Stockholm University

Urban Ecosystem Services

The Value of Green Spaces in Cities

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To my family

"Cities themselves present both the problems and solutions to sustainability challenges of an increasingly urbanized world."
Grimm et al., 2008

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Preface

This dissertation is submitted for the doctoral degree in Environmental Science and Technology at the Institute of Environmental Science and Technology (ICTA), Universitat Autònoma de Barcelona (UAB), Spain and Sustainability Science at the Stockholm Resilience Centre (SRC), Stockholm University (SU) in Sweden. It was developed between April 2012 and September 2015 under a *Cotutelle Agreement - Cooperation Agreement for the Joint Supervision of Doctorates* established between UAB and SU. The agreement states, that "*On basis of a single presentation of a PhD thesis, both universities agree to award the corresponding title of PhD ...*", if all additional targets established by each university are fulfilled. In accordance with the *Cotutelle Agreement*, this dissertation is submitted at both universities, and will be defended in a single disputation at SU on 7th December, 2015. The disputation will be organized following the regulation at SU. Due to this, I also decided to follow the common dissertation style at SU. However, the dissertation has still to meet all formal UAB requirements. Contrary to the common dissertation style at UAB, introduction to the topic, objectives, presentation of the research conducted, discussion of the results, conclusions and bibliography (minimum requirements under RD99/2011), as well as future research questions are all presented within Chapter 1, referred to as *kappa*. The *kappa* is a guide to the entire thesis and links the individual manuscripts presented in Chapter 2 to 6. The *kappa* explains what is the value and contribution of this thesis and puts the thesis work into context. The *kappa* is slightly longer than customary at SU to meet informal expectations at ICTA-UAB, such as an in depth discussion of results.

Apart from the collaboration between UAB and SU, the dissertation was strongly enriched by the collaboration with different partners as part of the BiodivERsA project 'Urban Biodiversity and Ecosystem Services' (URBES). This collaboration allowed for a 4-month research stay at the Humboldt University in Berlin during which Chapter 6 was developed. It also allowed for the presentation and discussion of individual studies during projects workshops.

This and other collaborations, including the EU-FP7 project OpenNESS and the EU-COST Action TU1201, allowed me to take part of a series of studies and research activities, outstanding among them the "Cities and Biodiversity

Outlook" under UNEP-CBD. These activities led to seven accepted peer-reviewed publications and three publications in review at the date of the thesis submission, in addition to the manuscripts embedded in this thesis.

All individual studies have further been presented and were object of discussions at international symposiums and conferences, such as the World conference of the Society for Urban Ecology (25-27th July 2013, Berlin, Germany) and the 6th Annual International Ecosystem Service Partnership Conference (26-30th August 2013, Bali, Indonesia). A full list of publications presentations held as part of the elaboration of my PhD can be found in Annex 1.

Acknowledgements

First of all, I would like to thank my supervisors, Erik Gómez-Baggethun and Thomas Elmqvist, for the company and support during the three and a half years of developing this dissertation. Thanks to their complementary roles the dissertation coud shape up into its current form. Erik's and Thomas' guidance was not limited to the elaboration of this dissertation and the corresponding publications; they further helped me to create a wide scientific network and facilitated a range of research collaborations. I also would like to thank Erik and Thomas for their company in my personal development during the elaboration of this dissertation, which has been an important experience in my life.

Secondly, I would also like to express my special thanks to Dagmar Haase and Niki Frantzeskaki as important mentors during the elaboration of this dissertation, and whose advice complemented the elaboration my dissertation. I further would like to thank Kaysara Khatun and Stephan Barthel in representation of all colleagues and friends at ICTA-UAB, SRC-SU and elsewhere, who facilitated and supported this dissertation with their advice, proof-reading, methodological support and reflections.

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Finally, I would like to thank my family: My partner, Silvia Bontempo, for her infinite patience and moral support during the last three and a half years; my daughter, Emma Lucia, for her refreshing smile after long days of work and her capacity to put things into perspective by her mere existence, and finally to my parents who always supported my education. I also thank Conny, Fabsen, Alexis, Ulf and Jan for being there when needed.

My work during this dissertation was made possible through funding from the Generalitat de Catalunya through an FI DGR scholarship grant (2012FI_B 00578). I further received funding from the ERA-Net BiodivERsA project 'Urban Biodiversity and Ecosystem Services' (URBES) through the Spanish Ministry of Economy and Competitiveness (code: PRI-PIMBDV- 2011-1179), from the European Commission project OpenNESS (FP7-Grant agreement: 308428) and from the EU-COST Action TU1201.

The individual chapters in this dissertation are the fruit of different collaborations and received funding from different sources. All contributions and funding bodies are acknowledged at the end of each Chapter.

Summary

In an ever more urban world, the role of green spaces in cities is increasingly highlighted for their capacity to provide ecosystem services for human well-being. Yet, the value of urban green spaces is still widely overlooked in urban policy and planning. This dissertation examines the evidence base for the multi-functionality and values of urban green spaces, in the context of decision support and for priority setting in urban policy and governance. First, the multi-functional character of urban green spaces and the many benefits they provide to humans through the delivery of ecosystem services is studied through a literature review. Secondly, the pluralism of values is examined through case studies from urban green spaces in Barcelona, Spain. Within these case studies, value perceptions, value emergence and value dimensions are scrutinized by combining different methods, including remote sensing, participatory observations, interviews, surveys, statistical analysis and geographical information systems. Finally, pathways for an integrated valuation of ecosystem services in urban planning are explored through a review of state-of-the-art knowledge on multi-criteria decision analysis applied in relation to ecosystem services. The dissertation shows the multi-functional character of urban green spaces and outlines their specific importance for the provision of cultural ecosystem services. It contributes to operationalize the perspective of value pluralism in the assessment of ecosystem services from urban green spaces. It is noted that the perception of diverging values is mainly determined by the characteristics of the 'valuator', the socio-institutional context, as well as different valuation languages through which values are assessed. The perspective of value pluralism endorsed in this thesis, underlines the need for an integrated valuation of ecosystem services to inform decision-making and governance. The thesis examines the potential of multi-criteria decision analysis as a tool to facilitate such integrated valuation of ecosystem services, in the context of urban planning. By putting forward the value of ecosystem services for humans, the thesis intents to provide a cornerstone for policies towards more sustainable and resilient cities that recognize the interconnection and dependency of cities on healthy ecosystems worldwide.

Resumen (Spanish Summary)

En un mundo cada vez más urbanizado, el papel de los espacios verdes en las ciudades se destaca cada vez más por su capacidad para proporcionar servicios de los ecosistemas. Sin embargo, el valor de los espacios verdes urbanos todavía está ampliamente pasado por alto. Esta tesis investiga la multifuncionalidad y la multiplicidad de valores asociados a los espacios verdes urbanos en el marco del apoyo a las decisiones en las policticas de planeamineto y en la gobernanza urbana. En primer lugar, investigamos a través de una revisión de la literatura el carácter multifuncional de los espacios verdes urbanos y los beneficios que generan para los humanos mediante la provisión de servicios de los ecosistemas. En segundo lugar, el pluralismo de valores asociados a los servicios de los ecosistemas urbanos se examina a través de casos de estudio de los espacios verdes urbanos en Barcelona, España. En estos casos de estudio, las percepciones aociadas a distintos tipos de valor son examinadas mediante una combinación de métodos, incluyendo teledetección, observaciones participativas, entrevistas, encuestas, análisis estadísticos y sistemas de información geográfica. Por último, mediante una revisión del conocimiento existente sobre análisis multicriterio para la toma de decisiones, se exploran las vías para desarrollar una valoración integrada de los servicios de los ecosistemas en el marco de la planificación urbana. La tesis muestra el carácter multifuncional de los espacios verdes urbanos mediante la generación de servicios y resalta su importancia específica para la provisión de servicios de los ecosistemas culturales. Adoptando la perspectiva del pluralismo de valores en relación a los servicios de los ecosistemas proporcionados por los espacios verdes urbanos, los datos obtenidos demuestran que la percepción de valores divergentes está determinada principalmente por las características del “valorador”, el contexto social e institucional, así como por los diferentes lenguajes de valoración adoptados. Laperspectiva del pluralismo de valores, tal como se demuestra en esta tesis, subraya la necesidad de una valoración integrada de los servicios de los ecosistemas para informar la toma de decisiones y la gobernanza. La tesis destaca el análisis multicriterio como una herramienta con gran potencial para facilitar la valoración integrada de los serviciso de los ecosistemas en el contexto de la planificación y la gobernanza urbana. Mediante la aplicación de métodos que ponen de relieve el valor de los servicios de los ecosistemas para el binestar humano, esta tesis pretende ofrecer herramientas para informar políticas que permitan avanzar hacia ciudades más sostenibles y resilientes que reconozcan la dependencia de las ciudades de ecosistemas saludables para asegurar la calidad de vida.

Sammanfattning (Swedish Summary)

I en alltmer urbaniserad värld, lyfts städers grönområden alltmer fram för deras förmåga att tillhandahålla ekosystemtjänster för mänsklig välfärd. Ändå förbises värdet av urbana grönområden ofta fortfarande i urban policy och planering. Denna avhandling granskar faktabasen för urbana grönområdens multifunktionalitet och värden, i samband med beslutsunderlag och för prioriteringar inom urban policy och styrning. Först studeras urbana grönområdens multifunktionella karaktär och de många fördelar de ger till människor genom tillhandahållandet av ekosystemtjänster i en litteraturöversikt. Sedan undersöks mångfalden av värden genom fallstudier från urbana grönområden i Barcelona i Spanien. I dessa fallstudier granskas uppfattningar av värden, deras uppkomst och olika dimensioner genom att kombinera olika metoder, bland annat fjärranalys, deltagande observationer, intervjuer, enkäter, statistisk analys och geografiska informationssystem. Slutligen utforskas olika sätt att integrera värdering av ekosystemtjänster i stadsplaneringen genom en översyn av den senaste kunskapen om multikriteria beslutsanalys tillämpad i relation till ekosystemtjänster. Avhandlingen visar urbana grönområdens multifunktionella karaktär och beskriver deras specifika betydelse för tillhandahållandet av kulturella ekosystemtjänster. Den bidrar till att operationalisera ett värdepluralistiskt perspektiv i bedömningen av ekosystemtjänster från urbana grönområden. Det bör noteras att uppfattningen av motstridiga värden bestäms huvudsakligen av egenskaperna hos ”värderaren”, den socio-institutionella kontexten, liksom genom vilket värderingsspråk värdena bedöms. Det värdepluralistiska perspektivet, som den här avhandlingen stödjer, understryker behovet av en integrerad värdering av ekosystemtjänster för att informera beslutsfattande och styrning. Avhandlingen undersöker potentialen för multikriteria beslutsanalys som ett verktyg för att underlätta för en sådan integrerad värdering av ekosystemtjänster, inom ramen för stadsplanering. Genom att lägga fram värdet av ekosystemtjänster för människor, avser avhandlingen att tillhandahålla en hörnsten för politik gentemot mer hållbara och resilienta städer som erkänner att städer världen över är tätt sammanlänkade med och beroende av friska ekosystem.

Chapter 1 – Kappa

1.1 Background

The world is increasingly urbanizing, with approximately 54% of the world population living in cities. The United Nations World urbanization prospects expect this number to rise to 66% by 2050 (United Nations, 2014a). If current trends continue, there will be twice the size of urbanized areas by 2030 and an additional 2.5 billion new urban inhabitants by 2050 (Elmqvist et al., 2013; Seto et al., 2011). Urbanization represents a great challenge to humanity but at the same time it provides an important opportunity to develop and implement policies to promote more sustainable and livable cities (Elmqvist et al., 2015; Pickett et al., 2013). Although urban areas cover less than 3% of the global terrestrial surface, 60% of the global residential water-use has been attributed to cities (Grimm et al., 2008); and between 30.5 and 40.8 % of the world's anthropogenic greenhouse gas emissions are caused in cities, while about 60-70 % of all global greenhouse gas emissions respond to the demand by urban inhabitants (Satterthwaite, 2010). As the places where the vast majority of people will be living in the 21st century and where the power for decision-making is accumulated, cities can be seen as the forefront of shaping the future of the planet in the 'Anthropocene' (Crutzen, 2002; Steffen et al., 2007; Rockström et al., 2009).

In face of this global trend, one of the *United Nations Sustainable Development Goals* is to "make cities and human settlements more inclusive, safe, resilient and sustainable" (United Nations, 2014b:11). Social inclusion and social equity have been persistent goals on the policy agenda for some time, but still remain unsolved (EC, 2014). From an environmental point of view, safer cities demand a better preparation for environmental extreme events such as droughts, flooding and heatwaves, whose frequency and intensity are expected to rise with human-induced climate change (IPCC, 2014). A key challenge for urban policy-makers is thus to promote policies that enhance urban resilience, which is to increase the adaptive and transformative capacity of cities to retain basic functions and identity in the face of shocks and transitions (Eraydin & Taşan-Kok, 2013; McPherson et al., 2015; Walker et al. 2006). Making cities more sustainable requires decreasing the degradation of ecosystems related to the demand by urban dwellers for land, environmental goods and services, as well as reducing cities' ecological foot-

prints and associated ecological debts (Folke et al., 1997, Rees, 1992, Rees & Wackernagel, 1996).

