOCAL ADAPTATION OF THE GUIDELINES

The guidelines will be promoted, disseminated and progressively translated into various languages to make them available to local actors and encourage their wide adaptation at the local, national and regional scales. Dissemination and proactive discussion on the potential application of the guidelines will be promoted through existing online platforms, such as "Trees for the Cities", a recently launched online forum on UPF, and "Food for the Cities", a well-established online discussion group managed by FAO. Social media will also be used for the dissemination of the guidelines through existing blogs and discussion groups.

KNOWLEDGE AND CAPACITY BUILDING

A lack of technical skills and knowledge is recognized as a major barrier to the sound implementation of UPF. The UPF community needs to capitalize on regional and international initiatives to exchange ideas and solutions on UPF. Actions related to the implementation of these guidelines will provide opportunities to identify realistic solutions to the issues facing cities. Capacity-development workshops, information and education events, factsheets, the collection of case studies and

best practices, infographics and other communication tools can be organized or created around various elements of the guidelines to improve and add value to local knowledge and technical skills.

RESOURCE MOBILIZATION

Financing opportunities emerging from funding instruments at the local-to-global level need to be explored and used to implement UPF, particularly in developing countries, where urban poverty is often a key issue. Because of their status as a globally derived document, and in light of evidence of the benefits of UPF, these guidelines can provide a pull factor for public and private investment, thereby helping to mobilize financial resources for the implementation of UPF. Co-funded projects, citizens' initiatives, private-sector support, donations, and "twinning cities" programmes, among other efforts, can be used in the implementation of the guidelines.

ACTION RESEARCH, RESEARCH IN ACTION

There has been a decisive acceleration in research and development on UPF in the last decade, and many regional and global research networks on UPF and in related fields are now active. The guidelines highlight the key role of research in the future of UPF and encourage an "action research" approach tailored to the needs of cities – especially those in developing countries or where there is urban poverty.

INTEGRATION OF URBAN FORESTS IN CITY PLANNING AND GOVERNANCE

These guidelines present the main aspects of the sustainable design, management, planning and governance of urban forests and other green infrastructure that will help in building the ecological and social resilience of cities and generate benefits for urban dwellers. Urban forests should be part of broader systemic, adaptive, sustainable urban land management strategies. One role of the guidelines is to provide a substantial basis for dialogue and integration in urban governance. UPF can be considered as a bridge between the various planning and management sectors of a city, and its application, therefore, requires a holistic, multisectoral approach. When it is a fully integrated part of urban planning and management, UPF can help transform cities into sustainable, healthy, equitable and pleasant places to live.

6 Glossary

Term	Definition‡*
Action research	The process of progressive problem-solving led by individuals working with others in teams or as part of a "community of practice" to improve the way they address issues and solve problems (FAO,2016a)
Adaptive management	A systematic process for continually improving management policies and practices by learning from the outcomes of previously employed policies and practices. In active adaptive management, management is treated as a deliberate experiment for purposes of learning (MEA, 2005)
Afforestation	The establishment of forest through planting and/or deliberate seeding on land that, until then, was not classified as forest (FAO, 2010a)
Air pollution	The introduction by humans, directly or indirectly, of substances or energy into the air resulting in deleterious effects of such a nature as to endanger human health, harm living resources and ecosystems and material property and impair or interfere with amenities and other legitimate uses of the environment, and "air pollutants" shall be construed accordingly (UNECE, 1979)
Arboriculture	The practice and study of the care of trees and other woody plants in the landscape (ISA, 2016)
Biodiversity	Variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems (CBD, 1992)
Brownfield	Abandoned, idled or underused industrial and commercial facilities/sites where expansion and commercial facilities/sites where expansion (Davidson and Dolnick, 2004)
Canopy cover (also crown cover)	The percentage of the ground covered by a vertical projection of the outermost perimeter of the natural spread of the foliage of plants. Cannot exceed 100 percent (and 100 percent canopy cover is also called crown closure) (IPCC, 2003)
Capacity building	The process of unleashing, strengthening and maintaining the ability of people, organizations and society as a whole to manage their affairs successfully (FAO, 2010b)
Capacity development	The process by which individuals, groups, organizations, institutions and countries develop, enhance and organize their systems, resources and knowledge; all reflected in their abilities, individually and collectively, to perform functions, solve problems and achieve objectives (OECD, 2006)
Carbon sequestration	The process by which trees and plants absorb carbon dioxide, release the oxygen therein, and store the carbon. Geologic sequestration is one step in the process of carbon capture and sequestration and involves injecting carbon dioxide deep underground where it stays permanently (US EPA, 2016a)
City parks and urban forests	Large urban or district parks with a variety of land cover and at least partly equipped with facilities for leisure and recreation. FAO (2016a)
City-region	An urban development on a massive scale: a major city that expands beyond administrative boundaries to engulf small cities, towns and semi-urban and rural hinterlands, sometimes expanding sufficiently to merge with other cities, forming large conurbations that eventually become city-regions (UNICEF, 2012)
Climate change	A change in the state of the climate that can be identified (e.g. by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer (IPCC, 2001)

‡ Sources are given in the box below.

* Definitions are not necessarily reproduced verbatim from their sources.

Community engagement	The process of working collaboratively with and through groups of people affiliated by geographic proximity, special interest or similar situations to address issues affecting the well-being of those people. It is a powerful vehicle for bringing about environmental and behavioural changes that will improve the health of the community and its members. It often involves partnerships and coalitions that help mobilize resources and influence systems, change relationships among partners, and serve as catalysts for changing policies, programmes and practices (CDC, 2011)
Deforestation	The conversion of forest to other land use or the long-term reduction of the tree canopy cover below the minimum 10 percent threshold (FAO, 2010a)
Desertification	Land degradation in arid, semi-arid or dry subhumid areas resulting from various factors, including climatic variations and human activities (UNCCD, 1994)
Disturbance	Damage caused by any factor (biotic or abiotic) that adversely affects the vigour and productivity of the forest and which is not a direct result of human activities (FAO, 2010a)
Drought	A naturally occurring phenomenon that exists when precipitation has been significantly below normal recorded levels, causing serious hydrological imbalances that adversely affect land resource production systems (UNCCD, 1994)
Ecological restoration	The process of assisting the recovery of an ecosystem that has been degraded, damaged or destroyed. It is an intentional activity that initiates or accelerates an ecological pathway – trajectory through time – towards a reference state (Gann and Lamb, 2006)
Ecosystem services	The benefits people obtain from ecosystems. These include provisioning services such as food and water; regulating services such as flood and disease control; cultural services such as spiritual, recreational and cultural benefits; and supporting services, such as nutrient cycling, that maintain the conditions for life on Earth (MEA, 2005)
Enabling environment	The context in which individuals and organizations put their capabilities into action and where capacity development processes take place. It includes the institutional set-up of a country, its implicit and explicit rules, its power structures, and the policy and legal environment in which individuals and organizations function (FAO, 2010a)
Extreme weather event	A weather event that is rare within its statistical reference distribution at a particular place. Definitions of "rare" vary, but an extreme weather event would normally be as rare as, or rarer than, the 10th or 90th percentile. By definition, the characteristics of what is called extreme weather may vary from place to place. An extreme climate event is an average of a number of weather events over a certain period, an average which is itself extreme (e.g. rainfall over a season) (IPCC, 2001)
Food and nutrition security	Food security exists when all people, at all times, have physical, social and economic access to sufficient safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life (WFS, 1996)
Forest	Land spanning more than 0.5 hectares with trees higher than 5 metres and a canopy of more than 10 percent, or trees able to reach these thresholds in situ. It does not include land that is predominantly under agricultural or urban land use (FAO, 2010a)
Governance	(A) The formal and informal institutions, rules, mechanisms and processes of collective decision-making that enable stakeholders to influence and coordinate their interdependent needs and interests and their interactions with the environment at the relevant scales. (Tacconi, 2011) (B) In urban forestry, this definition encompasses both the governance of urban forests themselves and the role of forests and trees in overall urban governance. Urban forest governance should aim to integrate the management of all green infrastructure in a city, at different scales and functions, which is often under the responsibility of several public authorities. It should encompass both public and private trees – that is, the urban tree canopy (FAO, 2016a)
Green belt	Large parcels of land in and around cities where urban development is totally prohibited through zoning or public ownership, easement, or development restriction (Kuchelmeister, 1998)

Green infrastructure	(A) A strategically planned network of high-quality natural, semi-natural and cultivated areas designed and managed to deliver a wide range of ecosystem services and protect biodiversity. (European Commission, 2013) (B) A holistic urban green planning concept on the level of cities and city-regions. As a planning strategy it can be narrowed down to keywords such as multifunctionality and connectivity of green structures as well as multiscale, communicative and social inclusive approaches (Czechowski, Hauck and Hausladen, 2014)
Green space	*See Open space*
Health	A state of complete physical, mental and social well-being and not merely the absence of disease or infirmity (WHO, 1946)
Urban heat island	An area within an urban area characterized by ambient temperatures higher than those of the surrounding area because of the absorption of solar energy by materials like asphalt (IPCC, 2001)
Land degradation	The reduction or loss of the biological or economic productivity and complexity of rainfed cropland, irrigated cropland, or range, pasture, forest and woodlands resulting from land uses or from a process or combination of processes, including processes arising from human activities and habitation patterns, such as: soil erosion caused by wind and/or water; deterioration of the physical, chemical and biological or economic properties of soil; and long-term loss of natural vegetation (UNCCD, 1994)
Land tenure	The relationship, whether legally or customarily defined, among people, as individuals or groups, with respect to land. (For convenience, "land" is used here to include other natural resources such as water and trees.) Land tenure is an institution: i.e. rules invented by societies to regulate behaviour. Rules of tenure define how property rights to land are to be allocated within societies. They define how access is granted to rights to use, control and transfer land, as well as associated responsibilities and restraints (FAO, 2002)
Megacity	An urban agglomeration with a population of 10 million people or more (UNICEF, 2012)
Metropolitan area/region	A formal local government area comprising the urban area as a whole and its primary commuter areas, typically formed around a city with a large concentration of people (i.e. a population of at least 100 000) (UNICEF, 2012)
Multifunctionality	The potential for green infrastructure to have a range of functions and to deliver a broad range of ecosystem services (Natural England, 2009)
Nature-based solutions	Interventions that use nature and the natural functions of healthy ecosystems to tackle some of the most pressing challenges of our time. These types of solutions help protect the environment but also provide numerous economic and social benefits (IUCN, 2015)
Non-wood forest products	Goods derived from forests that are tangible and physical objects of biological origin other than wood (FAO, 2010a)
Open space	Any open piece of land that is undeveloped (has no buildings or other built structures) and is accessible to the public. Open space can include: a) green space – land that is partly or completely covered with grass, trees, shrubs, or other vegetation. Green space includes parks, community gardens, and cemeteries; b) schoolyards; c) playgrounds; d) public seating areas; e) public plazas; f) vacant lots (US EPA, 2016b)
Other green spaces with trees	Urban agricultural plots, sports grounds, vacant lands, lawns, riverbanks, open fields, cemeteries and botanical gardens (FAO, 2016a)
Participation	(A1) Means to increase efficiency, the central notion being that if people are involved, then they are more likely to agree with and support the new development or service. (A2) A fundamental right, in which the main aim is to initiate mobilization for collective action, empowerment and institution building. (Pretty, 1995) (B) A process of equitable and active involvement of all stakeholders in the formulation of development policies and strategies and in the analysis, planning, implementation, monitoring and evaluation of development activities. An organized effort within institutions and organizations to increase stakeholder access and control over resources and related decision-making that contributes to sustainable livelihoods. An iterative process involving the continuous re-adjustment of relationships between different stakeholders in a society in order to increase stakeholder control and influence over development initiatives that affect their lives (Muraleedharan, 2006)