In Europe, urban population make up approximately 75% of the total population, and even though urbanization trends are currently slower than in other parts of the world, by 2020 about 80% of the European population is expected to live in cities (EEA, 2010). Expansions of urban areas in Europe are caused by urban sprawl that puts adjacent ecosystems under growing pressure (Kronenberg et al. 2013). In this context, decision-makers are paying growing attention to the sustainable management and restoration of urban and peri-urban green spaces (EC, 2015). A recent statement by the European Commission, namely the Commission's communication 'Green Infrastructure (GI) — Enhancing Europe's Natural Capital' (EC, 2013) and the Final Report of the Horizon 2020 Expert Group on 'Nature-Based Solutions and Re-Naturing Cities' (EC, 2015), indicate an important shift in the understanding of urban green spaces. In public policy discourse, urban ecosystems are increasingly portrayed as 'green infrastructure', a metaphor that captures the role that water and vegetation in or near the built environment play in delivering ecosystem services at different spatial scales (building, street, neighborhood, region) (Gómez-Baggethun and Barton, 2013). The view of urban green spaces is slowly changing towards a perspective "of green urban infrastructure for multipurpose benefits" (Gouglas & Ravetz, 2011) for the environment, biodiversity and humans (Tzoulas et al., 2007). For example, Konijnendijk et al. (2013) systematically describe the multiple benefits provided by urban parks, including for human health, species diversity and storm water regulation. From this perspective, the importance of urban green spaces for sustaining ecosystem services (ES) — ecosystem processes that are of benefit to humans (TEEB, 2010) — is increasingly highlighted (Elmqvist et al., 2015; Pauleit et al., 2011). Departing from the "utilitarian framing of beneficial ecosystem functions as services" in the late 1970s (Gómez-Baggethun et al., 2010), the ES approach has gained increasing importance since it was taken up and expanded by Gretchen Daily's book *The value of the world's ecosystem services and natural capital* (1997) and Robert Costanza and colleagues in *Nature's Services: Societal Dependence on Natural Ecosystems* (1997). Bolund & Hunhammar (1999) were the first to describe the flow of benefits humans obtain from urban green spaces as urban ES. Securing sustained flows of ES has been firmly set on the interna-

tional policy agenda over the last decade, in particular since the *Millennium Ecosystem Assessment* described a declining trend for 60% of the world's ES (MA, 2005).

The *Millennium Ecosystem Assessment* (MA) divided ES into supporting, provisioning, regulating, and cultural services (MA, 2005). Another commonly used classification of ES has been provided by *The Economics of Ecosystem Services and Biodiversity*, which divides ES into habitat, provisioning, regulating, and cultural & amenity services (TEEB 2010). More recently, the *Common International Classification of Ecosystem Services* (CICES, 2015) has been developed, which distinguishes provisioning, regulating / maintenance, and cultural services. In this dissertation, I largely utilize the MA and TEEB classification, where supporting or habitat services are included as a separate category to highlight the importance of ecosystems to provide refuge to animals and plants and to maintain biodiversity and core ecological processes, including water and nutrient cycles (TEEB, 2010). Concordant with CICES, MA and TEEB classifications further describe provisioning ES, including the flow of food, drinking water, and raw material, regulating services including air quality, climate, moderation of extreme events and erosion prevention among others, and cultural ES, or "the nonmaterial benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experiences" (MA, 2005).

The global trend of rapidly expanding urban areas (Seto et al., 2011) involves that a growing share of the world population is decoupling from ecosystems and their dynamics, both physically and cognitively (Gómez-Baggethun & De Groot 2010). This is accompanied by a loss of awareness for the human dependency on ecosystems, in what Miller et al. (2005) have referred to as the 'extinction of experience', that impinges upon environmental stewardship. The stewardship of ES worldwide was described as one of the greatest challenges for policy-making, planning and management in the 21st century (Rockström et al., 2015) and the United Nations recently defined the need to "protect, restore and promote sustainable use of terrestrial ecosystems" for the flow of benefits they sustain under the Sustainable Development Goal for the next fifteen years (UN, 2014b:15). A society that is ever more urban and increasingly decoupled from ecosystems is losing awareness about the human dependency on healthy ecosystems for the provision of life-

sustaining ES (Colding & Barthel, 2013; Miller, 2005). Built infrastructure such as pipelines and transport networks facilitate the access to ES and markets offer the possibility of accessing ES provided by ecosystems worldwide. This means that the generation of many ES consumed in cities, including the provision of drinking water, energy and food, air purification, waste disposal, and recreation, are often provided at distant locations (Steel, 2013). Furthermore, in cities, most ES are not directly obtained or enjoyed from nature as occurs in subsistence economies, but are 'embedded' in market products (e.g. imported food). Most ES are hence obtained from 'anonym' ecosystems in distant countries after going through multiple stages of transformation and distribution chains. In this manner, "the ecological contribution to the end-product becomes masked by an increasingly de-localized economic process, that alienates the consumer from the links between the source ecosystems and the final goods and services that are consumed or enjoyed" (Gómez-Baggethun & De Groot, 2010: 107). The complex, ecological processes, on which for example water and carbon cycles rely, remain invisible and incomprehensive to a wider urban population (Elmqvist et al., 2013). Consequently, the provision of fundamental ES is often taken for granted, especially by urban inhabitants living in the most developed parts of cities. Unconsciousness about the fundamental human dependencies on ecosystems causes that less care is taken to support, maintain and create healthy ecosystems; the steady erosion of ES worldwide can be seen as a consequence (Miller, 2005). The degradation of ecosystems and their services can thus be partly linked to the increasingly urbanized, global society and to the corresponding losses in ecological understanding and appreciation of environmental benefits.

In this context, the assessment of ES is increasingly used to raise societal awareness for nature's fundamental role in sustaining human life on earth (Gómez-Baggethun & Barton, 2013). Renewed awareness of urban citizens for their dependency on life-sustaining ES may positively influence environmental-friendly behavior and foster an urgently needed stewardship for the environment (Andersson et al., 2014; Colding & Barthel, 2013; Elmqvist et al., 2013; Miller, 2005). Lacking awareness for the importance of ES also impinges upon environmental governance (TEEB, 2010). Traditionally focused on ecosystem assessments, the ES approach needs now integration

into urban policy and governance (Kabisch, 2015; Primmer & Furman, 2012).

In their book *Urbanization, biodiversity and ecosystem services*, Elmqvist and colleagues (2013) attempt to raise stronger awareness for the value of ES and biodiversity in cities. Chapter 11 of the book, to which I have contributed, systematizes the state-of-the-art knowledge on urban ES and associated values (Gómez-Baggethun et al. 2013). Research on urban ES is increasing rapidly. A recent review identified 217 studies addressing ES in cities (Haase et al. 2014). Notwithstanding the considerable and rapidly growing number of studies, Haase et al. (2014) find that most assessments are still focusing on a narrow spectrum of ES, most often regulating services such as local climate regulation (reduction of heat island effects), air purification, and carbon sequestration. Frantzeskaki & Tilie (2014) also note an increased policy interest in regulating ES in cities. However, the limited size of urban green spaces often limit their capacity for providing regulating services. For example, Baró et al. (2014) show that urban green spaces in Barcelona only sequester 0.47% of the carbon emissions and 0.52% of NO_2 emissions reported for the city of Barcelona. The focus on a limited spectrum of ES remains a major limitation for assessing the multi-functional character of urban green spaces and their capacity to sustain multiple services to humans (Kronenberg et al. 2013). Furthermore, knowledge on urban ES remains largely fragmented and is often not readily available for an operationalization in environmental policy and governance (e.g. Primmer & Furman, 2012). Kabisch (2015) argues that an insufficient communication between different institutional actors limits awareness of the multiple benefits provided by urban green infrastructure in green space governance in Berlin. Urban environmental governance embraces all kinds of institutional arrangements by which people make decisions and share power (Folke et al., 2005; Lebel et al., 2006; Ostrom, 1990). ES governance needs to integrate "multiple knowledge sources and engaging those actors who understand, manage and benefit from the services" (Primmer & Furman, 2012). This includes the institutions related to top-down decision-making and rules implemented by institutional actors, such as urban planning departments and local governments, as well as rules and practices applying under community-based management of green spaces, as for example described for urban gardens (e.g. Bendt et al., 2013; Colding et al., 2013).

While studies on individual ES in cities are increasing, most studies on the topic have focused on limited value dimensions. For example, whereas ecological and economic values have been broadly examined in the literature, description or measurement of symbolic, cultural, identity and other social values remain under-researched (Chan et al., 2012a, b). Filling the knowledge around the values of urban ES constitutes a major challenge for environmental governance and facilitates an implementation of the ES framework in policy-making, planning and management that makes stronger consideration of the ecological, social and economic values of urban green spaces (Haase et al., 2014; Kabisch, 2015).

1.2 Research objectives

The aim of this thesis is to investigate the multi-functionality of urban green spaces through their capacity to deliver ES and to examine how ES valuation can inform environmental decision-making and governance. Under these general goals three specific objectives are pursued. First, I examine, classify and characterize ES provided by urban green spaces (Chapter 2). Secondly, I scrutinize human values in relation to urban ES. This includes, (i) the examination of perceptions and preferences of urban ES (Chapter 3), (ii) the assessment of the social, ecological and institutional contexts influencing the creation of these values (Chapter 4), and (iii) the combination of methods or 'valuation languages' to understand the societal importance of urban ES, including monetary and socio-cultural (non-monetary) valuation approaches (Chapter 5). Finally, I indicate pathways for developing an 'integrated valuation' of ES assessments to inform urban policy and governance through multi-criteria decision analysis (MCDA) (Chapter 6).

Assuming a need for pluralistic value representation and the current dominance of biophysical and monetary approaches in urban ES valuation (Haase et al., 2014), this dissertation mainly applies socio-cultural approaches to assess the values of urban ES, following the aim of advancing new frontiers in the integrated valuation of ES. Studies presented in Chapters 3, 4, and 5 use socio-cultural valuation approaches, and are among the first applications of this method to assess ES from urban green spaces. Chapter 3 and Chapter 4 rely on a two-step approach for the identification and valuation of ES. This innovative approach combines qualitative interviews and quantitative survey techniques. In Chapter 5, I will address in more depth the complementary

characteristics of monetary and non-monetary valuation of ES. As a consequence of pluralistic value theories, tools have been demanded to systematically represent different ontological and epistemological perspectives of societal values in decision-making (Martínez-Alier et al. 1998, Robertson, 2004). This is taken up in Chapter 6 by exploring MCDA for an integrated ES valuation within priority-setting in land-use policy and planning, with specific regard to the expression of values as ES supply and demand.

By addressing these objectives the dissertation advances the knowledge frontier on urban ES in at least three aspects. First, the multi-functionality of urban green spaces is assessed on the basis of empirical data. Secondly, values attached to urban green spaces are analyzed and further explored with regard to different perceptions, their emergence and valuation languages. Finally, the potential for the integration of ES values in urban governance is discussed. The research involves both qualitative and quantitative data and combines theoretical and empirical approaches from the fields of ecological economics, ES, social-ecological systems and urban ecology. Building on scientific literature reviews on urban ES and the application of MCDA in ES research (Chapters 2 and 6); empirical data on the perceived societal value of urban green spaces are presented and analyzed (Chapters 3 to 5). The dissertation not only advances scientific knowledge but also provides practical guidance for urban governance and green space policies. The dissertation lays out a framework for conducting an integrated valuation of urban ES to inform urban governance and decision-making (Chapter 6). In doing so, the dissertation provides a cross-disciplinary, policy-motivated and problem-driven representation of research insights (Brouwer & van Ek 2004; Parson 1995). While this dissertation is intended to advance the implementation of the ES concept in urban policy-making, planning and management, further steps are needed to make the concept fully operational, including the empirical testing of integrated valuation frameworks, such as MCDA, in planning processes.

1.3 Conceptual and methodological framework

Cities and urban areas are generally understood as an antipode to natural or rural ecosystems. However, this divide between the ‘urban’ and the ‘natural’ is increasingly seen an obstacle for a better understanding of the interrelated social and ecological process that characterize urban green spaces (Elmqvist

et al., 2013; James et al., 2009). The emerging research field of urban ecology tries to overcome the classical divide between nature and city by merging ecosystem science with insights from urban planning to the understanding of cities as coupled social-ecological systems (Berkes & Folke, 1998; Niemäla et al. 2011; Pickett et al., 2008; Pickett et al., 2013). Urban areas and natural areas are thereby understood as integrated parts of the earth's larger ecosystems (Niemelä et al., 2011). Departing from this understanding, the boundaries between cities and adjacent ecosystems become diffused, as do the limits between urban areas and green spaces nested within them. Urban green spaces are thus understood as an integral component of the urban fabric characterized by social and ecological interrelations, interdependency and feedbacks (Andersson et al., 2014). From this conceptual understanding, ES from urban green spaces are understood as co-produced by nature and humans, at the interface between complex ecological and social processes (Andersson, et al. 2007; Andersson et al. 2014; Jansson & Polasky, 2010).

The conceptual model adopted in this dissertation is the ES-cascade introduced by Haines-Young & Potschin (2009), which builds on previous work unpacking the links between ecosystems and human well-being (e.g. De Groot et al. 2002; Boyd & Banzhaff 2007). The cascade model consists of five main elements: i. Ecosystem structure, ii) processes (or functions), iii) ecosystem services, iv) benefits and v) values. Ecosystem structure comprises all abiotic and biotic elements of an ecosystem (including those created by humans). Ecosystem processes or functions describe the relation between the structural components and define the potential or capacity of an ecosystem to provide ES (Haines-Young & Potschin, 2009). ES are then described as those ecosystem processes that are beneficial to humans. Benefits describe the positive effects on human wellbeing and values describe the human appreciation of these benefits (De Groot, 2010; TEEB, 2010). In this way, the ES framework conceptually links ecological structures and processes of urban green spaces to human wellbeing and appreciation. In extension to the classical ES cascade model, information about human benefits and values may further create important feedback to the governance of urban green spaces (see Figure 1.i). Such information may enable the governance of urban ecosystems, which is the decision-making embedded in policy, planning, management and civic practices, to shape the physical structure and processes of urban green spaces with regard to human wellbeing and appreciation.

The flow of urban ES is thus supported by the interfaces between the non-living environment, living organisms such as plants and animals, as well as human perceptions and values which stipulate management practices (van Oudenhoven et al., 2012).

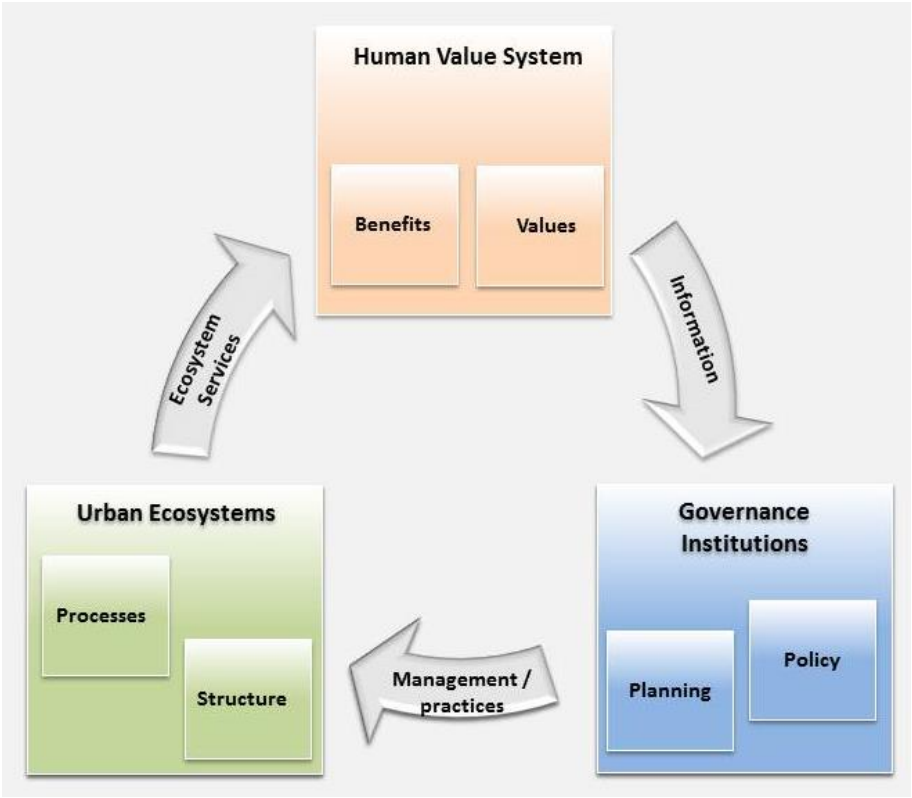

Figure 1.i: Urban green spaces as coupled social-ecological systems.
The figure depicts the conceptual framework adapted this dissertation, building on the 'Ecosystem Service Cascade' model (Haines-Young & Potschin, 2009). It covers the flow of ecosystem services sustained by the abiotic and biotic structure and processes of ecosystems and the human perception and appreciation of these services. It further highlights that benefits and values of ecosystem services can inform urban policy and governance, which itself influences the provision of ecosystem services by shaping the physical structure and processes of urban ecosystems.

Following Gómez-Baggethun et al. (2013), this dissertation, endorses 'value pluralism' as a core foundation in the examination of values related to ES[1]. In the ES literature, 'value' has often been conflated with 'monetary value' (Chan et al. 2011; Gómez-Baggethun et al., 2014; Jax et al. 2013). In this dissertation, I embrace a broad definition of value suggested by De Groot et al. (2002; 2010), who equate 'value' to 'importance', that means, values are originated in the preferences, principles, virtues and objectives of individuals or groups of the society (Chan et al., 2012b; Costanza, 2000; Gómez-Baggethun et al., 2014). The perspective of value pluralism, assumes that understanding the importance of nature involves dealing with multiple value dimensions that may be in conflict with each other and deserve distinct recognition (Gómez-Baggethun & Martín-López, 2015). The MA (2005), destinguishes ES values in three broad dimensions: ecological values, social values — also reffered to as 'cultural values' (Chan et al. 2012b) or 'socio-cultural values' (Groot et al. 2002; Gómez-Baggethun et al., 2014 — and economic values. From an ecological economics perspective, ES values might be conceptualized in accordance with the three nested systems of sustainability, i.e. ecological, social and economic systems (*cf.* Gómez-Baggethun & Martín-López, 2015) (see figure 1.ii). Ecological values define the potential supply of ES (Martín-Lopez, et al. 2014). They are determined by the ecosystem structure and processes (De Groot et al. 2002) that define the ecological health and integrity of an ecosystem and determines its capacity to sustain ecosystem services over time (Gómez-Baggethun & Martín-López, 2015; Pascual et al., 2010), thereby delineating the natural boundaries for a sustainable provision of ES (Rockström et al., 2009). Social and economic values both express the human demand for ES, based on the appraisal of individual or societal human preferences (Scholte et al., 2015). Comparing human supply and demand for ES can be an indicator for the (distant to) sustainability of a system (*cf.* Rockström et al., 2009). For urban areas it can generally be assumed that cities' demand for ES exceeds the capacity of urban areas to provide ES (Folke et al., 1997; Baró et al., 2014). However, green space governance has often strong capacities to shape urban

[1] Other global initiatives that emphasize the importance of recognizing multiple values related to ES are the *Convention on Biological Diversity* (CBD), *The Economics of Ecosystems and Biodiversity* (TEEB, 2010) and the *Intergovernmental Platform on Biodiversity and Ecosystem Services* (IPBES, 2015).

green spaces with regard to human demands. Thereby the matching between supply and demand for ES might be improved, which increases the sustainability of urban areas and reduces their dependency and pressure on distant ecosystems.

The assumption of value pluralism influences considerations on how different values can be combined, compared or weighted against each other. The field of ecological economics has largely discussed the complementary and incommensurable character of different values (e.g. Chan et al., 2012b; Daly, 1990; Martinez-Alier et al., 1998; Martín-López et al., 2014; Jax et al., 2013). Value pluralism builds on the assumption that losses along one value dimension cannot simply be compensated or substituted by gaining more of other values (Gómez-Baggethun & Barton, 2013; Gómez-Baggethun & Martín-López, 2015). This is for example the case for ES that have a vital value for subsistence, such as food or drinking water supply (Sanon et al., 2012), as well as for many spiritual and religious values that some people deem irreplaceable and non-compensable (Chan et al., 2012b; Martinez-Alier et al., 1998), for instance, those attached to sacred forests (Daniel et al., 2012). In the face of urban developments, value pluralism also implies that specific values attached to urban green spaces may not be compensated or substituted by services provided by built infrastructure. The incommensurability of values stands in opposition to monist value theories assuming the possibility to aggregate values to single measurement rods, such as labor, money, energy or land (e.g. Munda 2008:35; Spangenberg & Settele, 2010). To the contrary, value pluralism demands decision-making based on the representation of multiple values that embody different ecological, social and economic interests for nature and trade-offs between them (Gómez-Baggethun et al., 2014; Gómez-Baggethun & Martín-López, 2015).

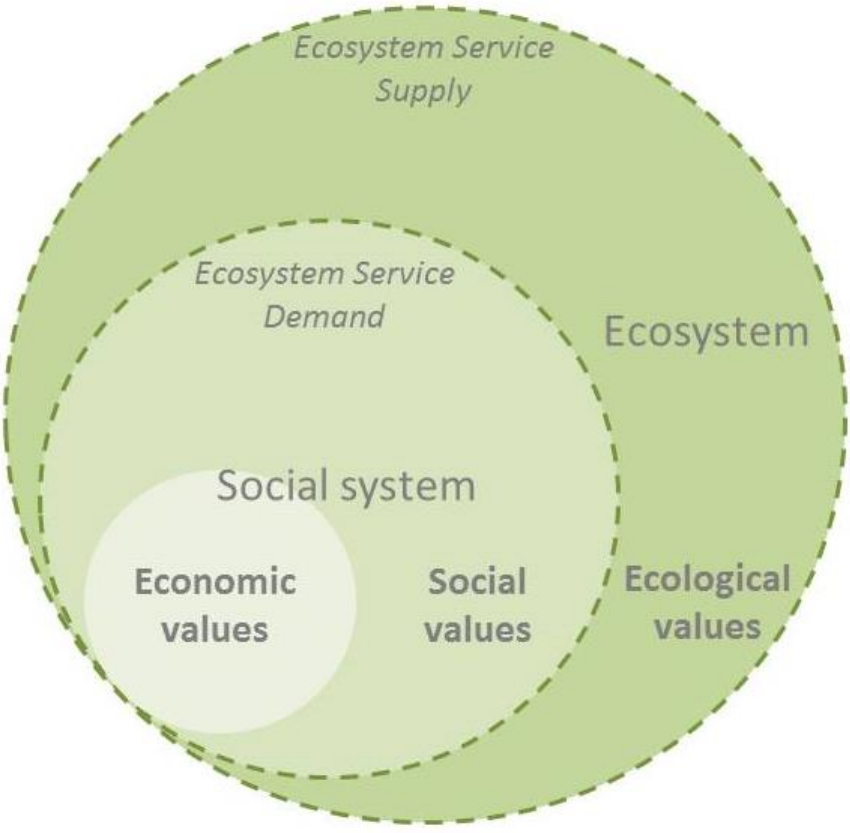

Figure 1.ii: Ecosystem service values in the nested systems of sustainability.
Ecological values determine the biophysical limits or the potential supply of an ecosystem to provide ecosystem services. Socio-cultural and economic values belong to the social system, which is a sub-system of the larger ecosystem. Socio-cultural and economic values express the human importance for ecosystem services, which can be interpreted as a demand for ecosystem services. The figure (adapted from Gómez-Baggethun & Martín-López, 2015) also illustrates the lack of sustainability of an ecosystem in which the demand for ES exceeds the potential supply.

Valuation concerns the assessment, appraisal or measurement of the importance or value of ES as foundations of human societies (Atkinson et al., 2012, Dendoncker et al., 2013, Gomez-Baggethun & de Groot, 2010). The valuation of ES might serve different purposes including awareness raising, environmental accounting, priority setting, instrument design, and litigation in courts (Gómez-Baggethun & Barton 2013). In this dissertation, I aim for a stronger recognition for future operationalization of ES in urban governance through the valuation of ES from urban green spaces. Consequently, awareness raising and priority setting are the main goals for which ES valuation is used in this thesis. The valuation of urban ES can be conducted by making use of different methodological approaches (Martín-López et al., 2014; Gómez-Baggethun et al., 2014; see Figure 1.iii).

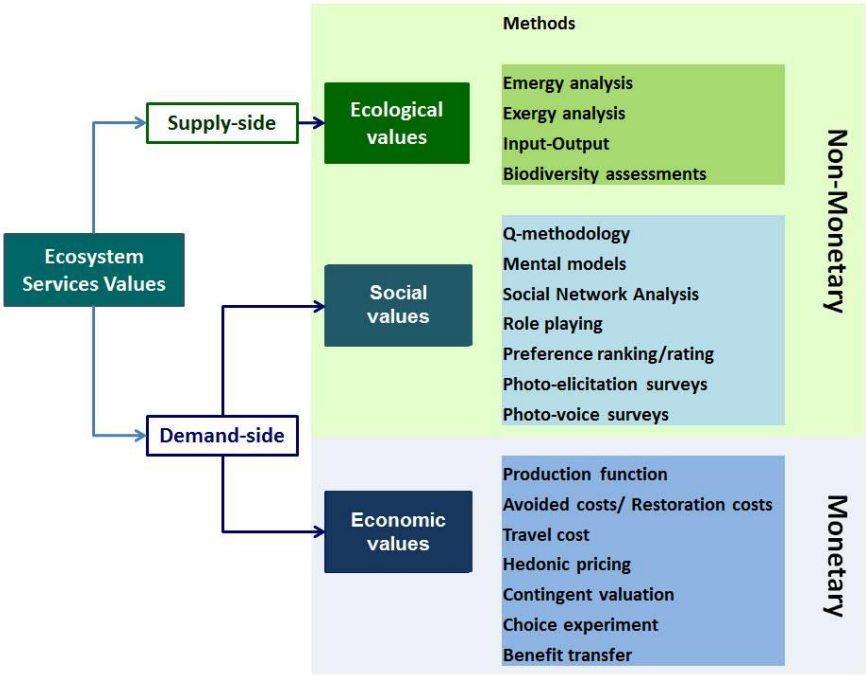

Figure 1.iii: Methodological toolbox for an integrated valuation of ecosystem services which considers non-monetary and monetary valuation methods and the value-pluralism (adapted from Gómez-Baggethun et al. 2014). *The link of certain valuation methods with certain value dimensions represents broader connections and should not be seen to be exclusive. For example, it is technically possible to use economic valuation methods or*

preference ranking methods to value ecological and cultural aspects and integrated (economic) approaches such as Cost-Benefit-Analysis (CBA) or Multi-Criteria-Decision-Analysis (MCDA) can cover different value dimensions.

The potential supply of ES is accounted for through different kinds of methods communicating nature's value in biophysical terms, such as energy or material flow accounting. Biophysical mehtods currently dominate the assessment of urban ES (Haase et al., 2014), and the biophysical capacity of urban green spaces to supply ES is increasingly taken into consideration. An example is the study previously mentioned by Baró et al. (2014), which used the iTree model to assess the biophysical capacity of urban green spaces to sequester carbon and reduce air pollution, such as CO, NO_2, O_3, SO_2, and PM-10.

The demand for ES is assessed through expressions of human appraisal and preferences, to date, most commonly assessed through monetary valuation methods (Scholte et al., 2015), such as travel-cost-method (applied in Chapter 5), contingent valuation, and choice experiments (Atkinson et al., 2012). Monetary valuation — also constituting an important approach to the valuation of ES in cities (Haase et al., 2014) — was established on the grounds of classical economic theory and its focus on individual utility (Gómez-Baggethun & Martín-López, 2015). Making values of ES explicit in monetary terms allows for their accountance in market systems, it is also expected to integrate ecological principles into urban planning and management (Seto et al., 2013). For example, monetary valuation has often been used for decision-making based on the aggregated monetary value of costs and benefits (Cost-Benefit-Analysis). The current dominance of monetary valuation approaches in ES assessments has raised important ethical concerns, for example for the role this may play in paving the way for commodification of nature (Gómez-Baggethun & Ruiz-Pérez, 2011; Kosoy & Corbera 2010; Jax et al. 2013). The critics also warn that monetary valuation can reduce citizen principles and convictions into consumer preferences (Spash, 2007; Vatn, 2009), ignore ecological thresholds and distributional impacts (Wegner & Pascual, 2011; Farley, 2012), and erode intrinsic motivations for conservation (Neutreleers & Engelen, 2015). Chan et al. (2012b) identified an obsta-

cle in the wider implementation of the ES framework if intangible social and cultural values are not better accounted for. To fill this gap, an increasing body of currently emerging literature attempts to describe the human demand for ES through non-monetary valuation approaches. Non-monetary valuation of ES — called by this term in delineation to the pre-dominance of monetary valuation approaches — embeds a broad range of methodological approaches to elicit ES values (including also biophysical assessments describing the supply of ES), without building on consistent conceptual and philosophical foundations (Chan et al., 2012a; Kelemen et al. 2014; Kenter, 2014) (see Figure 1.iii). A consolidated classification of non-monetary valuation approaches describing the demand for ES is still lacking, and "dividing the large group of non-monetary valuation methods into subgroups expressing the different ontological and epistemological foundations … is desirable for both theoretical and methodological clarity" (Gómez-Baggethun et al., 2014). Kelemen et al. (2014) provide a classification based on methodological similarities, including quantitative, qualitative and deliberative approaches. Scholte et al. (2015) distinguish valuation approaches assessing revealed values and stated values. The former includes qualitative and interpretative methods, such as storytelling sessions or participatory mapping sessions (Kenter, 2014).