Peri-urban forests and woodlands	Forests and woodlands surrounding towns and cities that can provide goods and services such as wood, fibre, fruit, other non-wood forest products, clean water, recreation and tourism (FAO, 2016a)
Place-keeping	The long-term management and maintenance of high-quality spaces to ensure that their economic, social and environmental qualities and benefits can be enjoyed by future generations (MP4, 2012)
Place-making	The process of creating high-quality spaces (MP4, 2012)
Pocket parks and gardens with trees	Small district parks equipped with facilities for recreation/leisure (FAO, 2016a)
Recreation	An activity that people engage in during their free time, enjoy, and recognize as having socially redeeming values. Unlike leisure, recreation has a connotation of being morally acceptable, not just to the individual but also to society as a whole, and thus we programme for those activities within that context (Hurd and Anderson, 2011)
Reforestation	The re-establishment of forest through planting and/or deliberate seeding on land classified as forest (FAO, 2010a)
Resilience	The capacity of a social and/or ecological system to absorb disturbance and to reorganize while undergoing change so as to retain essentially the same function, structure, identity and feedbacks (Walker *et al.*, 2004)
Risk management	Coordinated activities to direct and control an organization with regard to risk. A risk management process is the systematic application of management policies, procedures and practices to the activities of communicating, consulting, establishing the context, and identifying, analysing, evaluating, treating, monitoring and reviewing risk (ISO, 2009)
Silvicultural treatment	A planned programme of silvicultural operations that can be implemented during the entire or partial rotation of a stand. Within the context of silvicultural stand treatment, each stand is assigned a specific silvicultural objective and separately assessed for the characteristics of its site (e.g. locality, slope and soil type) and stocking (e.g. composition, age, diameter distribution and regeneration) (FAO, 2016b)
Slum	A heavily populated urban area characterized by substandard housing and squalor. An area that combines to various extents the following characteristics: a) inadequate access to safe water; b) inadequate access to sanitation and other infrastructure; c) poor structural quality of housing; d) overcrowding; and e) insecure residential status (UN-Habitat, 2003)
Soil quality	A soil's ability to provide ecosystem and social services through its capacity to perform its functions and respond to external influences (Toth, Stolbovoy and Montanarella, 2007)
Soil sealing	The permanent covering of an area of land and its soil by impermeable artificial material (e.g. asphalt and concrete), for example through buildings and roads (European Commission, 2012)
Stakeholders	Any individuals or groups who affect a project, or are affected by it, or exhibit an interest in it (Mathur *et al.*, 2007)
Stormwater runoff	Rainfall that flows over the ground surface. It is created when rain falls on roads, driveways, parking lots, rooftops and other paved surfaces that do not allow water to soak into the ground. Stormwater runoff is the number one cause of stream impairment in urban areas (CWP-USFS, 2008)
Sustainable development	Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs (WCED, 1987)
Trees on streets or in public squares	Linear tree populations, small groups of trees, and individual trees in squares and parking lots and on streets, etc. (FAO, 2016a)
Urban and peri-urban forest	The networks or systems comprising all woodlands, groups of trees, and individual trees located in urban and peri-urban areas; they include, therefore, forests, street trees, trees in parks and gardens, and trees in derelict corners. Urban forests are the backbone of the green infrastructure, bridging rural and urban areas and ameliorating a city's environmental footprint (FAO, 2016a)

Urban and peri-urban forestry	(A) The practice of managing urban forests to ensure their optimal contributions to the physiological, sociological and economic well-being of urban societies. It is an integrated, interdisciplinary, participatory and strategic approach to planning and managing forests and trees in and around cities. It involves the assessment, planning, planting, maintenance, preservation and monitoring of urban forests, and it can operate at scales ranging from single trees to landscapes (FAO, 2016a) (B) A specialized branch of forestry that has as its objective the cultivation and management of trees for their present and potential contribution to the physiological, sociological and economic well-being of urban society. In its broadest sense, urban forestry embraces a multimanagerial system that includes municipal watersheds, wildlife habitats, outdoor recreation opportunities, landscape design, recycling of municipal wastes, tree care in general and the production of wood fibre as a raw material. Urban forestry is a merging of arboriculture, ornamental horticulture and forest management. It is closely related to landscape architecture and park management and must be done in concert with professionals in these fields as well as with city planners. Urban forestry includes activities carried out in the city centre, suburban areas and the "urban fringe" or interface area with rural lands. Forestry activities can differ significantly according to the zone of a city. In central areas, the potential for significant new urban forestry efforts are relatively limited in most cities. Here, it is mainly an issue of maintaining or replacing trees planted long ago. In the suburban areas, more scope exists for tree-planting, as the availability of land is greater than in the city centre. The land is more likely to be privately owned than in the peri-urban or fringe area and the people more settled, thereby having a greater vested interest in tree protection and care (Kuchelmeister and Braatz, 1993)
Urban and territorial planning	A decision-making process aimed at realizing economic, social, cultural and environmental goals through the development of spatial visions, strategies and plans and the application of a set of policy principles, tools, institutional and participatory mechanisms and regulatory procedures (UN-Habitat, 2015)
Urban area	The built-up or densely populated area containing the city proper, suburbs, and continuously settled commuter areas (definitions of urban areas vary by country) (Kuchelmeister, 1998)
Urban poverty	Urban poverty is a multidimensional phenomenon. The urban poor live with many deprivations. Their daily challenges may include: a) limited access to employment opportunities and income; b) inadequate and insecure housing and services; c) violent and unhealthy environments; d) little or no social protection mechanisms; and e) limited access to adequate health and education opportunities. But urban poverty is not just a collection of characteristics, it is also a dynamic condition of vulnerability or susceptibility to risks (World Bank, 2016)
Urban sprawl	Incremental urban development in suburban and rural areas outside their respective urban centres, characterized by a low-density mix of land uses on the urban fringe, often accompanied by a lack of redevelopment or re-use of land within the urban centres themselves (European Commission, 2012)
Urbanization	The conversion of land from a natural state or managed natural state (such as agriculture) to cities; a process driven by net rural-to-urban migration through which an increasing percentage of the population in any nation or region come to live in settlements that are defined as urban centres (IPCC, 2001)
Watershed	A basin-like terrestrial region consisting of all the land that drains water into a common terminus (ESRI, 2016)
Well-being	The benefits gained from good psychological and physical health, also related to specific aspects such as favourable thoughts and feelings, satisfaction with life, ability to be self-sufficient and proactive, possessing a sense of happiness, and a positive evaluation of one's life in a general sense (Diener *et al.*, 1999)
Wood security	The process of optimization of the actually sustainable forest production for wood, timber, pulp and bioenergy for domestic and industrial uses (FAO, 2016a)
Woodfuel (removal)	The wood removed for energy production purposes, regardless of whether for industrial, commercial or domestic use (FAO, 2010a)
Woodfuel (removal)	The wood removed for energy production purposes, regardless whether for industrial, commercial or domestic use.

References for the glossary

CBD. 1992. *Convention on Biological Diversity*. United Nations.

CDC. 2011. *Principles of community engagement*. Clinical and Tanslational Science Awards Consortium, Community Engagement Key Function Committee Task Force on the Principles of Community Engagement. NIH Publication No. 11-7782. Centers for Disease Control and Prevention (CDC).

CWP-USFS. 2008. *Watershed forestry resource guide*. Center for Watershed Protection (CWP) and US Forest Service (USFS) (available at http://forestsforwatersheds.org). Accessed August 2016.

Czechowski, D., Hauck, T. & Hausladen, G., eds. 2014. *Revising green infrastructure: concepts between nature and design*. Boca Raton, USA, CRC Press, Taylor and Francis Group.

Davidson, M. & Dolnick, F. 2004. *A planner's dictionary*. APA.

Diener, E., Suh, E., Lucas, R.E. & Smith, H.L. 1999. Subjective well-being: three decades of progress. *Psychological Bulletin*, 125(2): 276–302.

ESRI. 2016. GIS dictionary. Webpage (available at: http://support.esri.com/sitecore/content/support/Home/other-resources/gis-dictionary/term/watershed). Accessed August 2016.

European Commission. 2012. *Guidelines on best practice to limit, mitigate or compensate soil sealing*. European Commission Staff Working Document. Luxembourg, Publications Office of the European Union (available at: http://ec.europa.eu/environment/soil/pdf/guidelines/pub/soil_en.pdf).

European Commission. 2013. *Green infrastructure (GI): enhancing Europe's natural capital*. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. Brussels.

FAO. 2002. *Land tenure and rural development*. FAO Land Tenure Studies No. 3. Rome.

FAO. 2010a. *Global Forest Resources Assessment 2010: terms and definitions*. Rome (available at: www.fao.org/docrep/014/am665e/am665e00.pdf).

FAO. 2010b. *Capacity building: helping other to help themselves* (available at: ftp://ftp.fao.org/docrep/fao/011/i0765e/i0765e15.pdf).

FAO. 2016a. *Guidelines on urban and peri-urban forestry*. FAO Forestry Paper No. 178. Rome.

FAO. 2016b. Silviculture in natural forests. Online module in the Sustainable Forest Management Toolbox (available at: www.fao.org/sustainable-forest-management/toolbox/modules/silviculture-in-natural-forests/basic-knowledge/en/). Accessed August 2016.

Gann, G.D. & Lamb, D., eds. 2006. *Ecological restoration: a mean of conserving biodiversity and sustaining livelihoods* (version 1.1). Tucson, Arizona, USA, and Gland, Switzerland, IUCN and Society for Ecological Restoration International.

Hurd, A.R. & Anderson, D.M. 2011. *The park and recreation professional's handbook with online resource*. Champaign, USA, Human Kinetics.

IPCC. 2001. *Climate change 2001: synthesis report*. A Contribution of Working Groups I, II, and III to the Third Assessment Report of the Integovernmental Panel on Climate Change (IPCC) [R.T. Watson & the Core Writing Team, eds.]. Cambridge, UK, and New York, USA, Cambridge University Press.

IPCC. 2003. *Good practice guidance for land use, land-use change and forestry*, edited by J. Penman, M. Gytarsky, T. Hiraishi, T. Krug, D. Kruger, R. Pipatti, L. Buendia, K. Miwa, T. Ngara, K. Tanabe & F. Wagner. Yamaguchi, Japan, Intergovernmental Panel on Climate Change (IPCC) (available at: www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf_files/GPG_LULUCF_FULL.pdf).

ISA. 2016. ISA Dictionary online (available at: www.isa-arbor.com/education/onlineresources/dictionary.aspx). International Society of Arboriculture (ISA). Accessed August 2016.

ISO. 2009. ISO Guide 73:2009 Risk management – Vocabulary. ISO Online Browsing Platform (available at: www.iso.org/obp/ui/#iso:std:iso:guide:73:ed-1:v1:en). International Organization for Standardization (ISO). Accessed August 2016.

IUCN. 2015. *Shaping a sustainable future for Europe*. Brussels, International Union for Conservation of Nature (IUCN) European Regional Office (available at: www.iucn.org/regions/europe/our-work/nature-based-solutions). Accessed August 2016.

Kuchelmeister, G. & Braatz, S. 1993. Urban forestry revisited. *Unasylva*, 173: 3–12.

Kuchelmeister, G. 1998. *Urban forestry in the Asia-Pacific region: status and prospects*. Asia-Pacific Forestry Sector Outlook Study Working Paper Series No. 44. Rome, FAO.

Mathur, V.N., Price, A.D.F., Austin, S. & Moobela, C. 2007. Defining, identifying and mapping stakeholders in the assessment of urban sustainability. *In* M. Horner, C. Hardcastle, A. Price & J. Bebbington, eds. *International conference on whole life urban sustainability and its assessment, Glasgow*. Online paper (available at: www.sue-mot.org/conference-2007/papers). Accessed August 2016.

MEA. 2005. *Ecosystems and human well-being: synthesis*. Millennium Ecosystem Assessment (MEA). Washington, DC, Island Press.

MP4. 2012. Making places profitable European partnership project. Definition of place-keeping. Webpage (available at: www.mp4-interreg.eu/documents/place-keeping-charter). Accessed August 2016.

Muraleedharan, K. 2006. *Participatory development: issues and lessons*. New Dehli, Serials Publications.

Natural England. 2009. Green infrastructure guidance. Webpage (available at: http://publications.naturalengland.org.uk/publication/35033). Accessed August 2016.

OECD. 2006. *DAC guidelines and reference series applying strategic environmental assessment: good practice guidance for development co-operation*. Paris, Organisation for Economic Co-operation and Development (OECD).

Pretty, J.N. 1995. Participatory learning for sustainable agriculture. *World Development*, 23(8): 1247–1263.

Tacconi, L. 2011. Developing environmental governance research: the example of forest cover change studies. *Environmental Conservation*, 38: 234–246.

Tóth, G., Stolbovoy, V. & Montanarella, L. 2007. *Soil quality and sustainability evaluation: an integrated approach to support soil-related policies of the European Union*. Ispra, Italy, European Commission Directorate-General Joint Research Centre.

UNCCD. 1994. *United Nations Convention to Combat Desertification*. Paris, United Nations Convention to Combat Desertification (UNCCD).

UNECE. 1979. *Convention on Long-range Transboundary Air Pollution*. United Nations Economic Commission for Europe (UNECE) (available at: www.unece.org/env/lrtap/lrtap_h1.html).

UN-Habitat. 2003. *The challenge of slums: global report on human settlements 2003*. United Nations Human Settlements Programme (UN-Habitat). London, Earthscan.

UN-Habitat. 2015. *International guidelines on urban and territorial planning*. Nairobi, United Nations Human Settlements Programme (UN-Habitat).

UNICEF. 2012. *The state of the world's children 2012: children in an urban world*. New York, USA, United Nations Children's Fund (UNICEF).

US EPA. 2016a. *Glossary of climate change terms*. United States Environmental Protection Agency (US EPA) (available at: www3.epa.gov/climatechange/glossary.html#content). Accessed August 2016.

US EPA. 2016b. Urban Environmental Program: What is open space/green space? United States Environmental Protection Agency (US EPA). Webpage (available at: www3.epa.gov/region1/eco/uep/openspace.html). Accessed August 2016.

Walker, B., Holling, C.S., Carpenter, S.R. & Kinzig, A. 2004. Resilience, adaptability and transformability in social–ecological systems. *Ecology and Society*, 9(2): 5.

WCED. 1987. *Our common future*. World Commission on Environment and Development (WCED). Oxford, UK, Oxford University Press.

WFS. 1996. *Rome Declaration on World Food Security and World Food Summit Plan of Action*. World Food Summit (WFS). Rome, FAO (available at: ww.fao.org/WFS). Accessed August 2016.

WHO. 1946. Preamble to the Constitution of the World Health Organization as adopted by the International Health Conference, New York, 19–22 June 1946. World Health Organization (WHO).

World Bank. 2016. Urban poverty: an overview. Webpage (available at: http://go.worldbank.org/19N9ZIG9K0. Accessed August 2016.

7 References

Agriculture Victoria. 2003. *Shelterbelts for control of wind erosion.* Note No. LC0422 (available at: http://agriculture.vic.gov.au/agriculture/farm-management/soil-and-water/erosion/shelterbelts-for-control-of-wind-erosion).

Akbari, H., Huang, J., Martien, P., Rainier, L., Rosenfeld, A. & Taha, H. 1988. The impact of summer heat islands on cooling energy consumption and global CO2 concentrations. In *Proceedings of ACEEE 1988 summer study in energy efficiency in buildings*, Volume 5, pp. 11–23. Washington DC, American Council for an Energy-Efficient Economy.

Arbor Day Foundation. 2012. Innovative urban forestry programme and projects (available at: www.arborday.org/shopping/conferences/brochures/pcf/2012/review/presentations/LightningRound2.pdf).

Aronson, M.F., La Sorte, F.A., Nilon, C.H., Katti, M., Goddard, M.A. & Lepczyk, C.A., *et al.* 2014. A global analysis of the impacts of urbanization on bird and plant diversity reveals key anthropogenic drivers. *Proceedings of the Royal Society B*, 281(1780): 20133330.

Awuah, K.G.B., Hammond, F.N., Lamond, J.E. & Booth, C. 2014. Benefits of urban land use planning in Ghana. *Geoforum*, 51, 37–46.

Barillet, C., Joffroy, T. & Longuet, I. Undated. *Cultural heritage and local development: a guide for African local governments*. Paris, Craterre-ENSAG and Convention France-United Nations Educational, Scientific and Cultural Organization (available at: http://whc.unesco.org/document/6856).

Betancur, J.J. 2007. Approaches to the regularization of informal settlements: the case of primed in Medellin, Colombia. *Global Urban Development*, 3(1) (available at: www.globalurban.org/GUDMag07Vol3Iss1/Betancur.htm).

Boyle, C., Gamage, G.B., Burns, B., Fassman-Beck, E., Knight-Lenihan, S., Schwendenmann, L. & Thresher, W. 2014. *Greening cities: a review of green infrastructure*. Auckland, New Zealand, Transforming Cities: Innovations for Sustainable Futures, University of Auckland.

Bucur, V. 2006. *Urban forest acoustics*. Springer Berlin Heidelberg.

Buijs, A., Elands, B., Havik, G., Ambrose-Oji, B., Cvejic, R., Debellis, Y., Davies, C., Delshammar, T., Erlwein, S., Gerőházi, E., Goodness, J., Hansen, R., Fors, H., van der Jagt, A., Luz, A., Mattijssen, T., Nastran, M., Steen Møller, M., Otten, R., Rall, E., Santos, A., Spanò, M., Száraz, L., Tosic, I., Vierikko, K. & Železnikar, S. 2016. *Innovative governance of urban greenspaces.* Collaborative report as part of the European Union FP7 (ENV.2013.6.2-5-603567) GREEN SURGE project (2013–2017). Brussels, European Union.

Buizer, M., Hendriks, R., Kruse, H. & Schenkels, J. 2015. Utrecht, the Netherlands. *In* R. Hansen, M. Buizer, E. Rall, Y. DeBellis, B.H.M. Elands, K.F. Wiersum & A.

Pauleit, eds. *Report of case study city portraits*. Appendix to GREEN SURGE study on urban green infrastructure planning and governance in 20 European case studies. Technical report. Brussels, European Union.

Carinaños, P. & Casares-Porcel, M. 2011. Urban green zones and related pollen allergy: a review. Some guidelines for designing spaces with low allergy impact. *Landscape and Urban Planning*, 101: 205–214 (available at: www.uco.es/rea/publicaciones/andalucia/granada/Urban%20green%20zones-Carinanos_2011.pdf).

City Fruit. Undated. *Annual report 2014* (available at: www.cityfruit.org/sites/default/files/file-uploads/2014_city_fruit_annual_report.pdf).

City of London Corporation. 2010. *Rising to the challenge: the City of London climate change adaptation strategy*. First published May 2007, revised and updated January 2010. London, City of London Corporation (available at: www.cityoflondon.gov.uk/services/environment-and-planning/sustainability/climate-change/Documents/climate-change-adaptation-strategy-2010-update.pdf).

City of Minneapolis. 2004. Urban forest policy (available at: www.minneapolismn.gov/www/groups/public/@cped/documents/webcontent/convert_282934.pdf).

City of Portland. 2005. 2005 *Portland watershed management plan: summary of the framework for integrated management of watershed health*. Portland, USA (available at: www.portlandoregon.gov/bes/article/108290).

City of Salisbury. 2015. Urban Forest Biodiversity Program. Webpage (available at: www.salisbury.sa.gov.au/Live/Environment_and_Sustainability/Sustainability_and_Climate_Change/Biodiversity_and_Open_Space/Urban_Forest_Biodiversity_Program).

City of Vancouver. 2012. Greenest City 2020 Action Plan (available at: http://vancouver.ca/files/cov/Greenest-city-action-plan.pdf).

Clark, J.R., Matheny, N.P., Cross, G. & Wake, V. 1997. A model of urban forest sustainability. *Journal of Arboriculture*, 23(1): 17–30.

Clark, K.H. & Nicholas, K.A. 2013. Introducing urban food forestry: a multifunctional approach to increase food security and provide ecosystem services. *Landscape Ecology*, 28(9): 1649–1669.

Coder, K.D. 1996. *Identified benefits of community trees and forests*. Athens, GA, USA, University of Georgia School of Forest Resources.

Coleman, G., Kontesi, A., Li, X., Masliah, A., Renwick, D., Torà, L. & Vargas, L. 2013. *Building successful public private partnerships in São Paulo's transportation sector*. Columbia University School of International and Public Affairs (available at: www.usp.br/iri/images/anexos/pesq_JoaoCV_Columbia_University-building-successful-ppps-in-sao-paulo.pdf).

Cook, D.I. 1978. Trees, solid barriers, and combinations: alternatives for noise control. *In* G. Hopkins, ed. *Proceedings: national urban forest conference*, pp. 330–339. Syracuse, USA, SUNY College of Environmental Science and Forestry.

Connor, S. 2013. Urban forestry and developing a green economy. Webpage (available at: http://ontheplatform.org.uk/article/urban-forestry-invest-now).

Cornell University. Undated. Participatory development of an urban forestry community engagement model – 2011. Webpage (available at: http://impact.

cals.cornell.edu/project/participatory-development-urban-forestry-community-engagement-model-2011).

Crompton, J.L. 2001. *Parks and economic development*. APA Planning Advisory Service Reports No. 502. , Washington, DC, American Planning Association (APA).

Dadvand, P., Villanueva, C.M., Font-Ribera, L., Martinez, D., Basagana, X., Belmonte, J., *et al.* 2014. Risks and benefits of green spaces for children: a cross-sectional study of associations with sedentary behavior, obesity, asthma, and allergy. *Environmental Health Perspectives*, 122(12): 1329–1335.

Desgroppes, A. & Taupin, S. 2011. Kibera: the biggest slum in Africa? *Les Cahiers de l'Afrique de l'Est*, 44 : 23–34.

Discovery Green. 2016. History of Discovery Green. Webpage (available at: www.discoverygreen.com/history-of-discovery-green).

Donovan, G.H. & Butry, D. 2009. The value of shade: estimating the effect of urban trees on summertime electricity use. *Energy and Buildings*, 41(6): 662–668.

Drayson, K. & Newey, G. 2014. *Green society: policies to improve the UK's urban green spaces*. Policy Exchange Report.