Within the large group of non-monetary valuation approaches describing the ES demand, socio-cultural methods for valuation — labeled under the umbrelly term of 'socio-cultural valuation' — have recently been highlighted for examining the importance people, as individuals or groups, assign to ES through (non-monetary) quantitative preference rankings embedded in surveys and interviews (Christie et al., 2012; Calvet-Mir et al. 2012; Gomez-Baggethun et al. 2014; Martín-López et al. 2012; Sijtsma et al., 2013). Socio-cultural valuation methods are based on research regarding the "subjective well-being value of green spaces" (Kenter, 2014) and have, been applied to value ES from different ecosystems (Martín-López et al. 2012), such as agricultural landscapes (Soy-Massoni et al., 2015) and rural vegetable gardens (Calvet-Mir et al., 2012).

In order to appraise the pluralism of values related to ES, the thesis adopts a perspective of integrated valuation (Gómez-Baggethun & Martín-López, 2015). An integrated valuation involves the effort for synthesizing; interpret-

ing and communicating knowledge about the multiple values of ES for informed decision-making (*cf.* Gomez-Baggethun et al., 2014). In urban areas, an integrated valuation approach is manifested by considering (i) multiple social actors as groups or individuals, (ii) different knowledge systems, including scientific and lay knowledge, as well as (iii) different valuation languages and methodological approaches by which values are expressed (Gomez-Baggethun et al., 2014). In this context, it is crucial to note that "valuation methods are not neutral tools that simply 'reveal' pre-existing perceptions about ES and associated values as they also have frame effects that shape these perceptions and values" (Martín-López et al., 2014; *cf.* Chapter 3). It has for example been argued that ecological values related to complex functions and processes are insufficiently captured in monetary terms (Kosoy & Corbera 2010). Aggregated values, for example in terms of energy or money, usually exhibit towards social equity (e.g. Munda 2008; Spangenberg & Settele 2010). Chan et al., (2012a, b) argue that intangible values and non-use values, for example related to place making, place attachment and community cohesion (Altman & Low 1992) — which to date are insufficiently considered within the ES framework and ES assessments — require the introduction of valuation approaches based on methods from the social sciences. Qualitative (non-monetary) valuation approaches may be better able to deal with power relationships and discuss unequal distributions of ES values among different groups in society. In contrast to monetary valuation based on the assumption of rational choices for individual utility (Parks & Cowdy 2013), quantitative valuation approaches from the social sciences, such as socio-cultural valuation, allow to assess both "self-oriented" and "other-oriented" values, i.e. values attached to ES for the sake of others (Scholte et al., 2015). Yet, socio-cultural valuation embeds its own limitations, such as the reliance on beneficiaries as "valuers" (further discussed in Chapter 3). From the perspective of a pluralistic value theory, decision-making should thus not exclusively rely on a single valuation approach, but combine different methodological approaches that reveal different types of information (Martín-López et al. 2014).

1.4 Case study

The dissertation is based on empirical data collected from urban green spaces in Barcelona, Spain. With over 4 million inhabitants in the metropolitan

area Barcelona stands among the 20 largest agglomerations in Europe and is the second largest city in Spain. Barcelona shares typical characteristics of major European Mediterranean cities, including high population density (160 inhabitants/ha), low levels of available green areas (6.82 m^2 greenery/inhabitant in the urban fabric) and considerable pressure on adjacent ecosystems from urban sprawl (Barcelona City Council, 2013; Fuller & Gaston, 2009; IDESCAT, 2013). Barcelona fringes are characterized by the inland mountain range of *Collserola* in the West (embedding 8,000 ha green spaces of which 1,795 ha belong to the city's administration) and the estuaries of river *Besos* and *Llobregat* in the North and in the South respectively. While the Northern fringe is strongly urbanized, the Southern parts of the metropolitan area are characterized by a land-use mix, including considerable areas of local agricultural production (Paül & Tonts, 2005). The Western fringe embeds considerable urbanizations but also protected areas of shrub and forest vegetation. In the West, Barcelona borders the Mediterranean Sea, although anthropogenic activities, such as harbor extensions, continuously reshape the coastline (Barcelona City Council, 2013). Given the small availability of green areas, the Barcelona City Council launched in 2013 *Barcelona's Green Infrastructure and Biodiversity Strategy* (Barcelona City Council, 2013). This strategic policy document aims at developing an integrated planning of multi-functional urban green spaces as parts of the city's infrastructure. This objective constitutes a momentum, where policy-makers and planners are open to novel and more holistic perspectives that integrate ES in the consideration of green spaces.

This dissertation specifically concentrates on ES from green spaces in the city's urban core, which is home to about 1.62 million inhabitants (IDESCAT, 2013). With the exception of the sea, blue areas, such as rivers or lakes, are rare in the urban core, and the most important green areas are trees located on streets, private gardens, urban parks and urban gardens (Burriell et al., 2006; Barcelona City Council, 2013). The latter two will be addressed in more depth in the following chapters. Urban parks are important components in the mosaic of urban green infrastructure in cities and have been highlighted for the multiple benefits they provide to urban inhabitants (Konijnendijk et al., 2013). Since the beginning of the 20th century, urban green space planners in Barcelona have prioritized the creation of urban parks, and today they make up almost 30% (1076 ha) of the city's green

spaces, while another 50% belong to the peri-urban forest of *Collserola* and 20% are private gardens (Barcelona City Council, 2013). Among the 46 larger urban parks (> 5 ha) in Barcelona, I specifically address *Park Montjuïc*, the city's largest park, which outstanding importance is proven by over 16 million annual visits (Barcelona City Council, 2010). The other target areas are urban gardens. Historically, horticultural gardens have been of critical importance for cities in moments of crisis, such as wars and environmental disasters. Although the importance of urban gardens is primarily associated with their capacity to supply food (e.g. Barthel & Isendahl, 2013), their importance also relates to their capacity to strengthen the social urban fabric and to provide non-material benefits, such as recreation and learning opportunities (Lawson, 2014). Chapter 2 depicts these benefits in detail. Over the second half of the 20th century, horticultural gardens and urban parks followed opposite developments in Barcelona. Horticultural gardens were increasingly replaced by built infrastructure and marginalized to the urban fringes (Camós et al. 1982; Domene & Saurí, 2007). The urban sprawl there, caused important reduction in horticulture land, as for example reported for the municipality of *Rubi* where about 70% of vegetable gardens where replaced between 1987 and 1999 (Domene, 2000 cited in Domene & Saurí, 2007). By the 1990s almost all arable land was erased within the municipal boundaries and today only about 30 ha of horticultural gardens (excluding family and school gardens) exist within the municipal boundaries, accounting for about 1 % of all public green areas and not more than 0.3 % of the city's total surface (Barcelona City Council, 2013). These small areas are the fruit of various attempts to re-establish urban gardening in the city, both by the municipal green space department and by civic initiatives, which are becoming increasingly popular since the economic crises in 2008.

1.5 Thesis description

The thesis consists of a compilation of five scientific articles. These include one book chapter and four papers, presented as individual manuscripts that compose the core of the dissertation. As a compilation of stand-alone publications each Chapter is independently readable. For the same reason, certain degrees of repetition in the background information and case study descriptions have been unavoidable. At the time of writing, Chapter 2 was in press as a Chapter of the book "Urban gardens in Europe" (offspring of the COST-

Action TU1201 "Allotment gardens in Europe"). Chapter 4 was invited for the submission to a special issue in *Landscape and Urban Planning*. Chapters 3 and 6 were accepted in *Environmental Science and Policy* with minor revisions, and Chapter 5 has already been published in *Ecosystem Services*.
All publications underlying the single Chapters, except Chapter 3, have been written under my personal lead with contributions by other authors as listed under each Chapter. The idea for Chapter 2 emerged from the ecology working group as part of the EU-COST Action TU1201 "Allotment gardens in Europe". I led the designing and the writing of the chapter in collaboration with two leading co-authors Monika Latkowski and Erik Gómez-Baggethun.
Chapter 3 is the only Chapter in which I am not the first author. The article resulted from data partly gained through a Master dissertation (Camps-Calvet, 2014), supervised by Erik Gómez-Baggethun and myself and conducted by Marta Camps-Calvet, who kindly agreed to include this publication as a Chapter of this dissertation. The Chapter contains my substantial contribution in all phases of its development, but especially in the selection of methods, data collection, writing, and, to a smaller extend, in the data analysis.
Each Chapter addresses different challenges in the integrated assessment and valuation of urban ES in the context of urban environmental governance. So doing, the dissertation examines urban ES from different angles. In the following, an overview of the dissertation structure is provided, summarizing the single Chapters and explaining how they relate to each other. An overview of the main characteristics of the five Chapters is given in Table 1.i.
Chapter 2 provides a literature review on the ES provided by urban gardens in Europe. The study illustrates the capacity of the ES concept as an interdisciplinary framework to examine the multi-functional character of urban green spaces. It highlights the potential of the framework to raise awareness about the social importance of urban ecosystems and basis for a stronger recognition of the value of urban green infrastructure in urban policy and planning, and the importance of green space management for the stewardship of ES.
Chapter 3 provides the first empirical contribution in the dissertation and is based on a research that assesses multiple benefits and values in urban gardens in Barcelona, Spain. Through a socio-cultural valuation approach the perception of benefits and values by urban gardeners are examined. Results

from this study affirm findings from Chapter 2, regarding the wide spectrum of ES sustained by urban gardens, with a special emphasis on its capacity to produce and sustain cultural ES. The finding of multiple benefits suggests the promotion of urban gardens as a promising strategy to increase human well-being in cities. For example, the study identifies elderly people, migrants, and lower income groups as the main beneficiaries of ES provided by the urban gardens of Barcelona; illustrating a potential for urban gardens to buffer social exclusion in cities, especially in times of economic crisis. In addition, the study found a range of benefits that, to the reach of my knowledge, have not previously been described in the context of ES, such as place-making, i.e. increasing the quality of places through cooperation (*cf.* Healey, 2007), and biophilia, i.e. satisfaction related to see life blooming (*cf.* Wilson 1984). Results indicate the importance of the social context as foundation for benefits and values from urban green spaces, which is further explored in Chapter 4.

Table 1.i: Characteristics of Chapters 2-6.

	Study type	**UES**	**Value dimension**	**Study focus**	**Green space type**
Chapter 2	Review	Multiple	N.A.	Benefits	Urban gardens
Chapter 3	Empirical	Multiple	Socio-cultural	Benefits/ value perception	Urban gardens
Chapter 4	Empirical	Multiple	Socio-cultural	Value formation	Urban gardens
Chapter 5	Empirical	Cultural	Socio-cultural / economic	Value dimensions	Urban park
Chapter 6	Conceptual / Review	multiple	Multiple	Value integration	Multiple

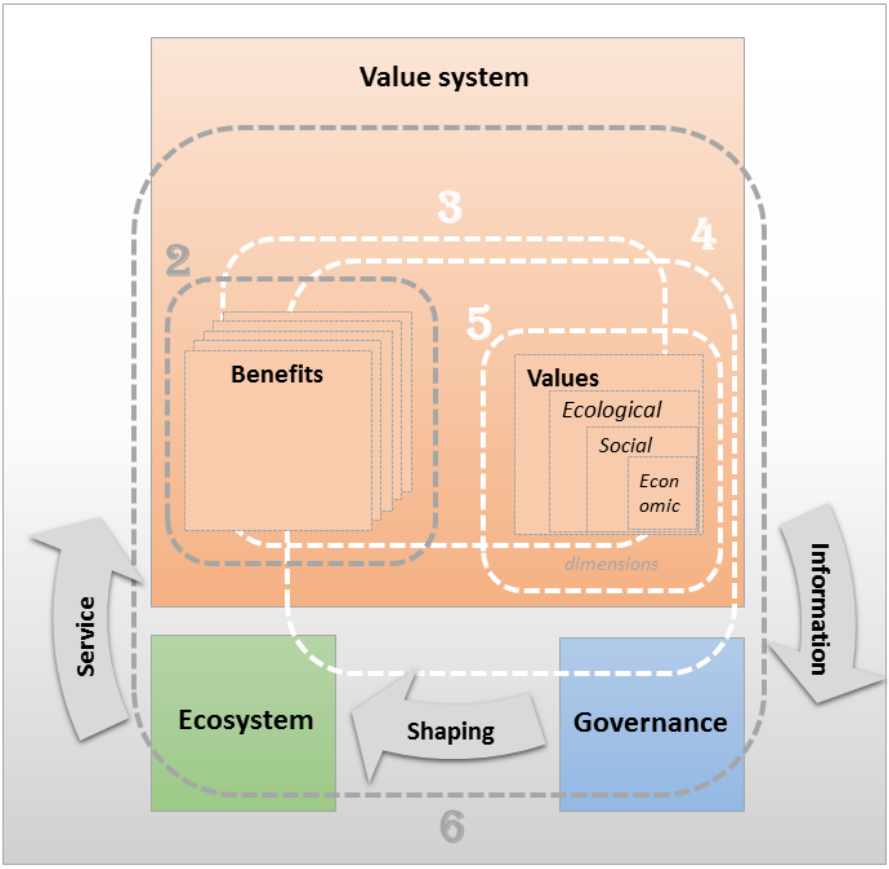

Figure 1.iv: Overview of Chapter II-VI in the conceptual framing of the dissertation.
The thesis consists in five individual manuscripts (Chapters 2-6). Chapter 2 describes multiple benefits humans obtain from urban ecosystems. Chapter 3 assesses benefits and related values as perceived by urban citizens. Chapter 4 examines the foundation of ES values with regard to governance institutions and ecosystem properties. Chapter 5 addresses different value dimensions, in which ES are perceived and assessed. Chapter 6 elaborates a conceptual framework for an integrated valuation of ES in urban planning and examines potential tools for its operationalization.