Drigo, R. & Salbitano, F. 2008. *WISDOM for cities: analysis of wood energy and urbanization using WISDOM methodology*. Rome, FAO (available at: ftp://ftp.fao.org/docrep/fao/010/i0152e/i0152e00.pdf).

EKO Asset Management Partners, NatLab, The Nature Conservancy & Natural Resources Defense Council. 2013. *Creating clean water cash flows: developing private markets for green stormwater infrastructure in Philadelphia*. Natural Resources Defense Council (available at: www.nature.org/ourinitiatives/regions/northamerica/unitedstates/pennsylvania/pastormwater-report.pdf).

EPA. 2010. *Green infrastructure case studies: municipal policies for managing stormwater with green infrastructure*. EPA Office of Wetlands, Oceans and Watersheds. Washington, DC, US Environmental Protection Agency (EPA) (available at: www.epa.gov/owow/NPS/lid/gi_case_studies_2010.pdf).

FAO. 2009. *Stratégie de développement et Plan d'action pour la promotion de la foresterie urbaine et périurbaine de la ville de Bangui*. Foresterie urbaine et périurbaine – Document de travail 3. Rome.

FAO. 2012. *Voluntary guidelines on the responsible governance of tenure of land, fisheries and forests in the context of national food security*. Rome.

FAO. 2014. *State of the world's forests 2014*. Rome.

Firewise Communities. 2015. Firewise Communities USA/Recognition Program. Webpage (available at: www.firewise.org/usa-recognition-program.aspx?sso=0).

Frühauf, A., Niedermeier, M., Elliott, L.R., Ledochowski, L., Marksteiner, J. & Kopp, M. 2016. Acute effects of outdoor physical activity on affect and psychological well-being in depressed patients – a preliminary study. *Mental Health and Physical Activity*, 10: 4–9.

Gemeente Arnhem. 2010. Groene Agenda – De kracht van het groen (concept) (available at: http://www.nmfdrenthe.nl/groene-agenda/)

Hartig, T., Evans, G.W., Jamner, L.D., Davis D.S. & Gärling, T. 2003. Tracking restoration in natural and urban field settings. *Journal of Environmental Psychology*, 23: 109–123 (available at: www.sciencedirect.com/science/article/pii/S0272494402001093).

Hay, D. Undated. Reforestation and reclamation of Detroit's vacant land. Presentation at Partners in Community Forestry National Conference.

Hostnik, R. Undated. The context of urban forests and the development of urban forestry in highly forested EU country: the experience of Celje, Slovenia (available at: http://ec.europa.eu/agriculture/fore/events/28-01-2011/hostnik_en.pdf).

Huang, Y.J., Akbari, H., Taha, H. & Rosenfeld, A.H. 1987. The potential of vegetation in reducing summer cooling loads in residential buildings. *Journal of Climate and Applied Meteorology*, 26(9): 1103–1116.

ICLEI. 2015. ICLEI – Local Governments for Sustainability. Webpage (available at: www.iclei.org).

Informal Urban Communities Initiative. 2011. Primary school park. Webpage (available at: http://sqwater.be.washington.edu/wp/primary-school-park).

Johannesburg City Parks and Zoo. 2015. Building an urban forest. Webpage (available at: www.jhbcityparks.com/index.php/tree-planting).

Kaushik. 2014. The cotton tree in Freetown, Sierra Leone. Amusing Planet. Webpage (available at: www.amusingplanet.com/2014/09/the-cotton-tree-in-freetown-sierra-leone.html).

Keniger, L.E., Gaston, K.J., Irvine, K.N. & Fuller, R.A. 2013. What are the benefits of interacting with nature? *International Journal of Environmental Research and Public Health*, 10(3): 913–935.

Kenney, W.A., van Wassenaer, P.J.E. & Satel, A.L. 2011. Criteria and indicators for strategic urban forest planning and management. *Arboriculture & Urban Forestry*, 37(3): 108–117.

Kumasi Metropolitan Assembly. 2014. Tree planting project (available at: http://kma.gov.gh/kma/?mayor-bonsu-launches-tree-planting-project&page=5442).

Kuo, F. & Sullivan, W. 2001. Environment and crime in the inner city: does vegetation reduce crime? *Environment & Behavior*, 33(3): 343–367.

Luchi, N., Vannuccini, M., Panzavolta, T., Tiberi, R., Feducci, M., Salbitano, F., Giachini, M., Zocco Pisana, L. & Capretti, P. 2008. Censimento e indicazioni gestionali contro le avversità delle alberature dell'Opera delle Mura di Lucca. *Forest@*, 5: 253–261 (available at: www.sisef.it/forest@).

Marien, J.N. 2009. Peri-urban forests and wood energy: what are the perspectives for Central Africa? *In* C. de Wasseige *et al.*, eds. *The forests of the Congo Basin: state of the forest 2008*, Chapter 13. Luxembourg, Publications Office of the European Union.

McPherson, G., Simpson, J.R., Peper, P.J., Maco, S.E. & Xiao, Q. 2005. Municipal forest benefits and costs in five US cities. *Journal of Forestry*, 103(8): 411–416.

Metropolitan Area of Barcelona. 2013. Barcelona green infrastructure and biodiversity plan 2020 (available at: http://ajuntament.barcelona.cat/ecologiaurbana/ca).

Millennium Ecosystem Assessment. 2005. *Ecosystems and human well-being: synthesis.* Washington, DC, Island Press.

Miller, R.W., Hauer, R.J. & Werner, L.P. 2015. *Urban forestry: planning and managing urban greenspaces*. Waveland Press.

MillionTreesNYC. 2015. MillonTreesNYC. Webpage (available at: www.milliontreesnyc.org).

Nagre, P. 2013. Advances in cultivation of jamun (*Syzgyium cumini*). Webpage (available at: http://www.academia.edu/4558338/Jamun).

National Recreation and Park Association. 2012. Revitalizing inner city parks: new funding options can address the needs of underserved urban communities (available at http://www.nrpa.org/uploadedFiles/nrpaorg/Grants_and_Partners/Recreation_and_Health/Resources/Issue_Briefs/Urban-Parks.pdf).

National Urban Forest Alliance. 2015. Welcome to the National Urban Forest Alliance. Webpage (available at: www.nufa.com.au).

Nowak, D.J. & Crane, D.E. 2002. Carbon storage and sequestration by urban trees in the USA. *Environmental Pollution*, 116(3): 381–389.

Nowak, D.J., Crane, D.E. & Stevens, J.C. 2006. Air pollution removal by urban trees and shrubs in the United States. *Urban Forestry & Urban Greening*, 4(11): 5–123.

Nowak, D.J., Hirabayashi, S., Bodine, A. & Greenfield, E. 2014. Tree and forest effects on air quality and human health in the United States. *Environmental Pollution*, 193: 119–129.

Parker, J.H. 1983. Landscaping to reduce the energy used in cooling buildings. *Journal of Forestry*, 81(2): 82–105.

Peper, P.J., McPherson, E.G., Simpson, J.R., Gardner, S.L., Vargas, K.E. & Xiao, Q. 2007. *New York municipal forest resource analysis*. US Department of Agriculture Forest Service, Pacific Southwest Research Station and Center for Urban Forest Research.

Rogers, K., Sacre, K., Goodenough, J., & Doick, K. 2015. *Valuing London's urban forest: results of the London i-Tree eco project*. Treeconomics London (available at: www.itreetools.org/resources/reports/Valuing_Londons_Urban_Forest.pdf).

Schure, J., Ingram, V., Marien, J-N., Nasi, R. & Dubiez, E. 2011. *Woodfuel for urban centres in the Democratic Republic of Congo*. Brief No. 7. Bogor, Indonesia, Center for International Forestry Research.

Seattle Department of Neighborhoods. 2016. Beacon Food Forest. Webpage (available at: www.seattle.gov/neighborhoods/programs-and-services/p-patch-community-gardening/p-patch-list/beacon-food-forest).

Seburanga, J.L. & Zhang, Q. 2013. Heritage trees and landscape design in urban areas of Rwanda. *Journal of Forestry Research*, 24(3): 561–570 (available at: http://link.springer.com/article/10.1007%2Fs11676-013-0388-z).

Secretariat of the Convention on Biological Diversity. 2012. *Cities and biodiversity outlook*. Montreal, Canada.

Simson, A.J. 2000. The post-romantic landscape of Telford New Town. *Landscape and Urban Planning*, 52(2–3): 189–197. DOI: 10.1016/S0169-2046(00)00133-X.

Snowden, H. 2006. *Evaluation of the Chopwell Wood Health Project*. Newcastle upon Tyne, UK, Primary Care Development Centre, Northumbria University (available at: www.forestry.gov.uk/pdf/fr0406_chopwell_final.pdf/$FILE/fr0406_chopwell_final.pdf).

Soemarwoto, O. 1987. Homegardens: a traditional agroforestry system with a promising future. In *Agroforestry: a decade of development*, Chapter 10. International Council for Research in Agroforestry.

Sohel, M.S.I., Mukul, S.A. & Burkhard, B. 2014. Landscape's capacities to supply ecosystem services in Bangladesh: a mapping assessment for Lawachara National Park. *Ecosystem Services*, 12: 1–8. DOI: 10.1016/j.ecoser.2014.11.01.

Taylor, M.S., Wheeler, B.W., White, M.P., Economou, T. & Osborne, N.J. 2014. Research note: Urban street tree density and antidepressant prescription rates – a cross-sectional study in London, UK. *Landscape Urban Planning*, 136: 174–179. DOI: 10.1016/j.landurbplan.2014.12.005.

Thaiutsa, B., Puangchit, L., Kjelgren, R. & Arunpraparut, W. 2008. Urban green space, street tree and heritage large tree assessment in Bangkok, Thailand. *Urban Forestry & Urban Greening*, 7(3): 219–229.

Tisdell, C.A. 1985. Conserving and planting trees on farms: lessons from Australian cases. *Review of Marketing and Agricultural Economics*, 53.

Toronto Parks, Forestry and Recreation. 2016. Tree protection policy and specifications for construction near trees (available at: www1.toronto.ca/city_of_toronto/parks_forestry__recreation/urban_forestry/files/pdf/TreeProtSpecs.pdf).

Troy, A., Grove, J.M. & O'Neil-Dunne, J. 2012. The relationship between tree canopy and crime rates across an urban-rural gradient in the greater Baltimore region. *Landscape and Urban Planning*, 106: 262–270 (available at: www.sciencedirect.com/science/article/pii/S0169204612000977).

Tuaño, P.A. & Sescon, J. 2013. The "Alliance of 7": climate change adaptation in the Greater Metro Manila Region. HDN Discussion Paper Series, PHDR issue 2012/2013 No. 13: 1–31.

Uddin, M.N. 2006. The relationship between urban forestry and poverty alleviation: Dhaka as a case study (available at: www.fao.org/uploads/media/The_relationship_between_Urban_forestry_and_poverty_alleviation_Dhaka_case_study.pdf).

Ulrich, R.S. 1984. View through a window may influence recovery from GP practice. *Science*, 224: 420–421 (available at: www.ideal.forestry.ubc.ca/frst524/09_ulrich.pdf).

UNEP. 2008. *City of Curitiba, Brazil BioCity Programme: mainstreaming biodiversity*. Brochure. United Nations Environment Programme (UNEP) (available at: www.unep.org/urban_environment/PDFs/Curitiba_Final.PDF).

UNEP. 2015. Moroccan city defies desertification by harnessing solar power and treated wastewater. UNEP News Centre. United Nations Environment Programme (UNEP) (available at: www.unep.org/NewsCentre/default.aspx?DocumentID=26851&ArticleID=35524&l=en).

UNEP & ICLEI. 2008. *Amsterdam, the Netherlands: conserving biodiversity through careful local and regional planning*. United Nations Environment Programme (UNEP) and Local Governments for Sustainability (ICLEI) (available at: http://cbc.iclei.org/Content/Docs/Case_study_Amsterdam_25_Aug_08_Final_.pdf).

UN-Habitat. 2014. *The State of African Cities 2014*: re-imagining sustainable urban transitions. Nairobi, United Nations Human Settlements Programme (available at:

unhabitat.org/books/state-of-african-cities-2014-re-imagining-sustainable-urban-transitions).

UN-Habitat. 2015. International guidelines on urban and territorial planning. Nairobi (available at: http://unhabitat.org/books/international-guidelines-on-urban-and-territorial-planning/).

Ursic, M., Satel, A. & van Wassenaer, P. Undated. Tools for engaging the community in urban forest stewardship (available at: https://treecanada.ca/files/3113/7043/9207/CUFC_Presentation_Paper_-_MUrsic_FINAL.pdf).

Västra Götalandsregionen. 2015. Gröna Rehab. Webpage (available at: epi.vgregion.se/sv/gronarehab).

Walls, M. 2009. Parks and recreation in the United States Local Park Systems (available at: http://www.rff.org/files/sharepoint/WorkImages/Download/RFF-BCK-ORRG_Local%20Parks.pdf).

Watt, J. & Ball, D.J. 2009. *Trees and the risk of harm*. Report for the National Tree Safety Group. Centre for Decision Analysis and Risk Management, Middlesex University.

WHO. 1998. *Health promotion glossary*. Geneva, Switzerland, World Health Organization (WHO).

Wolf, K. 1998a. *Urban forest values: economic benefits of trees in cities*. Factsheet #29. Seattle, USA, University of Washington.

Wolf, K.L. 1998b. *Trees in business districts: positive effects on consumer behavior!* Fact Sheet #5. Seattle, USA, University of Washington.

Woodland Trust. Webpage (available at: www.woodlandtrust.org.uk).

Xinhua. 2015. Village that moved to protect just 1 tree. China.org.cn (webpage) (available at: http://china.org.cn/china/2015-11/27/content_37175730.htm).

Zainuddin, Z. 2014. Urban backyard food production as a strategy for food security in Melbourne (Australia). Permaculture Research Institute. Webpage (available at: http://permaculturenews.org/2014/02/28/urban-backyard-food-production-strategy-food-security-melbourne-australia/).

Zulauf, W. 1996. Legal, institutional and operation structure of urban green-area systems. Paper presented at Urban Greening Seminar, Mexico City, Mexico, 2–4 December 1996.

© FAO/SIMONE BORELLI

8 Further reading

INTRODUCTION/GENERAL

Carreiro, M.M., Song, Y.C. & Wu, J., eds. 2008. *Ecology, planning, and management of urban forests*. New York, USA, Springer.

FAO. 1993. Special issue: urban and peri-urban forestry. *Unasylva*, 44(173).

FAO. 1995. *An annotated bibliography of urban forestry in developing countries.* FO:MISC/94/12. Rome.

FAO. 1999. *Urban and peri-urban forestry: case studies in developing countries.* Rome.

Fuwape, J.A. & Onyekwelu, J.C. 2011. Urban forest development in West Africa: benefits and challenges. *Journal of Biodiversity and Ecological Sciences*, 1(1): 77–94 (available at: www.jbes.ir/doc/2011-v1-i1/2011-V1-I1-7.pdf).

Grey, G.W. & Deneke, F.J. 1986. *Urban forestry*. New York, USA, John Wiley and Sons.

Konijnendijk, C.C. & Gauthier, M. 2006. Urban forestry for multifunctional urban land use. *In* R. van Veenhuizen, ed. *Cities farming for the future, urban agriculture for green and productive cities*, pp. 411–442. RUAF Foundation, International Development Research Centre and International Institute of Rural Reconstruction.

Konijnendijk, C.C., Nilsson, K., Randrup, Th.B. & Schipperijn, J., eds. 2005. *Urban forests and trees: a reference book*. Berlin, Germany, Springer.

Kuchelmeister, G. & Braatz, S. 1993. Urban forestry revisited. *Unasylva*, 173(44): 3–12.

Kuchelmeister, G. 1998. *Urban forestry in the Asia-Pacific region: status and prospects*. APFSOS Working Paper No. 44. Rome, FAO.

Miller, R.W. 1997. *Urban forestry: planning and managing urban greenspaces*. Second edition. New Jersey, USA, Prentice Hall.

Murray, S. 1997. *Urban and peri-urban forestry in Quito, Ecuador: a case study*. Rome, FAO.

Nilsson, K. & Konijnendijk, C.C. 2002. *COST Action E12 urban forests and trees.* Final report. Brussels, COST.

Nilsson, K., Gauthier, M., Rodbell, P. & Escobedo, F. 2009. *Urban and peri-urban forestry as a vehicle for healthy and sustainable development*. Position paper. 13th World Forestry Congress, Argentina.

Salbitano, F., Borelli, S. & Sanesi, G. 2015. Urban forestry and agroforestry. *In* H. De Zeeuw, ed. *Cities, food and agriculture: towards resilient urban food systems. A state of the art*, Chapter 11. Oxford, UK, Routledge Earthscan.

Singh, V.S., Pandey, D.N. & Chaudhry, P. 2010. *Urban forests and open green spaces: lessons for Jaipur, Rajasthan, India*. RSPCB Occasional Paper. Jaipur, India, Rajasthan State pollution Control Board (RSPCB).

United Nations. 2015. *Transforming our world: the 2030 Agenda for Sustainable Development*. A/RES/70/1.

ENABLING ENVIRONMENT

Governance

Abbott, J. 2012. *Green infrastructure for sustainable urban development in Africa*. Abingdon, UK, Earthscan.

Åkerlund, U. 2006. *Urban and peri-urban forestry and greening in west and Central Asia: experiences, constraints and prospects*. Livelihood Support Programme Working Paper No. 36. Rome, FAO.

Benedict, M.A. & McMahon, E.T. 2006. *Green infrastructure: linking landscapes and communities*. Island Press.

Conigliaro, M., Borelli, S. & Salbitano, F. 2014. Urban and peri-urban forestry as a valuable strategy towards African urban sustainable development. *Nature & Faune*, 28(2): 21–26.

Dobbs, C., Escobedo, F.J. & Zipperer, W.C. 2011. A framework for developing urban forest ecosystem services and goods indicators. *Landscape and Urban Planning*, 99: 196–206.

Dobbs, C., Kendal, D. & Nitschke, C.R. 2014. Multiple ecosystem services and disservices of the urban forest establishing their connections with landscape structure and sociodemographics. *Ecological Indicators*, 43: 44–55.

FAO. 2012. Proposition de fiches-projets prioritaires pour la phase 1 de la stratégie de foresterie urbaine et périurbaine de la ville de N'Djaména, Tchad. Appui à la formulation d'une stratégie nationale et d'un plan d'action de foresterie urbaine et périurbaine à N'Djaména, République du Tchad. Document de travail. Rome.

FAO. 2012. *Synthèse des études thématiques sur la foresterie urbaine et périurbaine de N'Djaména, Tchad*. Foresterie urbaine et périurbaine. Document de travail 7. Rome, FAO.

FAO. 2012. *Etude sur la foresterie urbaine et périurbaine de N'Djaména, Tchad. Rôle et place de l'arbre en milieu urbain et périurbain*. Foresterie urbaine et périurbaine. Document de travail 6. Rome, FAO.

Haut Commissaire aux Eaux et Forêts et à la Lutte Contre la Désertification. 2010. *Guide des forêts urbaines et périurbaines*. Conception & impression.

Konijnendijk, C.C., Sadio, S., Randrup, T.B. & Schipperijn, J. 2004. Urban and peri-urban forestry in a development context: strategy and implementation. *Journal of Arboriculture*, 30: 269–275.

Lawrence, A., De Vreese, R., Johnston, M., Konijnendijk, C.C. & Sanesi, G. 2013. Urban forest governance: towards a framework for comparing approaches. *Urban Forestry & Urban Greening*, 12(4): 464–473.

Nielsen, A.B., Konijnendijk, C.C., Wiström, B. & Jensen, R.B. 2013. Municipal woodland in Denmark: resources, governance and management. *Scandinavian Journal of Forest Research*, 28(1): 49–63.

Policy

Besse, F., Conigliaro, M., Fages, B., Gauthier, M., Mille, G., Salbitano, F. & Sanesi, G. 2014. Montpellier, green city. *Unasylva*, 65(242): 23–28.

Borelli, S., Chen, Y., Conigliaro, M. & Salbitano, F. 2015. *Green infrastructure: a new paradigm for developing cities*. Technical paper at the XIV World Forestry Congress, Durban, South Africa, 7–11 September 2015. DOI: 10.13140/RG.2.1.1689.8320.

Carter, E.J. 1994. *The potential of urban forestry in developing countries: a concept paper*. Rome, FAO.

FAO. 2005. *Legal and institutional aspects of urban, peri-urban forestry and greening*. Working Paper Legislative Study. Rome.

Sandberg, L.A., Bardekjian, A. & Butt, S., eds. 2014. *Urban forests, trees and greenspace: a political ecology perspective*, pp. 35–46. Oxford, UK and New York, USA, Routledge.

Planning, design and management

Awuah, K.G.B., Hammond, F.N., Lamond, J.E. & Booth, C. Benefits of urban land use planning in Ghana. *Geoforum*, 51: 37–46.

Bucur, V. 2006. *Urban forest acoustics*. Heidelberg, Germany, Springer.

Campbell, P., James, S. & Edwards, C. 2011. *The canopy: London's urban forest: a guide for designers, planners and developers*. Trees & Design Action Group, Design of London, Mayor of London (available at: www.tdag.org.uk/the-canopy.html).

Corona, P., Agrimi, M., Baffetta, F., Barbati, A., Chiriacò, M.V., Fattorini, L., Pompei, E., Valentini, R. & Mattioli, W. 2011. Extending large-scale forest inventories to assess urban forests. *Environmental Monitoring and Assessment*, 184(3): 1409–1422.

de Foresta, H., Somarriba, E., Temu, A., Boulanger, D., Feuilly, H. & Gauthier, M. 2013. *Towards the assessment of trees outside forests*. Resources Assessment Working Paper No. 183. Rome, FAO.

FAO. 2009. *Stratégie de développement et Plan d'action pour la promotion de la foresterie urbaine et périurbaine de la ville de Bangui*. Foresterie urbaine et périurbaine. Document de travail 3. Rome, FAO.

FAO. 2012. *Stratégie de développement et plan d'action pour la promotion de la foresterie urbaine et périurbaine de la ville de N'Djaména, Tchad*. Foresterie urbaine et périurbaine. Document de travail 5. Rome, FAO.

Ferrini, F. & Fini, A. 2011. Sustainable management techniques for trees in the urban areas. *Journal of Biodiversity and Ecological Sciences*, 1(1): 1–20.

Gopal, D. & Nagendra Manthey, M. 2015. Vegetation in Bangalore's slums: composition, species distribution, density, diversity, and history. *Environmental Management*, 55(6): 1390–1401.