Building on the findings from Chapter 3, Chapter 4 assesses the context dependent emergence of ES values through examining interfaces between social and ecological properties of urban gardens. Data was obtained through

interviews, field observations and remote sensing in Barcelona, Spain, and urban gardens are characterized with regard to various properties, such as gardeners' demographic profiles, property rights, management, and land-cover. Statistical approaches, including cluster analysis and a non-metrical dimensional scale (NMDS) approach were applied to scrutinize diverging value perceptions by different beneficiary groups and in different types of gardens. Findings illustrate the social-ecological co-production of ES and related benefits and values, and highlight urban gardeners as stewards of these ES. Contrary to the traditional view of ES being produced solely or primarily by ecosystems, the article uncovers the importance of social dynamics behind the generation of ES. In addition to demographic factors, the study shows that the institutional environment (rules and norms) and management regimes of urban gardens have a strong influence on the perception of ES values. This finding provides evidence for the capacity to improve human-wellbeing through appropriate governance of ES, which is the major conceptual assumption underlying Chapter 6. The study further illustrates that ES values provide crucial knowledge for adaptive governance and the management of urban green spaces, something addressed more in detail in Chapter 5.

Chapter 5 combines different valuation methods to assess the importance of urban ES, thereby exploring another aspect of the pluralism of values and the applicability of integrated valuation approaches to assess ES provided by urban green spaces. Based on a case study at Montjuïc, Barcelona's largest urban park, this study exclusively focusses on cultural ES. Data is assessed through a survey among park users by means of an economic travel-cost method and a socio-cultural valuation approach, based on Likert-scale rankings. Results allow for the comparison between values derived through monetary and socio-cultural (non-monetary) valuation in relation to different land-uses and management regimes. Findings outline the importance of different land-use types and management regimes for the generation of ES and related values; thereby reinforcing results from Chapter 4. Furthermore, the study demonstrates considerable differences between the results obtained from monetary and socio-cultural valuation. For example, environmental education shows a relative low monetary value based on individual utility, but an outstanding value in socio-cultural terms, epistemologically also including other-oriented values. It thereby demands urban planning and man-

agement to consider complementary value dimensions in urban green spaces and the services they produce. This is a crucial empirical insight for the conceptual considerations developed in Chapter 6.

Finally, in Chapter 6, I develop a conceptual framework for the integrated valuation of ES using multi-criteria decision analysis (MCDA). The conceptual framework links the ES cascade model to the policy cycle, including agenda setting, policy development, policy assessment, decision-making and policy implementation. The framework makes allowance to findings from the previous Chapters and conceptualizes the role of governance in sustaining ES from urban green spaces, using a planning example from Berlin as illustration. The Chapter further explores the use of MCDA as a tool for the integrated valuation of ES in urban land-use planning, whereby findings from Chapters 2, 3, 4, and 5 about multiple ES and the pluralism of values are core considerations. Based on a review of studies that applied MCDA for ES assessments guidelines for the integrated valuation of ES by MCDA are developed. This includes insights into the stages of problem definition, stakeholder engagement, definition and weighting of ES criteria and prioritization of alternatives. However, the study also demonstrates that besides broad general steps, there is no blueprint for ES assessments by MCDA, and the consideration of value pluralism demands assessments that are tailored to specific decision-making contexts.

Figure 1.v illustrates the overarching structure of the dissertation and the position of each Chapter within this structure.

1.6 Discussion

In this section, I will discuss the main findings from the dissertation. The section is structured as follows. First, I discuss the evidence shown from my studies on the multi-functionality of urban green spaces via ES delivery. Secondly, I will underline the dissertations' advances in the practical consideration of value pluralism in ES. Finally, I will discuss the implications of the dissertation for an integrated valuation of ES in priority setting and urban governance.

1.6.1 Multi-functionality of urban green spaces

Urban ecology recognizes the role of green areas as important pieces of the urban fabric (Cressey, 2015). The concept of green infrastructure embeds the

connotation of multi-functionality of urban green spaces. This dissertation provides evidence for the multi-functionality of urban green spaces and characterizes the multiple ES that urban green spaces sustain, especially cultural ES. For example, the review conducted in Chapter 2 as well as the empirical assessment of benefits in Chapter 3 provides new evidence for the wide range of ES provided by urban gardens, such as experiences of nature sense of place and social cohesion as well as environmental learning. The provision of multiple benefits is an important difference between green infrastructure and the use of technical or civil engineering solutions to urban demands (*cf.* Elmqvist et al., 2013). Where engineering solutions are generally designed to address a single problem, green infrastructure may cost-efficiently address and contribute to different demands in parallel. For example, levees are the civil engineering approach to protect cities from flooding events. While an increase in coastal wetlands may serve as good a levees against storm surges and waves (Costanza et al., 2006), it may, in addition, provide an affluent filter, habitat for species and opportunities for recreational uses. The predominance of a "modernist ideology" in urban planning and design since the 1950s favored civil engineering based solutions (Elmqvist et al., 2013) and still constitutes an obstacle for a stronger implementation of approaches based on the notion of urban green infrastructure. Under the narrow focus on single problem solutions, green infrastructure will often appear less efficient. Hence, the full potential of urban green infrastructure can only be recognized under a holistic perspective that acknowledges the multi-functionality of urban green spaces as a foundation to multiple human benefits. Using an ES framework facilitates the collection and communication of scattered information about the contributions of urban green spaces to human well-being under a common conventional frame. Experiences from Barcelona show the ES approach to be very intuitive to beneficiaries, urban planners and policy-makers (Chapter 3). Furthermore, the awareness about multiple benefits identified in urban gardens allowed further questioning the origin and the generation of ES (Chapter 4). Therewith, additional sensitivity was raised by gardeners for the underlying structure and processes that enabled the ES (including both social and ecological aspects). Such awareness enables practices to sustain ES and is crucial for civic stewardship of ES. Yet, awareness raised through the presented studies is not limited to the beneficiaries. Strategic planners in the City Councils green space department

were strongly welcoming the assessment of multiple values from urban garden. This information is supposed to enable them to defend public gardening initiatives in front of other departments and local politicians. Benefits assessed in Chapter 2 confirmed that the policy push to create new gardens not only matches its main objectives to provide social inclusion and recreational activity to elders, but also created new awareness about multiple (cultural) ES that were simultaneously provided, which planners were not fully aware of before. The ES approach has thus shown itself capable of facilitating awareness raising for the importance of multi-functional green spaces at two levels: (i) among beneficiaries (in this case urban gardeners), and (ii) among practitioners and policy makers, who recognized the usefulness of the ES concept as a tool to communicate green infrastructure benefits across departmental boundaries (*cf.* Kabisch, 2015). For Barcelona the awareness raised can be expected to positively influence the local stewardship for urban gardens, both at the level of practitioners as well as at the level of policy-makers and planners. At the planning level, insights on multiple benefits from urban gardens and parks may contribute to foster further debate about green infrastructure policies in Barcelona. Currently the objectives for green infrastructure creation and maintenance are still narrow, dominated by recreation, aesthetics and habitat connectivity. The studies presented in this thesis justify an expansion of the objectives related to green infrastructure strategies, which may enhance their use as alternative or complement to technological solutions in urban planning. It has been argued that addressing the ES provided by urban green spaces may raise awareness for cities' and citizens' interconnections and dependencies on the non-human nature with other parts of a global ecosystem. Such awareness would be important and desirable in the face of an urgent need for stewardship of ecosystems worldwide (Miller et al., 2005). However, the extent to which a general awareness for the human dependency on natural ecosystems can be raised through the valuation of urban ES remains unclear from the studies presented.

It should be noted that using an ES approach to highlight multi-functionality of urban GI as suggested by Pauleit et al., (2011) and as conducted in Chapters 2 and 3, does not cover all relevant values from urban nature. Given its anthropocentric focus, an ES approach departing from a focus on benefits may overlook important functions of urban ecosystems (especially if they are not connected to human well-being, such as soil formation and water

cycles) as well as intrinsic values of nature and biodiversity (Jax et al., 2013).

1.6.2 Value pluralism and the lack of understanding in human demands

ES assessments in cities have widely focused on ES supply, i.e. on the biophysical capacity of urban green spaces to sustain ES (Haase et al. 2013). Demand is at best assessed through monetary valuation, while non-monetary valuation approaches articulating multiple, intangible ES provided by urban green spaces are still lacking and remain uncondiered by policy-making and planning in cities. Yet, in addition to the important knowledge on the limited capacity of urban green spaces to supply ES (Stott et al., 2015), a diversified understanding on ES demands provides crucial information to steer urban priority setting and decision-making on land-uses. Such understanding, I argue, will help to better inform policies aimed at enhancing urban sustainability, resilience and citizens' wellbeing. First, land-uses and the correlated ES supply in urban areas adapted to citizen ES demands may increase urban sustainability. If the local provision of ES is adapted to the demand, the 'import' of ES to cities may decrease, and this will most probably (in the absence of rebound effects) lower the pressure on distant ecosystems and decrease environmental degradation taking place through teleconnections (Seto et al. 2012), i.e. the ecological exploitation of distant ecosystems for the supply of ES to cities (Hubacek et al., 2009). When thinking about 'sustainable cities', it is however important to note that the capacity to generate ES within urban areas is limited (e.g. Baró et al., 2014). Self-sustainability of urban areas in terms of ES supply covering the demand is unlikely to be reached in most cities, in particular in dense cities such as Barcelona. Consequently, the protection and restoration of urban ecosystems will not substitute the stewardship for healthy ecosystems elsewhere. Secondly, adapting urban green spaces based on a better understanding of ES demands and a partial decrease in the dependency of cities on distant ecosystems may also enhance urban resilience (Mc Phearson et al., 2014). Environmental extremes and wars often strongly affect transport networks and can thereby jeopardize the supply of crucial ES, such as food, water and raw materials. In addition, citizens' purchasing power may be lowered in moments of economic crisis, which lowers the capacity to obtain commodified ES from dis-

tant sources. In the case of minor crisis this can for instance affect the capacity to go on vacation and achieve recreation, in more extreme cases often observed throughout history it may threaten the capacity to guarantee the food supply and cause famines (Barthel & Isendahl, 2013). Thirdly, green spaces adapted to ES demands will also have direct improvements for human health and well-being in cities. The example of urban gardens in Barcelona shows that even small green spaces sustain a broad range of ES if they are adapted to the beneficiaries' demands. The communication of ES values expressing the societal demand for ES has been addressed at the heart of this dissertation. In addition to the ontological and epistemological considerations made in 1.3, the dissertation raises new challenges for the operationalization of ES values in urban priority setting and urban governance, but it also provides a diversified understanding of ES values in cities. Results from Chapters 3, 4, and 5 provide empirical insights on (i) diverging perceptions of values, (ii) context dependency of values and (iii) complementarity ofvaluation languages.

Diverging perceptions of value

Scholte et al. (2015) summarize 'valuers' personal characteristics (as individuals or groups) as one of the main determinants for the perception of ES values. Chapter 3 illustrates the high appreciation of urban gardens with regard to the ES they provide. Findings from Chapter 2 and 3 show that cultural ES are most widely perceived and appreciated in urban areas, thereby confirming insights from socio-cultural valuations in other cultural landscapes (Daniel et al., 2012; Plieninger et al., 2013) and reinforcing previous indications that socio-cultural valuation approaches are required to appraise the values of cultural ES (Gómez-Baggethun & Martín-López, 2015). Value perceptions are not homogenous across different individuals or societal groups; values held for ES may for example change with educational background, age, and gender, only to name a few relevant variables (Bieling et al., 2014; Castro et al., 2011, Martín-López et al. 2012). Annex 6 shows unpublished results from socio-cultural values obtained at Park Montjuïc in Barcelona. These results underline the diverging appreciation of urban ES by local experts, neighbors to the park, Barcelona citizens, as well as national and international tourists. Differences in the values, based on a socio-cultural valuation approach, are however relative small with higher appreciations for

habitat for by experts species, and for air quality regulation by neighbors. Also Chapter 4 shows a different appreciation of ES from urban gardens with regard to the sex, age and origin of the beneficiaries. The consideration of social differences in the perception of values has therefore been highlighted as a democratic requirement to inform urban policy and planning (Chiesura & Martínez-Alier, 2010).

From such different perceptions and under the consideration of social equity, important difficulties emerge to identify the relevant population of 'valuers' (Spash, 2008) to inform urban policy and governance. The survey-based, socio-cultural valuation used in the case studies of Chapter 3, 4 and 5, addressed only garden and park users as beneficiaries and 'valuing' individuals. Values held by citizens who do not use parks or gardens remain thus unconsidered. A further limitation in the applied approach consists in the exclusive examination of individual values, while many scholars argued that especially intangible cultural values can better be elicited through deliberative group valuation (Atkinson et al., 2012; Kenter, 2014; Kenter et al., 2015). It has further been argued that deliberative valuation makes stronger allowance to the public good character of many ES and urban green spaces (Colding & Barthel, 2013; Ostrom 1990:23) which escapes individual valuation. This supports our conclusion from Chapter 6, where the broader use of deliberative approaches for valuation is recommended. However, also deliberative valuation approaches have drawbacks for practical application in priority setting showing difficulties in the involvement of larger social groups.

Context dependency of values

Values attached to ES are assumed also to depend on the specific ecological, social and economic contexts (Chan et al. 2012; Scholte et al. 2015). Chapter 4 underlines different factors underlying the formation of values beyond the characteristics of individuals and social groups. Results indicate that socio-cultural values of ES from urban gardens are especially sensitive to the institutions governing their generation, i.e. the rules, norms and practices, in place, including different property rights and management regimes. The implication of this finding are at least threefold: First, it underlines the context dependency of socio-cultural ES values (Chan et al. 2012; Scholte et al. 2015), which - in the light of priority setting - requires critical consideration

of value transfer approaches, as commonly used for economic values. Secondly, results from Chapter 4 reinforce the hypothesis of ES and related values as being co-produced between social and ecological factors and the importance of understanding urban green spaces as social-ecological systems (Andersson et al. 2007; Jansson & Polasky, 2010). However, results also indicate that ecological and social factors may influence different ES, where social factors seem to have a stronger influence on cultural ES, while ecological and biophysical characteristics, e.g. plot size, relate more strongly to supporting and regulating ES. Thirdly, the results indicate illustrate the critically important role for green space governance in the generation of ES values (*cf.* Gómez-Baggethun & Kelemen 2008). Governance of urban ecosystems seems to influence ES values in two different ways. On the one hand, it provides the institutional molds for the management practices that shape green space structure and functions, which in turn influence the ecological value of urban green spaces (Stott et al., 2015). On the other hand, rules in use, such as the regulation of access seem to directly shape the demand for ES, regardless of the physical shape of the green space. From our results, causal relation between governance institutions, such as property rights, and the importance of ES remain speculative. Yet, the result that institutions influence ES values, and vice versa suggests the need to gain better understanding of the institutions involved in the governance of urban green spaces (Dietz et al., 2003).