Gunderson, V., Frivold, L.H., Myking, T. & Øyen, B-H. 2006. Management of urban recreational woodlands: the case of Norway. *Urban Forestry & Urban Greening*, 5: 73–82.

Lafortezza, R., Davies, C., Sanesi, G. & Konijnendijk, C.C. 2013. Green infrastructure as a tool to support spatial planning in European urban regions. *iForest*, 6:102–108.

Li, J. & Yang, T., eds. 2016. *China's eco-city construction*. Springer.

McGee, J.A., Day, S.D., Wynne, R.H. & White, M.B. 2012. Using geospatial tools to assess the urban tree canopy: decision support for local governments. *Journal of Forestry*, 110(5): 275–286.

Mell, I.C. 2010. *Green infrastructure: concepts, perceptions and its use in spatial planning*. School of Architecture, Planning and Landscape, Newcastle University (doctoral dissertation).

Nagendra, H. & Gopal, D. 2010. Street trees in Bangalore: density, diversity, composition and distribution. *Urban Forestry & Urban Greening*, 9(2): 129–137.

Randrup, T.B. & Persson, B. 2009. Public green spaces in the Nordic countries: development of a new strategic management regime. *Urban Forestry & Urban Greening*, 8(1): 31–40.

Randrup, T.B. 2006. Editorial: Integrated green-space planning and management. *Urban Forestry & Urban Greening*, 4: 91.

Schwab, J.A., ed. 2009. *Planning the urban forest: ecology, economy, and community development*. Chicago, USA, American Planning Association.

Wang, X.-J. 2009. Analysis of problems in urban green space system planning in China. *Journal of Forestry Research*, 20(1): 79–82.

Zetter, R. & Watson, G.B., eds. 2006. *Designing sustainable cities in the developing world*. Berlin, Germany, Routledge.

ISSUES

Human health and well-being

Carrus, G., Scopelliti, M., La Fortezza, R., Colangelo, G., Ferrini, F., Salbitano, F., Agrimi, M.G., Portoghesi, L., Semenzato, P. & Sanesi, G. 2015. Go greener, feel better? The positive effects of biodiversity on the well-being of individuals visiting urban and peri-urban green areas. *Landscape and Urban Planning*, 134: 221–228.

De Vries, S., Classen, T., Eigenheer-Hug, S., Korpela, K., Maas, J., Mitchell, R. & Schantz, P. 2011. Contributions of natural environments to physical activity: theory and evidence base. *In* K. Nillson, M. Sangster, C. Gallis, T. Hartig, S. de Vries, K. Seeland & J. Schipperijn, eds., *Forests, trees and human health*, pp. 205–244. Berlin, Germany, Springer.

Escobedo, F.J. & Nowak, D.J. 2009. Spatial heterogeneity and air pollution removal by an urban forest. *Landscape and Urban Planning*, 90(3–4): 102–110.

Escobedo, F.J., Kroeger, T. & Wagner, J.E. 2011. Urban forests and pollution mitigation: analyzing ecosystem services and disservices. *Environmental Pollution*, 159: 2078–2087.

Guite, H.F., Clark, C. & Ackrill, G. 2006. The impact of the physical and urban environment on mental well-being. *Public Health*, 120: 1117–1126.

Hillsdon, M., Jones, A. & Coombes, E. 2011. *Green space access, green space use, physical activity and overweight*. Natural England Commissioned Reports, Number 067.

Lafortezza, R., Carrus, G., Sanesi, G. & Davies, C. 2009. Benefits and well-being perceived by people visiting green spaces in periods of heat stress. *Urban Forestry & Urban Greening*, 8: 97–108.

Louv, R. 2005. *Last child in the woods: saving our children from nature deficit disorder*.

Chapel Hill, USA, Algonquin Books.
Tzoulas, K., Korpela, K., Venn, S., Yli-Pelkonen, V., Ka´zmierczak, A., Niemela, J. & James, P. 2007. Promoting ecosystem and human health in urban areas using green infrastructure: a literature review. *Landscape and Urban Planning*, 81: 167–178.
Zupancic, T., Westmacott, C. & Bulthuis, M. 2015. *The impact of green space on heat and air pollution in urban communities: a meta-narrative systematic review*. Vancouver, Canada, David Suzuki Foundation.

Climate change

Bowler., Buyung-Ali, L., Knight, T.M. & Pullin, A.S. 2010. Urban greening to cool towns and cities: a systematic review of the empirical evidence. *Landscape and Urban Planning*, 97: 147–155.
Bussotti, F., Pollastrini, M., Killi, D., Ferrini, F. & Fini, A. 2014. Ecophysiology of urban trees in a perspective of climate change. *Agrochimica*, July–September: 247–268.
Cullington, J. & Gye, J. 2010. *Urban forests: a climate adaptation guide*. British Columbia, Canada, Ministry of Community, Sport and Cultural Development (available at: www.retooling.ca/_Library/docs/Urban_Forests_Guide.pdf).
Escobedo, F.J., Varela, S., Zhao, M., Wagner, J.E. & Zipperer, W. 2010. Analyzing the efficacy of subtropical urban forests in offsetting carbon emissions from cities. *Environmental Science and Policy*, 13: 362–372.
Gill, S.E., Handley, J.F., Ennos, A.R. & Pauleit, S. 2007. Adapting cities for climate change: the role of green infrastructure. *Climate Change and Cities*, 33(1): 115–133.
IPCC. 2014. *Climate change 2014: mitigation of climate change*. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [O. Edenhofer, R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K.Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlömer, C. von Stechow, T. Zwickel and J.C. Minx, eds.]. Cambridge, UK, and New York, USA, Cambridge University Press.
McPherson, E.G. & Simpson, J.R. 1999. *Carbon dioxide reductions through urban forestry: guidelines for professional and volunteer tree planters*. General Technical Report PSW-171. Albany, USA, USDA Forest Service, Pacific Southwest Research Station.
McPherson, E.G., Nowak, D., Heisler, G., Grimmond, S., Souch, C., Grant, R. & Rowntree, R. 1997. Quantifying urban forest structure, function, and value: the Chicago urban forest climate project. *Urban Ecosystems*, 1: 49–61.
Ruth, M. & Coelho, D. 2007. Understanding and managing the complexity of urban systems under climate change. *Climate Policy*, 7: 317–336.
Tuaño, P.A. & Sescon, J. 2013. The "Alliance of 7": climate change adaptation in the greater metro Manila region. HDN Discussion Paper Series, PHDR ISSUE 2012/2013 No. 13 (available at: http://hdn.org.ph/wp-content/uploads/DP_13_Tuano_Sescon.pdf).

Biodiversity and landscapes

Elmendorf, W. 2008. The importance of trees and nature in community: a review of the relative literature. *Arboriculture & Urban Forestry*, 34(3): 152–156.

Elmqvist, Th., Fragkias, M., Goodness, J., Güneralp, B., Marcotullio, P.J., McDonald, R.I., Parnell, S., Schewenius, M., Sendstad, M., Seto, K.C. & Wilkinson, C., eds. 2013. *Urbanization, biodiversity and ecosystem services: challenges and opportunities. A global assessment*. Springer.

Lundholm, J.T. & Marlin, A. 2006. Habitat origins and microhabitat preferences of urban plant species. *Urban Ecosystems*, 9: 139–159.

Sandström, U.G. 2008. *Biodiversity and green infrastructure in urban landscapes: the importance of urban green spaces*. Saarbrüken, Germany, VDM Verlag.

Economic benefits and green economy

CABE Space. 2006. *Does money grow on trees?* London, CABE Space.

Del Saz Salazar, S. & García Menéndez, L. 2007. Estimating the non-market benefits of an urban park: does proximity matter? *Land Use Policy*, 24(1): 296–305.

Escobedo, F.J., Wagner, J.E., Nowak, D.J., De la Maza, C.L., Rodriguez, M. & Crane, D.E. 2008. Analyzing the cost effectiveness of Santiago, Chile's policy of using urban forests to improve air quality. *Journal of Environmental Management*, 86: 148–157.

Gopal, D. & Nagendra, H. 2014. Vegetation in Bangalore's slums: boosting livelihoods, well-being and social capital. *Sustainability*, 6(5): 2459–2473.

Harnik, P. & Welle, B. 2009. *Measuring the economic value of a city park system*. Chicago, USA, The Trust for Public Land.

Jim, C.Y. & Chen, W.Y. 2009. Ecosystem services and valuation of urban forests in China. *Cities*, 26(4): 187–194.

Konijnendijk, C.C., Annerstedt, M., Maruthaveeran, S. & Nielsen, A.B. 2013. *Benefits of urban parks: systematic review of the evidence*. A report for International Federation of Parks and Recreation Administration. Copenhagen and Alnarp, University of Copenhagen and Swedish University of Agricultural Sciences (available at: www.ifpra.org/images/park-benefits.pdf).

Rogers, K., Sacre, K., Goodenough, J. & Doic, K. 2015. *Valuing London's urban forest results of the London i-Tree Eco Project*. London, Treeconomics.

Risk management

Dunster, J.S., Smiley, E.T., Matheny, N. & Lilly, S. 2013. *Tree risk assessment manual*. Champaign, USA, International Society of Arboriculture.

Yang, J., McBride, J., Zhou, J. & Sun, Z. 2005. The urban forest in Beijing and its role in air pollution reduction. *Urban Forestry & Urban Greening*, 3: 65–78.

Land and soil degradation

Kuchelmeister, G. 1997. Urban trees in arid landscapes: multipurpose urban forestry for local needs in developing countries. *Arid Lands Newsletter*, 42 (available at: ww.cals.arizona.edu/OALS/ALN/aln42/kuchelmeister.html).

Nowak, D.J. & Greenfield, E.J. 2012. Tree and impervious cover change in US cities. *Urban Forestry & Urban Greening*, 11: 21–30.

Scalenghe, R. & Marsan, F.A. 2009. The anthropogenic sealing of soils in urban areas. *Landscape and Urban Planning*, 90 (1–2): 1–10.

Water and watersheds

Arnbjerg-Nielsen, K. & Fleischer, H.S. 2009. Feasible adaptation strategies for increased risk of flooding in cities due to climate change. *Water Science and Technology*, 60(2): 273–281.

Berthier, E., Dupont, S., Mestayer, P.G. & Andrieu, H. 2006. Comparison of two evapotranspiration schemes on a sub-urban site. *Journal of Hydrology*, 328: 635–646.

Cappiella, K., Schueler, T. & Wright, T. 2005. *Urban watershed forestry manual*. Part 1: Methods for increasing forest cover in a watershed. United States Department of Agriculture.

Cappiella, K., Schueler, T. & Wright, T. 2006. *Urban watershed forestry manual*. Part 2: Conserving and planting trees at development sites. United States Department of Agriculture.

Cappiella, K., Schueler, T. & Wright, T. 2006. *Urban watershed forestry manual*. Part 3: Urban tree planting guide. United States Department of Agriculture.

Marchand, M. & TrinhThi Long, S. 2012. *Adaptive water management for delta regions: towards GREEN water defense in East Asia*. World Bank.

Food and nutrition security

Konijnendijk, C. & Gauthier, M. 2006. Urban forestry for multifunctional land use. *In* R. van Veenhuizen, ed. *Cities farming for the future: urban agriculture for green and productive cities*. Ottawa, International Development Research Centre.

Kyle, H.C. & Kimberly, A.N. 2013. Introducing urban food forestry: a multifunctional approach to increase food security and provide ecosystem services. *Landscape Ecology*, 28:1649–1669.

Wood security

Abd'razack, N.T.A. & Nazir bin, M.A. 2013. Wood fuel consumption and ecological footprint of African cities. *International Journal of Education and Research*, 1(2): 129–146.

Drigo, R. & Salbitano, F. 2008. *WISDOM for cities: analysis of wood energy and urbanization using WISDOM methodology*. Rome, FAO.

FAO. 2010. *Foresterie urbaine et périurbaine en Afrique. Quelles perspectives pour le bois- énergie?* Foresterie urbaine et périurbaine. Document de travail 4. Rome.

FAO. 2012. *Plateforme WISDOM pour N'Djaména, Tchad. Diagnostic et cartographie de l'offre et de la demande en combustible ligneux*. Foresterie urbaine et périurbaine. Document de travail 8. Rome.

FAO. 2012. *Urban and peri-urban forestry in Africa: the outlook for woodfuel*. Urban and Peri-urban Forestry Working Paper No. 4. Rome.

Schure, J., Ingram, V., Marien, J-N., Nasi, R. & Dubiez, E. 2011. *Woodfuel for urban*

centres in the Democratic Republic of Congo. CIFOR Brief No. 7. Bogor, Indonesia, Center for International Forestry Research (CIFOR).

Sociocultural values

Ernstson, H., Sarlin, S. & Elmqvist, T. 2008. Social movements and ecosystem services: the role of social network structure in protecting and managing urban green areas in Stockholm. *Ecology and Society*, 13: 27.

Escobedo, F.J., Clerici, N., Staudhammer, C.L. & Corzo, G.T. 2015. Socio-ecological dynamics and inequality in Bogotá, Colombia's public urban forests and their ecosystem services. *Urban Forestry & Urban Greening*, 14(4): 1040–1053.

Konijnendijk, C.C. 2008. *The forest & the city: the cultural landscape of urban woodland*. Berlin, Germany, Springer.

Seeland, K., Dübendorfer, S. & Hansmann, R. 2009. Making friends in Zurich's urban forests and parks: the role of public green space for social inclusion of youths from different cultures. *Forest Policy and Economics*, 11: 10–17.

SUPPORTING THE PROCESS

Communication and awareness-raising

FAO. 2009. *Trees connecting people: in action together*. Meeting proceedings, Bogotá, Colombia, 29 July to 1 August 2008. Urban and Peri-urban Forestry Working Paper No. 1. Rome.

FAO. 2014. *Developing guidelines for decision and policy makers: optimizing trees and forests for healthy cities*. Meeting proceedings, New Delhi, India, 7 March 2012. Urban and Peri-urban Forestry Working Paper No. 10. Rome.

FAO. 2014. *Trees connecting people in action together: developing guidelines for decision and policy makers: trees and forests for healthy cities*. Glasgow, UK, 30–31 May 2011. Urban and Peri-urban Forestry Working Paper No. 9. Rome.

Gulsrud, N.M., Gooding, S. & Konijnendijk, C.C. 2013. Green space branding in Denmark in an era of neoliberal governance. *Urban Forestry & Urban Greening*, 12(3): 330–337.

ICLEI. 2006. *Talking trees: an urban forestry toolkit for local governments*. Local Governments for Sustainability (ICLEI) (available at: www.milliontreesnyc.org/downloads/pdf/talking_trees_urban_forestry_toolkit.pdf).

O'Brien, L. & Murray, R. 2007. Forest school and its impacts on young children: case studies in Britain. *Urban Forestry & Urban Greening*, 6: 249–265.

O'Brien, L., Townsend, M. & Ebden, M. 2010. "Doing something positive": volunteers' experiences of the well-being benefits derived from practical conservation activities in nature. *Voluntas*, 21: 525–545.

Community engagement

Abd-Elrahman, A.H., Thornhill, M.E., Andreu, M.G. & Escobedo, F. 2010. A

community-based urban forest inventory using online mapping services and consumer-grade digital images. *International Journal of Applied Earth Observation and Geoinformation*, 12(4): 249–260.

Kothari, A. & Rao, S. 1997. How are we managing? Saving Delhi's natural ecosystems: a model of citizen participation. *Ecosystem Health*, 3(2): 124–126.

Lamichhane, D. & Thapa, H.B. 2012. Participatory urban forestry in Nepal: gaps and ways forward. *Urban Forestry & Urban Greening*, 11: 105–111.

Lawrence, A. 2006. "No personal motive?" Volunteers, biodiversity and the false dichotomies of participation. *Ethics, Place and Environment*, 9: 279–298.

Qureshi, S., Breuste, J.H. & Jim, C.Y. 2013. Differential community and the perception of urban green spaces and their contents in the megacity of Karachi, Pakistan. *Urban Ecosystems*, 16: 853–870.

Scopelliti, M., Carrus, G., Adinolfi, C., Suarez, G., Colangelo, G., Lafortezza, R., Panno, A. & Sanesi, G. 2016. Staying in touch with nature and well-being in different income groups: the experience of urban parks in Bogotá. *Landscape and Urban Planning*, 148: 139–148.

Townsend, M. 2006. Feel blue? Touch green! Participation in forest/woodland management as a treatment for depression. *Urban Forestry & Urban Greening*, 5: 111–120.

Van Herzele, A., Collins, K. & Heyens, V. 2005. *Interacting with greenspace: public participation with professionals in the planning and management of parks and woodlands*. Brussels, Ministerie van de Vlaamse Gemeenschap, afdeling Bos & Groen.

Van Herzele, A., De Clercq, E.M. & Wiedemann, T. 2005. Strategic planning for new woodlands in the urban periphery: through the lens of social inclusiveness. *Urban Forestry & Urban Greening*, 3: 177–188.

Alliances and partnerships

McPherson, E.G., Simpson, J.R., Xiao, Q. & Wu, C. 2010. Million trees Los Angeles canopy cover and benefit assessment. *Landscape and Urban Planning*, 99(1): 40–50.

Research needs and perspectives

Alonzo, M., Bookhagen, B. & Roberts, D.A. 2014. Urban tree species mapping using hyperspectral and lidar data fusion. *Remote Sensing of Environment*, 148: 70–83.

Bentsen, P., Lindholst, A.C. & Konijnendijk, C.C. 2010. Reviewing eight years of *urban forestry & urban greening*: taking stock, looking ahead. *Urban Forestry & Urban Greening*, 9: 273–280.

He, C., Convertino, M., Feng, Z. & Zhang, S. 2013. Using LiDAR data to measure the 3D green biomass of Beijing urban forest in China. *PLoS ONE*, 8(10): e75920.

MacFaden, S.W., O'Neil-Dunne, J.P., Royar, A.R., Lu, J.W. & Rundle, A.G. 2012. High resolution tree canopy mapping for New York City using LIDAR and object-based image analysis. *Journal of Applied Remote Sensing*, 6(1).

Nilsson, K., Nielsen, T.S. & Pauleit, S. 2009. Integrated European research on

sustainable urban development and peri-urban land use relationships. *Urbanistica*, 138: 106.

Nowak, D.J., Crane, D., Stevens, J., Hoehn, R., Walton, J. & Bond, J. 2008. A ground-based method of assessing urban forest structure and ecosystem services. *Arboriculture & Urban Forestry*, 34(6): 347–358.

Zhang, C & Qiu, F. 2012. Mapping individual tree species in an urban forest using airborne lidar data and hyperspectral imagery. *Photogrammetric Engineering & Remote Sensing*, 78(10): 1079–1087.

FAO FORESTRY PAPERS

1 Forest utilization contracts on public land, 1977 (E F S)
2 Planning forest roads and harvesting systems, 1977 (E F S)
3 World list of forestry schools, 1977 (E F S)
3 Rev.1 World list of forestry schools, 1981 (E F S)
3 Rev.2 World list of forestry schools, 1986 (E F S)
4/1 World pulp and paper demand, supply and trade – Vol. 1, 1977 (E F S)
4/2 World pulp and paper demand, supply and trade – Vol. 2, 1977 (E F S)
5 The marketing of tropical wood in South America, 1976 (E S)
6 National parks planning, 1976 (E F S)
7 Forestry for local community development, 1978 (Ar E F S)
8 Establishment techniques for forest plantations, 1978 (Ar C E* F S)
9 Wood chips – production, handling, transport, 1976 (C E S)
10/1 Assessment of logging costs from forest inventories in the tropics – 1. Principles and methodology, 1978 (E F S)
10/2 Assessment of logging costs from forest inventories in the tropics – 2. Data collection and calculations, 1978 (E F S)
11 Savanna afforestation in Africa, 1977 (E F)
12 China: forestry support for agriculture, 1978 (E)
13 Forest products prices 1960–1977, 1979 (E F S)
14 Mountain forest roads and harvesting, 1979 (E)
14 Rev.1 Logging and transport in steep terrain, 1985 (E)
15 AGRIS forestry – world catalogue of information and documentation services, 1979 (E F S)
16 China: integrated wood processing industries, 1979 (E F S)
17 Economic analysis of forestry projects, 1979 (E F S)
17 Sup.1 Economic analysis of forestry projects: case studies, 1979 (E S)
17 Sup.2 Economic analysis of forestry projects: readings, 1980 (C E)
18 Forest products prices 1960–1978, 1980 (E F S)
19/1 Pulping and paper-making properties of fast-growing plantation wood species – Vol. 1, 1980 (E)
19/2 Pulping and paper-making properties of fast-growing plantation wood species – Vol. 2, 1980 (E)
20 Forest tree improvement, 1985 (C E F S)
20/2 A guide to forest seed handling, 1985 (E S)
21 Impact on soils of fast-growing species in lowland humid tropics, 1980 (E F S)
22/1 Forest volume estimation and yield prediction – Vol. 1. Volume estimation, 1980 (C E F S)
22/2 Forest volume estimation and yield prediction – Vol. 2. Yield prediction, 1980 (C E F S)
23 Forest products prices 1961–1980, 1981 (E F S)
24 Cable logging systems, 1981 (C E)
25 Public forestry administrations in Latin America, 1981 (E)
26 Forestry and rural development, 1981 (E F S)
27 Manual of forest inventory, 1981 (E F)
28 Small and medium sawmills in developing countries, 1981 (E S)