Complementarity of valuation languages

Different methodological approaches are supposed to influence the articulation of ES values (Martín-López et al. 2012). Chapter 5 reinforces theoretical and empirical considerations regarding the differences between monetary and non-monetary (socio-cultural) valuation approaches (Gomez-Baggethun & Martín-López, 2015). While monetary valuation often fails to capture the less tangible social and ethical concerns,(Chan et al., 2012a, b), results from this dissertation suggest a stronger capacity of socio-cultural valuation approaches to capture ‘others-oriented’ and non-utilitarian values (e.g. intrinsic, deontological, and relational values) as underlying motivations for environmental stewardship.An example is the value of Montjuïc for environmental education (Chapter 5). While its monetary value — expressing the park users’ individual utility — is low, the value obtained through socio-cultural

valuation is high due to the importance given to the benefits from environmental education provided to others. However, despite some apparent advantages over monetary valuation in addressing cultural ES, social-cultural valuation approaches are also not immune to limitations. Some specific restrictions of socio-cultural valuation approaches, such as a potential bias in the survey-technique to overestimate the value of cultural ES (Calvet-Mir et al., 2012), have been raised in Chapters 3 and 4. A major drawback for the communication of green space values in the context of urban priority-setting and decision-making is given by the lack of reference values and hence a weak comparability of values. The social-cultural valuation approach applied in this dissertation allows for the comparison of values between the different ES addressed in the same survey, but it does not allow a comparison with other values. For example, the socio-cultural valuation results presented in Chapter 3 show that in urban gardens recreation is perceived as more important than any other cultural ES. However, I am unable to compare the value of urban gardens for recreation with the value of demolishing the garden to construct, for example, a social housing project. Furthermore, because the survey was conducted among direct beneficiaries, the socio-cultural values presented here do not allow quantifying the overall value for the entire urban society. Monetary valuation — such as applied to derive the value for cultural urban ES at Montjuïc in Chapter 5 — shows a clear advantage in this respect, which partly explains its appeal. As socio-cultural valuation gains further importance in the valuation of ES, further limitations will most probably enter the spotlight as has been the case with monetary valuation approaches, which have captured most of the attention to date.

1.6.3 Integrated valuation

Cities are unlikely to become independent from non-urban ecosystems for the supply of ES. In fact, the more cities grow, the more they often depend on non-urban areas (Elmqvist et al., 2013). Urban planning in the future is supposed to be capable of shaping urban green spaces to optimize the provision of ES (Stott et al., 2015). However, this dissertation shows that there is global optimal match between supply and demands of ES, given diverging perceptions of values, their context dependency and the complementary character of different valuation languages. By addressing the epistemological and ontological complexity embedded in the valuation of urban ES, this dis-

sertation shows the difficulty of providing a global blueprint for the integrated valuation of urban ES. However, it sheds light on current challenges and important aspects to be considered for an integrated valuation of urban ES in different contexts. Awareness about this complexity is, I believe, a crucial insight for a stronger operationalization and practical consideration of ES in urban decision-making. Above I described challenges related to (i) diverging value perceptions, (ii) context dependency of values, and (iii) valuation languages. Based on these findings, I call for an valuation of urban ES that: (i) considers values expressed by different social actors, (ii) is adapted to the social and ecological context, and (iii) incorporates different value dimensions to represent the supply and demand of ES (*cf.* Paetzold et al., 2010), including a representation of ecological, social and economic values. Based on the results obtained for Park Montjuïc (Chapter 5), monetary valuation alone does not seem to provide a good representation of the social demand for ES. An integrated valuation of ES fulfilling these conditions may provide the informational foundation for a governance of green space that leads to a good match between the supply and demand of ES (Gomez-Baggethun & Martin-Lopez, 2015). Yet, enabling green space governance in cities based on the integrated vision of ES may also be challenging for other reasons. For example, it may include different institutional actors across administrative sectors and scales (Primmer & Furman, 2012), including policy-makers, planners and managers to whom information about ES value need to be facilitated. The ES-policy-cycle developed in Chapter 6 provides an ideal conceptualization for an integrated valuation of ES to enable an adaptive governance loop, when institutional actors are included. To date there is no global blueprint for the practical conduction of an integrated valuation of ES and practical testing of the theoretical considerations is needed. However, the review conducted in Chapter 6 indicates strong capacities to MCDA as a tool to operationalize the integrated valuation of ES. The usefulness of this tool will be judged on at least two requisites: (i) a conceptually sound representation of the pluralism of values (as partly discussed in this dissertation), and (ii) the effective communication of ES values to decision-makers.

1.7 Concluding remarks

This dissertation is the fruit of three and a half years of research motivated by the aim of assessing ES to enhance societal awareness for the human

dependency on healthy ecosystems and the consideration of ES in priority setting and decision-making. Firstly, this dissertation enhances the awareness on multi-functional urban green spaces as sources of ES for urban inhabitants as a foundation for the governance of urban green spaces. Secondly, it provides additional understanding of the pluralism of ES values. Advances in this sense can be divided into better understanding of value perceptions by different societal groups, the context dependent character of ES values, as well as complementary valuation languages. Finally, the dissertation provides insights and guidance for an integrated assessment of ES informing the governance of urban green spaces. With the results obtained from the interdisciplinary research conducted in this dissertation, I hope to contribute primarily to the two research fields: (i) urban ecosystem service research, and (ii) urban ecology.

1.7.1 Advances in urban ecosystem service research

The contribution of this dissertation to the research field of ES is threefold. First, the dissertation underlines the need for context specific, adapted classifications of ES. While this need is frequently demanded, it is still often neglected in practical assessments. The assessments of ES from urban green areas and related values have shown significant differences to the most commonly used ES-classifications (MA, 2005; TEEB, 2010) — especially by eliciting a wider range of cultural ES (e.g. biophilia, place-making). While the study at Park Montjuïc relied on standard ES categories as established by TEEB, studies on urban gardens identified a wide variety of specific urban ES – often related to intangible values such as place-making and biophilia which had not had been described as ES before. The need for adapted ES classifications (for studies focusing on local scales) is thus especially important for ES valuation. Secondly, in the field of monetarily dominated research on ES, this dissertation further advances the methodological and theoretical understanding on the non-monetary, socio-cultural valuation of urban ES, adding to recent progress in this direction (e.g. Chan et al. 2012a, b). In this context, the dissertation provides further insights on values from different social actors, about the context-dependency of values, and the complementarity character of monetary and non-monetary valuation approaches. By doing so, it provides further reasoning for overcoming the paradigm of single-monetary valuation in ES research and for broadening the

foundation to mainstream socio-cultural valuation approaches. One step in this direction is the acknowledgement of methodological challenges and shortcomings in the application of socio-cultural valuation approaches. For example, the need for comparable reference values to inform practical land-use decision-making. Thirdly, this dissertation contributes to bring the ES approach closer to an implementation in urban policy and planning. From a practical perspective, small scale assessments of ES values, such as provided for Park Montjuïc, can inform urban planners in undertaking concrete measures that enhance the provision of specific urban ES, for example through adaptations in the management regime of green spaces. Through the examination of MCDA I have further outlined a promising approach to operationalize integrated assessments of ES in policy and planning.

1.7.2 Advances in urban ecology

Ecologists have only recently embraced their urban side (Cressey, 2015), and scholars like Niemäla, Elmqvist and Pickett were pioneers in approaching cities and urban areas as coupled social-ecological-systems (Niemelä et al., 2011; Pickett et al. 2013; Elmqvist et al., 2013). The City of Barcelona has recently developed a substantial urban green infrastructure strategy. Therein, it embraces urban green spaces as integrated components of the urban fabric – just in the sense of an urban ecology. Within urban ecology research, this dissertation puts strong emphasis on the social aspects. Where most previous research in the field addressed ecological processes, human perceptions and values of green spaces are an important complementary focus. The valuation of ES from urban green spaces helps to understand the 'hybrid nature of urban systems' (Pickett et al. 2013: 476) with humans as an integral ecosystem component. The thesis may advance urban ecology in two ways: First, it may help to further overcome the strict division between the rural and the urban, the human and the natural, which is still immanent in ecology as well as in urban planning and design. As argued in this dissertation, cities' inner and adjacent green spaces must be included in the global effort to maintain healthy ecosystem and guarantee the ES supply. Highlighting the multi-functionality and multiple benefits of urban green spaces, as exemplary conducted for urban gardens in Barcelona, is a step forward in this direction. This may also help to overcome the paradigm of cities as 'par-

asites of the biosphere' (Odum, 1971) with large environmental footprints on the earth's ecosystems. The latter understanding of cities is – I believe – manifesting the division between the urban and the rural and therefore contra-productive for holistic solutions to the global challenge that the depletion of ecosystems and related ES constitute. Secondly, an ES approach may facilitate an urgently needed integration and operationalization of principles derived from urban ecology into urban governance. The dissertation shows that green space governance matters when it comes to the stewardship of ES from urban green spaces. Green space governance, planning and management alter the physical shape and conditions of urban green spaces and its capacity to provide ES. In addition, I showed here conceptually and empirically that the governance of green spaces, including rules, norms, and practices, is part of the foundation of ES and related values. In praxis, the empirical data gained through this dissertation on the perception and appreciation of ES from urban green spaces has already shown to provide useful information for the implementation of green infrastructure strategies. For example, uncovering links between ES values and property and management regimes in urban gardens and parks provides information for ecosystem stewardship to boost specific values. The proof of multiple values from urban horticulture gardens has encouraged the green space department to further promote gardening initiatives in the city of Barcelona. However, if urban ecology embraces the ES approach it is important to notice that the ES approach can be both an 'eye-opening metaphor' as well as a 'complexity-blinder' (*cf.* Noorgard, 2010). Even an integrated valuation of urban ES following the principles of value pluralism as outlaid in this thesis may be blind to ecological complexity. Due to the anthropocentric perspective the ES approach embeds, the importance of ecological processes and biodiversity which do not show clear links to human benefits might lose attention. In my opinion, this should not shy urban ecologists away from the use of an ES approach; it should rather motivate them to stronger engagement in public debates and to demonstrate the need of healthy ecosystems, even if they are rather future assets than immediate benefits.

1.8 Future research

The findings from this dissertation indicate future research in the fields of urban ecosystem service research and urban ecology. Here I specify those which I find the most interesting and relevant to pursue.

The dissertation frames urban green spaces as integrated elements of urban landscapes with strong entanglement and interdependencies with the urban fabric. I argued above that research on urban ES from such perspective might constitute a momentum to move from a one-dimensional, engineering problem-solution based thinking in urban planning and design towards a more holistic understanding of green spaces as multi-functional green infrastructure capable of enhancing urban resilience and prepare cities for uncertain effects of climate and other global environmental change. A challenge in this context is gaining better understanding of the interplay between green infrastructure, built infrastructure, and institutional arrangement in providing urban ES, or phrased differently the combination of 'nature-based solutions' with technical-engineering solutions and governance. In this context, the creation of cross-scale learning labs with broad stakeholder representation might serve as arenas for developing, testing and evaluating the co-design of multi-functional, nature-based solutions adapted to local demands for urban ES in urban areas.

Another research challenge that could be addressed in such learning labs is the further operationalization of an integrated valuation of ES in practical urban policy-making, planning and management situations. One important question in this context is: Whose values are to be considered, and in which decision-making context? This question is by no means new; it is rather one of the initial questions in the development of political systems since ancient times. But it needs to be newly discussed in face of urban policy-making as a driver behind distributional effects in the provision of urban ES, which poses a new need for policy-makers to justify planning decisions. Assessing the value of green spaces for urban societies and distribution of benefits poses an important challenge to the emerging field of socio-cultural valuation of ES and requires the development of new methodological approaches. Another remaining question in ES research regards the integration of different value dimensions. Operational guidelines need to be provided for the consideration of multiple value dimensions in practical decision-making. In this context the further development, testing and implementation of tools such as

MCDA for a systematic integration of multiple values in real-world decision-making processes seems strongly demanded.

Finally, I believe that urban horticulture and peri-urban agriculture merit an even stronger focus in the face of urbanization and the resilience of social-ecological urban systems. On the one hand, a research challenge results from the enhanced disconnection of urban inhabitants from ecosystems and ecosystem processes. Food production is an easy to comprehend, life-sustaining ES, which may help to raise new awareness for the human dependency on nature and the link between human behavior and the health of ecosystems. On the other hand, local agricultural production is threatened by urbanization processes and therewith the resilience of urban social-ecological systems. Yet, today urban agriculture is still widely conducted and local food-webs are still partly intact in many parts of the world, this is also partly the case for Barcelona. I believe a better understanding of agricultural areas as future assets or insurance values in the face of urban resilience is required, as well as an identification of co-benefits in form of other ES resulting from the production of food. Such insights might help to alter the current trend of transformation of agricultural area and "support positive economic, social and environmental links between urban, peri-urban and rural areas" (United Nations, 2014:11.a) as proposed as an UN development goal for 2030 through sustainable development strategies and adaptive governance systems.

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Chapter 2

Ecosystem services from urban gardens

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2.1 Introduction

Urban allotment and community gardens provide a flow of important and miscellaneous benefits to humans, such as the provision of food (e.g. Buchmann et al. 2009; Barthel & Isendahl 2013), pollination (Andersson et al. 2007), and local climate regulation (Gómez-Baggethun and Barton 2013), as well as recreation (e.g. Kaplan 1973) and social cohesion (e.g. Armstrong 2000).

Urban gardens in Europe are experiencing contrasting trends. In many cities urban gardens are threatened by urbanization pressures, as the following examples illustrate. In Barcelona almost all urban gardens were removed for the Olympic Games in 1992 and currently only about 0.05% of the city's surface is covered by allotment and community gardens (Camps-Calvet et al. forthcoming). In Poland, the country with the highest number of allotment gardens per person in Europe (Wycichowska 2013), gardens are increasingly under development pressure for housing, office building and shopping centers in order to increase land revenues for public and private owners (Kronenberg et al. 2013). In Vienna, a creeping loss of allotment gardens is occurring caused by changes in garden regulations that allow owners to live permanently in the gardens (Voigt 2014).

In parallel with these trends, a revival of urban gardening is taking place and new initiatives, often for community gardens, are emerging across Europe, as societal awareness of the multiple benefits and ecosystem services they provide increases. For example, in Barcelona the community garden '*Hort Fort Pienc*' is a successful case of civic greening of vacant plots (Camps-Calvet et al. 2015). In Berlin, the allotment garden colony ('*Kleingartenkolonie'*) Oeynhausen has recently gained a district referendum regarding its future continuation against city development plans. So the multifunctionality and societal importance of urban gardens are often still underestimated by local authorities and urban planners in many European cities (e.g. Pawlikowska-Piechotka 2010; Kronenberg et al. 2013; Wycichowska 2013).

In this Chapter, we examine ecosystem services, understood as the flow of benefits from urban gardens to humans, thereby providing a collection of empirical evidence for their multi-functionality. Urban gardens are here understood as coupled socio-ecological systems that include humans as an integrated and interacting part of the garden ecosystem (e.g. Buchmann 2009;

Barthel et al. 2010). Ecosystem services are thus understood as being a co-production of ecological processes and human activities, such as gardening. The Chapter follows the classification of ecosystem services introduced by *The Economics of Ecosystems & Biodiversity* (TEEB 2010) based on the *Millennium Ecosystem Assessment* (MA 2005), these being classified as provisioning, regulating, habitat and cultural services. To illustrate this the Chapter provides in-depth insights from a selection of urban garden case studies selected from cities located in the culturally and geographically different regions across Europe, including Paris (France) and Salzburg (Austria) as an examples for Western Europe, Bologna (Italy) for Southern/Mediterranean Europe, Warsaw (Poland) for Eastern Europe, and Tampere (Finland) for Northern Europe. Practical guidance on how to enhance ecosystem services from urban gardens is given in Chapter 7.

2.2 Urban gardens and quality of life

The concept of ecosystem services is increasingly being used to highlight the links between urban ecosystems and human well-being (Bolund & Hunhammar 1999; MA 2005). They have been defined as a flow of benefits from an ecosystem, sustained by its structure and processes, to humans (Haines-Young and Potschin 2009; TEEB 2010). In urban contexts the ecosystem service approach is increasingly used to describe the flow of benefits that the planned network of urban green spaces (urban green infrastructure) provides to humans (Bolund & Hunhammar 1999; Anderson et al. 2007; Breuste 2010; Pauleit et al. 2011; Guitart et al. 2012; Gómez-Baggethun et al. 2013). A socio-ecological-systems perspective widens our perception of ecosystem services from purely ecological characteristics towards social and cultural aspects. This involves a consideration of specific garden properties (such as reciprocal human-plant-soil interactions), its ecological, cultural and historical development, as well as gardens' functions within a broader urban environment (see Box 6.4). Assessing the flow of ecosystem services from urban gardens and acknowledging the ecological, social and economic values attached to them may support an increased visibility of the societal importance of urban gardens and appreciation of them by policy-makers.

2.3 Types of ecosystem services

Provisioning services describe the physical flow of goods that humans obtain from ecosystems, such as food, fiber and medicinal plants (Pourias et al. 2015). *Regulating services* are flows of physical benefits that humans indirectly obtain from ecosystems, including pollination (Kearns et al. 1998), local climate regulation (Henn 2000), pest control (Barthel et al. 2010), and seed dispersal (Andersson et al. 2007). *Habitat services* (also referred to as *supporting services*) refer to the underlying flow of indirect benefits on which the delivery of all other ecosystem services ultimately depends (TEEB 2010). They include water, nutrient and energy cycles as well as the complex capacity to host biological diversity, such as the provision of habitats for plant and animal species (Breuste 2010). Finally, *cultural ecosystem services* are the non-material flows of benefits from ecosystems to humans (TEEB 2010; Chan et al. 2012), including recreation, amenity, and social cohesion (e.g. Camps-Calvet et al. forthcoming; van den Berg et al. 2010).

Despite the growing understanding of the multiple benefits humans can derive from urban gardens, most of the existing research on the topic is fragmented. Comprehensive assessments about the wider range of ecosystem services provided by urban gardens have appeared only recently. For example, within a recent study by Camps-Calvet et al. (forthcoming) conducted in Barcelona, gardeners identified 20 ecosystem services for urban gardens, with cultural ecosystem services being the category most widely appreciated and most highly valued by gardeners.

2.3.1 Provisioning ecosystem services

Provisioning services describe material outputs from ecosystems, including food and other resources (TEEB 2010). Primary material outputs of urban gardens in Europe are edible plants such as vegetables, herbs and fruits, and animal products such as eggs and honey (Box 6.1). However, urban garden products are more diverse and may include wood, medicinal and ornamental plants. A case study from Warsaw (Stępien 2014) demonstrates that the production of food has lost importance in allotment gardens, and edible plants are replaced by ornamentals (Box 6.3). This trend can be observed in many urban allotment gardens across Europe and may indicate a larger, current shift in urban gardens from provisioning material benefits, especially the provision of food, towards cultural benefits including aesthetics and recrea-

tion. In Salzburg, for instance, 23% of the gardeners stated that they reduced areas used for vegetable production; while over 40% increased the area of flower beds (Box 6.5) (Breuste & Artmann 2014).

Food provision

The contribution of urban gardening to city food supply has been estimated in a number of cities, for example, in Salzburg, Austria, out of 156 urban gardeners, 76% cultivate their own fruits and vegetables, providing, for the majority of gardeners, 10% of their annual fruit and 44% of their vegetable consumption (Breuste & Artmann 2014). However, the full recognition of urban garden's importance for the provision of food has been hindered by scant, scattered and fragmented data, given that comprehensive research has scarcely addressed this topic (Orsini et al. 2013; Pourias et al. 2015). A broader understanding of the role of urban gardens in terms of food security and healthier diets is thus still lacking. This knowledge gap is being addressed through research programs and research networks, such as *Farming Concrete* in the USA (Gittleman 2012), *Jassur*[2] in France and the *Italian Research Centre on Urban Horticulture and Biodiversity* in which data is collected and knowledge exchanged about the (potential) contribution of urban gardens to household consumption. Boxes 6.1 and 6.2 show some results from cutting edge research on production yields and potential food production by urban roof-top gardens. Pourias et al. (2015) highlight the high variability of yields from one garden plot to another, explained by the variable social and ecological factors influencing garden productivity, including the size of the plots and cultivated areas, regulations, cultural practices and skills as well as the motivations of gardeners (*cf.* Box 6.1).

Two critically important benefits from food production in urban gardens are contributions to food security and diet improvement. Today, urban societies in Europe mostly depend on agricultural areas to meet their demands for food. Yet, as demonstrated in Chapter 1, urban gardens have played an important role for the supply of food and food security in many historical periods, with the importance of urban gardens for food security increasing during economic and political crises (e.g.–Barthel & Isendahl 2013; Gomez-Baggethun et al. 2013). For example, in Europe and the United States, the provision of food by urban gardens formed part of adaptation strategies in

times of wars (McClintock 2010). Barthel et al. (2010) estimate that during World War II, when Sweden was affected by severe food shortage, 10% of the food consumed in the country came from urban (allotment) gardens.

Box 1: Food provision by collective urban gardens in Paris, France

By Jeanne Pourias

Collective gardening in Paris has developed substantially in recent years, both in terms of the number of gardens and people participating in them. Within the city there are currently more than 120 shared gardens, compared to five in 2003, when the City Program "Main Verte" (Green Thumb) was created in order to promote and supervise the creation of collective gardens. From 2011 to 2014, seven collective gardens in Paris and its suburbs were monitored (Pourias et al., 2015), and the gardeners in charge of each plot were interviewed on the importance of the provisioning services of their plots.

Figure 2.i Parisian gardener weighing her harvest of raspberries before filling her booklet, Paris (France). *Photo Jeanne Pourias.*

[2] See http://www6.inra.fr/jassur for further details on this ongoing national research project

Garden products in Paris are highly variable. The largest proportion found in all seven gardens consists of vegetables, fruits, and herbs. The same is true for flowers, which provide aesthetic values, are edible (such as nasturtiums, borage, etc.), or protect vegetables against pests and diseases. In six out of seven gardens ─ those in which trees may be planted ─ fruit trees (apples, pears, cherries, plums, etc.) can form a substantial part of the harvest. Finally, the gardens occasionally supply other products such as wood (1 out of 7), eggs and snails (2 out of 7). Breeding small animals (chicken or rabbits) is tolerated in certain shared gardens but the municipality's position on this subject is extremely vague. It is however prohibited in most family gardens in the suburbs.

In 2012, 14 gardeners agreed to weigh all their harvests and to report them in a "harvest booklet". The total amounts of fruit and vegetables produced varied considerably from one plot to another. It did not only depend on the size of the plot, but on the distribution of different land-uses within the plots (e.g. area of food crops, lawn, garden cabins and picnic area), as well as cultivation practices. Peri-urban family gardens usually offer big individual plots: in such gardens, in some cases, an important part of the plot was dedicated to paths, garden cabins, picnicking and playing areas to the detriment of productive areas. In intra-urban gardens, where plots are smaller, the plots were more often dedicated in their entirety to food production.

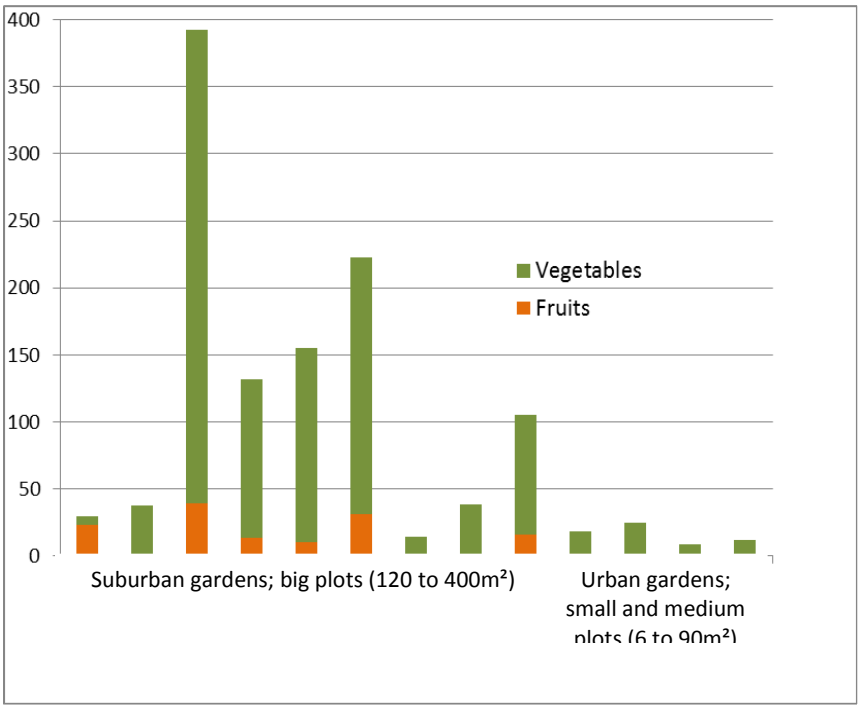


Figure 2.ii. Fruit and vegetable harvest (in kg) in collective gardens in Paris (France). *Secondary data from Pourias et al. (2015) collected at 14 sites.*

Currently, urban gardens have been described as a way to tackle the emergence of inner city food deserts, i.e. guaranteeing the provision of food in areas of the city where it had disappeared (Corrigan 2011). As further discussed in Chapter 13, urban gardens have been described as an important source of resilience, not least, due to their potential to provide food to urban people in moments of crisis (Andersson et al. 2007; Barthel et al. 2010; Barthel & Isendahl 2013). Although the value of resilience is difficult to measure (Jansson and Polasky 2010), the importance of urban gardens in sustaining urban societies through the provision of food is obvious when looking at cities in the global South (e.g. Altieri et al. 1999; Buchmann 2009).

Despite the crucial of gardens in times of crisis, studies indicate that urban gardens may also help to improve citizens' daily diets. Keatinge et al. (2011)

demonstrated that in London, fruits and vegetables from urban gardens reduced malnutrition and promoted healthier diets among gardeners. Similarly, urban gardeners in Barcelona recognized the improvement of the quality of their food as an important benefit (Camps-Calvet et al. forthcoming). US citizens involved in community gardens consumed fruits and vegetables 5.7 times per day on average, against 4.9 times a day for people gardening in a private garden and 3.9 times per day for non-gardeners (Alaimo et al. 2008; Litt et al. 2011). What remains unclear is if gardening contributes to greater awareness of nutrition issues or whether the increased accessibility to fruit and vegetables is creating this different consumption pattern.

Box 2: Urban horticulture and food production in Bologna

By Francesco Orsini

The city of Bologna has always been at the forefront of urban agriculture in Italy. Its Mediaeval structure still contains a number of inner voids, such as parks and gardens that were formerly classed as "hortus conclusus". The city regulated urban allotment gardens in the 1980s. Today, their number is still one of the greatest in Italy (more than 3,000 plots within the city boundary plus other 2,700 plots in the province). The commitment of the local municipality and University (where the first Italian Research Centre on Urban Horticulture and Biodiversity was recently established) has led to the implementation of the first municipal rooftop horticulture program in Italian social housing. These community gardens are promoted for their multifunctional role, which spans food production and a range of social and ecosystem services.

In a recent study (Orsini et al. 2014) the potential for food provision from urban green roofs was examined. The study was based on experimental trials on a pilot rooftop garden (over 200 m^2, hosting three simplified soilless systems and 8 vegetable crops over three years of experimentation), and extended using assessment of aerial images to identify the city's flat rooftops. It was estimated that if the 82 ha of available rooftops in the whole city could host simplified, soilless gardens, a potential yield of 12500 tonnes per year could be obtained, amounting to more than three quarters of the city's

demand for vegetables.