29 World forest products, demand and supply 1990 and 2000, 1982 (E F S)
30 Tropical forest resources, 1982 (E F S)
31 Appropriate technology in forestry, 1982 (E)
32 Classification and definitions of forest products, 1982 (Ar E F S)
33 Logging of mountain forests, 1982 (E F S)
34 Fruit-bearing forest trees, 1982 (E F S)
35 Forestry in China, 1982 (C E)
36 Basic technology in forest operations, 1982 (E F S)
37 Conservation and development of tropical forest resources, 1982 (E F S)
38 Forest products prices 1962–1981, 1982 (E F S)
39 Frame saw manual, 1982 (E)
40 Circular saw manual, 1983 (E)
41 Simple technologies for charcoal making, 1983 (E F S)
42 Fuelwood supplies in the developing countries, 1983 (Ar E F S)
43 Forest revenue systems in developing countries, 1983 (E F S)
44/1 Food and fruit-bearing forest species – 1. Examples from eastern Africa, 1983 (E F S)
44/2 Food and fruit-bearing forest species – 2. Examples from southeastern Asia, 1984 (E F S)
44/3 Food and fruit-bearing forest species – 3. Examples from Latin America, 1986 (E S)
45 Establishing pulp and paper mills, 1983 (E)
46 Forest products prices 1963–1982, 1983 (E F S)
47 Technical forestry education – design and implementation, 1984 (E F S)
48 Land evaluation for forestry, 1984 (C E F S)
49 Wood extraction with oxen and agricultural tractors, 1986 (E F S)
50 Changes in shifting cultivation in Africa, 1984 (E F)
50/1 Changes in shifting cultivation in Africa – seven case-studies, 1985 (E)
51/1 Studies on the volume and yield of tropical forest stands – 1. Dry forest formations, 1989 (E F)
52/1 Cost estimating in sawmilling industries: guidelines, 1984 (E)
52/2 Field manual on cost estimation in sawmilling industries, 1985 (E)
53 Intensive multiple-use forest management in Kerala, 1984 (E F S)
54 Planificación del desarrollo forestal, 1984 (S)
55 Intensive multiple-use forest management in the tropics, 1985 (E F S)
56 Breeding poplars for disease resistance, 1985 (E)
57 Coconut wood – Processing and use, 1985 (E S)
58 Sawdoctoring manual, 1985 (E S)
59 The ecological effects of eucalyptus, 1985 (C E F S)
60 Monitoring and evaluation of participatory forestry projects, 1985 (E F S)
61 Forest products prices 1965–1984, 1985 (E F S)
62 World list of institutions engaged in forestry and forest products research, 1985 (E F S)
63 Industrial charcoal making, 1985 (E)
64 Tree growing by rural people, 1985 (Ar E F S)
65 Forest legislation in selected African countries, 1986 (E F)

66 Forestry extension organization, 1986 (C E S)
67 Some medicinal forest plants of Africa and Latin America, 1986 (E)
68 Appropriate forest industries, 1986 (E)
69 Management of forest industries, 1986 (E)
70 Wildland fire management terminology, 1986 (E F S)
71 World compendium of forestry and forest products research institutions, 1986 (E F S)
72 Wood gas as engine fuel, 1986 (E S)
73 Forest products: world outlook projections 1985–2000, 1986 (E F S)
74 Guidelines for forestry information processing, 1986 (E)
75 Monitoring and evaluation of social forestry in India – an operational guide, 1986 (E)
76 Wood preservation manual, 1986 (E)
77 Databook on endangered tree and shrub species and provenances, 1986 (E)
78 Appropriate wood harvesting in plantation forests, 1987 (E)
79 Small-scale forest-based processing enterprises, 1987 (E F S)
80 Forestry extension methods, 1987 (E)
81 Guidelines for forest policy formulation, 1987 (C E)
82 Forest products prices 1967–1986, 1988 (E F S)
83 Trade in forest products: a study of the barriers faced by the developing countries, 1988 (E)
84 Forest products: World outlook projections – Product and country tables 1987–2000, 1988 (E F S)
85 Forestry extension curricula, 1988 (E F S)
86 Forestry policies in Europe, 1988 (E)
87 Small-scale harvesting operations of wood and non-wood forest products involving rural people, 1988 (E F S)
88 Management of tropical moist forests in Africa, 1989 (E F P)
89 Review of forest management systems of tropical Asia, 1989 (E)
90 Forestry and food security, 1989 (Ar E S)
91 Design manual on basic wood harvesting technology, 1989 (E F S) (Published only as FAO Training Series, No. 18)
92 Forestry policies in Europe – An analysis, 1989 (E)
93 Energy conservation in the mechanical forest industries, 1990 (E S)
94 Manual on sawmill operational maintenance,1990 (E)
95 Forest products prices 1969–1988, 1990 (E F S)
96 Planning and managing forestry research: guidelines for managers, 1990 (E)
97 Non-wood forest products: the way ahead, 1991 (E S)
98 Timber plantations in the humid tropics of Africa, 1993 (E F)
99 Cost control in forest harvesting and road construction, 1992 (E)
100 Introduction to ergonomics in forestry in developing countries, 1992 (E F I)
101 Management and conservation of closed forests in tropical America, 1993 (E F P S)
102 Research management in forestry, 1992 (E F S)
103 Mixed and pure forest plantations in the tropics and

subtropics, 1992 (E F S)

104 Forest products prices 1971–1990, 1992 (E F S)

105 Compendium of pulp and paper training and research institutions, 1992 (E)

106 Economic assessment of forestry project impacts, 1992 (E F)

107 Conservation of genetic resources in tropical forest management – Principles and concepts, 1993 (E F S)

108 A decade of wood energy activities within the Nairobi Programme of Action, 1993 (E)

109 Directory of forestry research organizations, 1993 (E)

110 Proceedings of the Meeting of Experts on Forestry Research, 1993 (E F S)

111 Forestry policies in the Near East region – Analysis and synthesis, 1993 (E)

112 Forest resources assessment 1990 – Tropical countries, 1993 (E)

113 *Ex situ* storage of seeds, pollen and *in vitro* cultures of perennial woody plant species, 1993 (E)

114 Assessing forestry project impacts: issues and strategies, 1993 (E F S)

115 Forestry policies of selected countries in Asia and the Pacific, 1993 (E)

116 Les panneaux à base de bois, 1993 (F)

117 Mangrove forest management guidelines, 1994 (E)

118 Biotechnology in forest tree improvement, 1994 (E)

119 *Number not assigned*

120 Decline and dieback of trees and forests – A global overview, 1994 (E)

121 Ecology and rural education – Manual for rural teachers, 1995 (E S)

122 Readings in sustainable forest management, 1994 (E F S)

123 Forestry education – New trends and prospects, 1994 (E F S)

124 Forest resources assessment 1990 – Global synthesis, 1995 (E F S)

125 Forest products prices 1973–1992, 1995 (E F S)

126 Climate change, forests and forest management – An overview, 1995 (E F S)

127 Valuing forests: context, issues and guidelines, 1995 (E F S)

128 Forest resources assessment 1990 – Tropical forest plantation resources, 1995 (E)

129 Environmental impact assessment and environmental auditing in the pulp and paper industry, 1996 (E)

130 Forest resources assessment 1990 – Survey of tropical forest cover and study of change processes, 1996 (E)

131 Ecología y enseñanza rural – Nociones ambientales básicas para profesores rurales y extensionistas, 1996 (S)

132 Forestry policies of selected countries in Africa, 1996 (E F)

133 Forest codes of practice – Contributing to environmentally sound forest operations, 1996 (E)

134 Estimating biomass and biomass change of tropical forests – A primer, 1997 (E)

135 Guidelines for the management of tropical forests – 1. The production of wood, 1998 (E S)

136 Managing forests as common property, 1998 (E)

137/1 Forestry policies in the Caribbean – Volume 1: Proceedings of the Expert Consultation, 1998 (E)

137/2 Forestry policies in the Caribbean – Volume 2: Reports of 28 selected countries and territories, 1998 (E)

138 FAO Meeting on Public Policies Affecting Forest Fires, 2001 (E F S)
139 Governance principles for concessions and contacts in public forests, 2003 (E F S)
140 Global Forest Resources Assessment 2000 – Main report, 2002 (E F S)
141 Forestry Outlook Study for Africa – Regional report: opportunities and challenges towards 2020, 2003 (Ar E F)
142 Cross-sectoral policy impacts between forestry and other sectors, 2003 (E F S)
143 Sustainable management of tropical forests in Central Africa – In search of excellence, 2003 (E F)
144 Climate change and the forest sector – Possible national and subnational legislation, 2004 (E)
145 Best practices for improving law compliance in the forest sector, 2005 (E F R S)
146 Microfinance and forest-based small-scale enterprises, 2005 (Ar E F S)
147 Global Forest Resources Assessment 2005 – Progress towards sustainable forest management, 2006 (E F S)
148 Tendencias y perspectivas del sector forestal en América Latina y el Caribe, 2006 (S)
149 Better forestry, less poverty – A practitioner's guide, 2006 (Ar E F S)
150 The new generation of watershed management programmes and projects, 2006 (E F S)
151 Fire management – Global assessment 2006, 2007 (E)
152 People, forests and trees in West and Central Asia – Outlook for 2020, 2007 (Ar E R)
153 The world's mangroves 1980–2005, 2007 (E)
154 Forests and energy – Key issues, 2008 (Ar C E F R S)
155 Forests and water, 2008 (E F S)
156 Global review of forest pests and diseases, 2009 (E)
157 Human–wildlife conflict in Africa – Causes, consequences and management strategies, 2009 (E F)
158 Fighting sand encroachment – Lessons from Mauritania, 2010 (E F)
159 Impact of the global forest industry on atmospheric greenhouse gases, 2010 (E)
160 Criteria and indicators for sustainable woodfuels, 2010 (E)
161 Developing effective forest policy – A guide, 2010 (E F S)
162 What woodfuels can do to mitigate climate change, 2010 (E)
163 Global Forest Resources Assessment 2010 – Main report (Ar C E F R S)
164 Guide to implementation of phytosanitary standards in forestry, 2011 (C E F R)
165 Reforming forest tenure – Issues, principles and process, 2011 (E S)
166 Community-based fire management – A review (E)
167 Wildlife in a changing climate (E)
168 Soil carbon monitoring using surveys and modelling – (E)
169 Global forest land-use change 1990 – 2005 (E F S)
170 Sustainable management of *Pinus radiata* plantations (E)
171 Edible insects: future prospects for food and feed security
172 Climate change guidelines for forest managers (E F S)
173 Multiple-use forest management in the humid tropics (E S)

174 Towards effective national forest funds (E)
175 Global guidelines for the restoration of degraded forests and landscapes in drylands (E)
176 Forty years of community-based forestry (E S)
177 Forestry for a low-carbon future (E)

Ar – Arabic
C – Chinese
E – English
I – Italian
F – French
P – Portuguese
S – Spanish
R – Russian
Multil – Multilingual
* – Out of print

FAO Forestry Papers are available through the authorized FAO Sales Agents or directly from Sales and Marketing Group, FAO, Viale delle Terme di Caracalla, 00153 Rome, Italy, or at www.fao.org/forestry/58718/en/

178
FAO FORESTRY PAPER

Guidelines on urban and peri-urban forestry

Although cities occupy only 2 percent of the planet's surface, their inhabitants use 75 percent of its natural resources; by 2050, 70 percent of the global population will live in cities and towns. Sustainable urban development is crucial, therefore, for ensuring the quality of life of the world's people.

Forests and trees in cities, if properly managed, can make important contributions to the planning, design and management of sustainable, resilient urban landscapes. They can help make cities more pleasant, attractive and healthy places in which to live, as well as safer, wealthier and more diverse.

A few years ago, FAO initiated a collaborative process to develop voluntary guidelines aimed at optimizing the contributions of forests and trees to sustainable urban development. Scientists, practitioners and public administrators from cities worldwide were brought together to discuss the elements and key challenges of urban forestry, and a smaller team of experts was assembled to distil this vast knowledge.

This document is the ultimate result of that process. Intended for a global audience comprising urban decision-makers, civil servants, policy advisors and other stakeholders, it will assist in the development of urban and peri-urban forests that help meet the present and future needs of cities for forest products and ecosystem services. These guidelines will also help increase community awareness of the contributions that forests and trees can make to improving quality of life, and of their essential role in global sustainability.

ISBN 978-92-5-109442-6 ISSN 1999-2882
9 789251 094426
I6210E/1/10.16

THE BELGIAN DEVELOPMENT COOPERATION .be