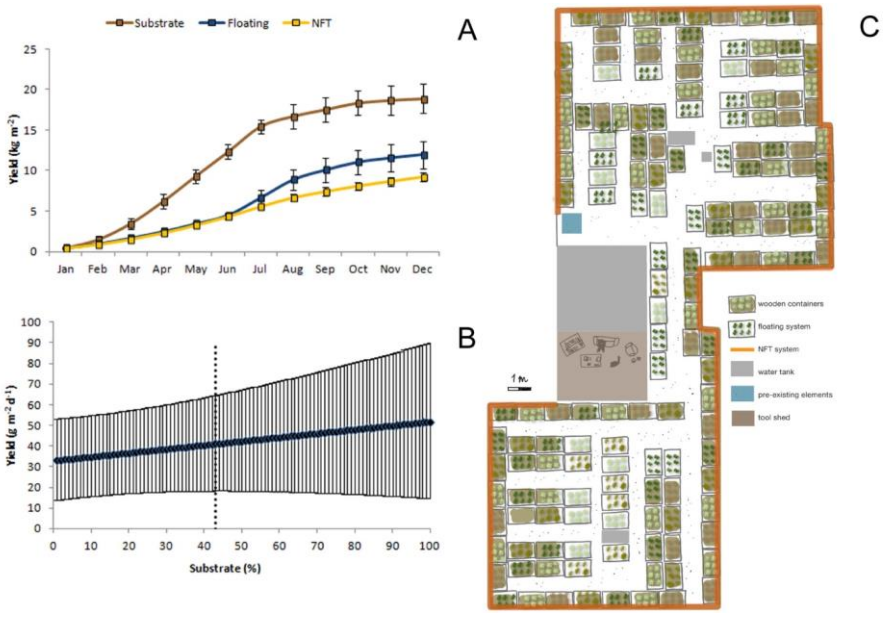


Figure 2.iii. Procedure for defining optimal garden composition
Re-arranged from Orsini et al., 2014.

A) Cumulated yield of the simplified soilless systems (Substrate, Floating and NFT) used in the experiments according to crops grown in each season. Data calculated on mean values of tested crops in each growing system. Vertical bars indicate standard errors. B) Optimum ratio between floating system and substrate cultivation system. Mean daily productivity (g m−2 d−1) within seasons across the year. Vertical bars indicate standard errors. Dotted vertical bar represents optimum ratio (43:57 for substrate: floating system) enabling satisfactory yield and reduced seasonal fluctuations in productivity. C) Graphical representation of the garden to be implemented in this case study rooftop according to optimum growing system ratios.

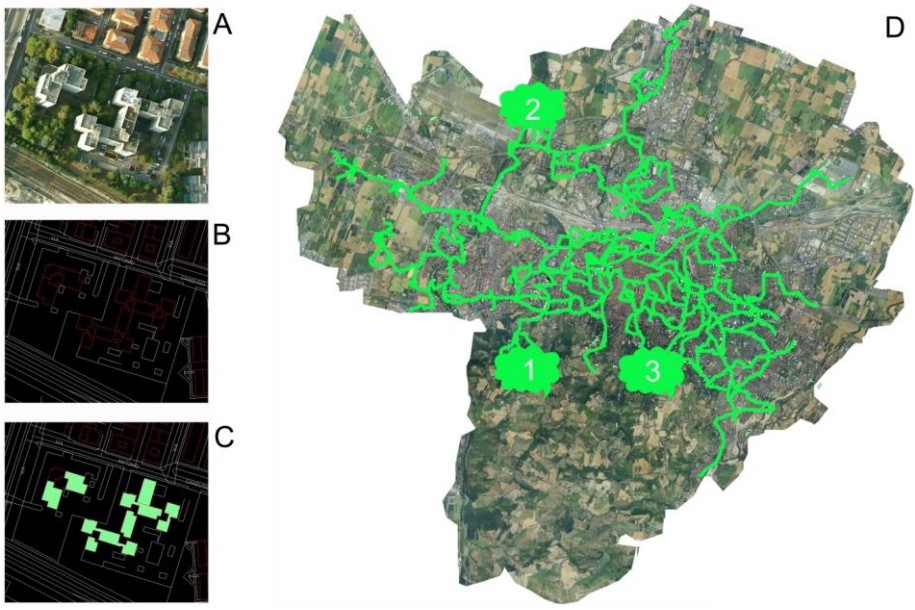


Figure 2.iv. Procedure for identification of available flat surfaces and green corridors creation. *Re-arranged from Orsini et al., 2014.*

A) Identification of flat rooftops on GoogleEarth(r), B) Transfer on urban city maps, C) Calculation of available surfaces through Autocad(r), D) Localization of three biodiversity reservoirs (1, Bosco di San Luca SIC-ZPS IT4050029, 2, Golena del Lippo SIC-ZPS I T4050018, 3 Giardini Margherita) and flat surfaces identified for RTG implementation (black spots). Green lines identify ecological corridors across the city of Bologna connecting RTGs within 500 m distance of each other.

Provision of medicinal and seasoning plants

Vegetables and herbs grown in urban gardens are sometimes rare or exotic and difficult to find in shops. The links between crop diversity and cultural values and benefits of gardeners is highlighted by Duchemin et al. (2010), who looked at the potential of community gardens to supply minority groups with fruits and vegetables appropriate for their diet. A study on vegetable gardens in New Orleans showed their importance for producing exotic vegetables in the neighborhood of Versailles, the largest Vietnamese district in

the United States. A wide variety of vegetables and herbs was grown, allowing residents to maintain traditional eating habits, reducing the effects of acculturation, especially among elder people, and substantially reducing food expenditure in household budgets (Airriess & Clawson 1994). In Parisian urban gardens many traditional medicinal and culinary plants were found, including exotic species from Asia and Africa grown by immigrants (Pourias et al. 2015). In studies in three Polish cities (Breslau, Cracow, Katowice) only seven species of medicinal plants were found, including *Mentha piperita, Melissa officinalis* (the two most common ones), *Matricaria chamomilla, Viola tricolor, Artemisia abrotanum, Urtica dioica* and *Hypericum perforatum*. They were very rarely grown because the gardeners rarely used them as fresh products. Seasoning herbs were more popular, with *Anethum graveolens, Levisticum officinale, Armoracia lapithifolia* and *Ocimum basilicum* as the most common species (Klepacki 2012).

Ornamental plants

Ornamental plants are an important element in urban gardens. As they have relatively small economic value, they have been the subject of very few studies (e.g. Szczurek & Zych 2012). Yet, as seen in Poland (*cf.* Box 6.3), the production of edible plants is increasingly being replaced by ornamentals indicating that they are becoming more important. Researchers participating in the Polish project *'dzieło - działka'* (*'work - allotment'*) of 2009-2011 showed the increased role of ornamental plants in the contemporary Polish allotment gardens (Kujawska 2009) grown for their decorative value, with herbaceous ornamentals (i.e. 'flowers') as the main element of garden decoration or as cut flowers (for personal use or as gifts) (Dunnet & Quasim 2000). These usually need less maintenance than vegetables and woody and hardy perennials can last for many years.

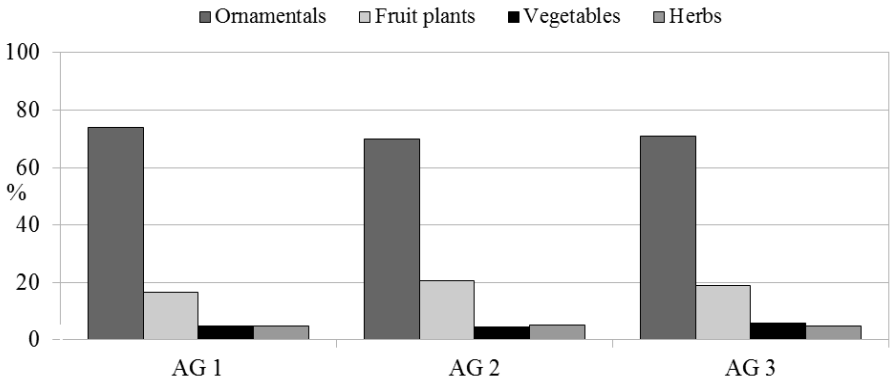
Box 3: Provision of ornamental plants in allotment gardens in Warsaw, Poland

By Monica P. Stępień &Monika J. Latkowska

Allotment gardens are the main type of urban gardens in Poland, the country with the highest density of urban gardens per capita (ca. 6 plots per 100 in-

habitants). In Warsaw there are 176 allotment gardens (belonging to the Polish Federation of Allotment Garden Holders) covering an area of about 1170 ha (0.2% of city area) (data from 2013). In 2012 – 2013, in three allotment gardens in Warsaw 90 randomly selected plots were surveyed using structured interviews with the plot owners and on-site *observations* to identify the plot use and cultivation of different plant species (Figure 2.v). In all plots both ornamental and edible plants (fruits, vegetables and herbs) were grown, however, cultivation of edible plants is now not the main type of garden usage. In all gardens studied, the number of ornamental plant species dominated over edible plants; reaching ca. 70% of all cultivated species. Among them herbaceous species (mainly hardy perennials), providing flowers, were more popular than woody ones (Figure 2.vi).

Figure 2.v. Groups of plants cultivated in three allotment gardens (AG) as percentage of all cultivated species. *Secondary data from Stępień (2014).*



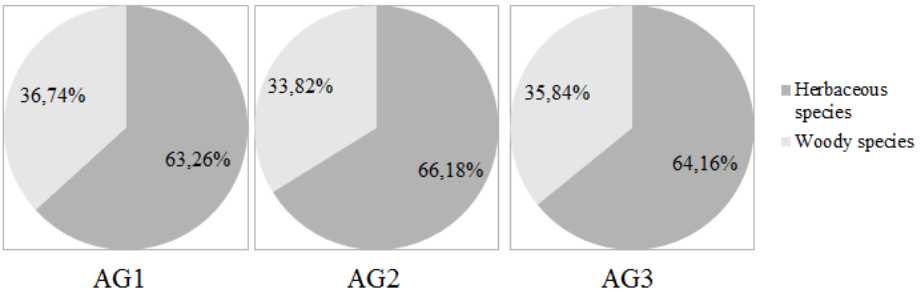


Figure 2.vi. Ornamental plants cultivated in three allotment gardens (AG) as percentage of cultivated ornamental species. *Secondary data from Stępień (2014).*

2.3.2 Regulating Services

The interconnected global biosphere, including species, soil, air and water, acts as a natural regulator of the human environment and maintains the conditions required to sustain human life on earth (TEEB 2010). Urban green spaces and urban gardens are only a small fraction of the global biosphere; hence, the role of urban gardens, for example, in global water and carbon cycles is limited. However urban gardens can provide important local regulating services, such as an improvement of soil quality, soil erosion prevention, water retention, runoff mitigation, microclimate regulation and pollination (e.g. Cameron et al. 2012; Edmondson et al. 2014).

Improvement of soil quality

Chapter 6 describes the quality of soil as determined by a complex interplay of soil components, such as minerals, nutrients, temperature, water and microorganisms. One direct benefit from improved soil quality in urban gardens lies in enhanced yields (Boen et al. 2013), as well as beneficial effects on biodiversity. Several studies have examined the contribution of urban gardens to the improvement of soil quality. Malinowska & Szumacher (2008) found in Warsaw that, in comparison to non-cultivated soils outside the city, soils in allotment gardens had higher humus content (due to organic fertilization), good cloddy structure and were rich in nutrients. A second benefit resulting can be the cleansing of contaminated soils, since urban gardens are often located on former brown fields and landfill sites or close to traffic infrastructure (see also Chapter 6). Minerals and organic components

in soils, such as plant roots, have the capacity to bind different pollutants, preventing their migration into the ground water, and reducing risks to drinking water supplies. Research has demonstrated that mineral material in soils can immobilize heavy metals, such as lead, by up to 30% (Li et al. 2009). However, the potential pollutant stabilization of different soils is still disputed (Shi et al. 2008; Xiu-Zhen et al. 2008).

Erosion prevention and water retention

Erosion is mainly prevented by the root systems of vegetation, which stabilizes soil against rainwater run-off, thereby decreasing the risk of floods and landslides. Plant and soil characteristics are both crucial for the water retention capacity of urban gardens. Due to minimal presence of non-permeable surfaces, allotment gardens help to regulate the natural water cycle such as precipitation, evapotranspiration, retention, infiltration and outflow (Malinowska & Szumacher 2008). Water retention by urban gardens is based on critical and interrelated soil functions including the water-holding capacity, aggregate stability, and infiltration capacity (Edmondson et al. 2014). The addition of organic materials such as compost and mulch may stabilize the soil by increasing the aggregation rate of water (Watts & Dexter 1997). Enhanced water retention provides benefits by buffering and protecting urban inhabitants from flooding, which might be valued as reduced costs of storm water management. For many cities benefits of flood mitigation by urban gardens must generally be expected to be small due to their limited area except in some German and Polish cities, or where urban gardens are especially placed in the flooding areas of rivers, for example in the Baltic riparian cities Riga and Stockholm.

Local climate and air quality regulation

Urban gardens can play an important role in local climate and air quality regulation. For example, they form part of the network of urban green spaces and corridors in cities that enhance air circulation and provide microclimate regulation and improvements in air quality by allowing the circulation of cool and clean air from the hinterland to the city. Local climate regulation is a reported benefit provided within the gardens and adjacent neighborhoods. Plant transpiration increases the air humidity and creates a buffer against the urban heat island effect, i.e. an increased heat in cities in warmer periods.

Garden plants also contribute to the regulation of local air quality due to the filtration of pollutants, such as particulate matter, heavy metals, microorganisms and gaseous pollutants including NH_3, SO_4, NO_x, O_3. The capacities for air pollution filtration strongly depend on the growing period and variety of species. Air filtration is especially intensive during the growing season (Szumacher 2005). While studies that explicitly determine the air pollution reduction by urban gardens are still lacking, especially high air filtration capacities have been reported for evergreen plant species (especially trees) (e.g. Baró et al. 2014). Recent studies demonstrated increased carbon sequestration and storage capacities by urban gardens in comparison with other green space types (Edmondson et al. 2014). Nonetheless, the total amount of carbon stored in urban gardens is assumed to be relatively small when compared to urban and peri-urban forests due to their higher tree densities (*cf.* Baró et al. 2014).

Pollination and seed dispersal

Pollination and seed dispersal are fundamentally important in the provision of food (MA 2005; TEEB 2010). Both are highly related to the provision of habitats, mainly for insects and birds. Andersson et al. (2007) and Jansson & Polasky (2010) show that urban gardens are crucial elements in the network of habitats for pollinators, such as bumble bees. Species which guarantee the dispersion of pollen and thereby enhance agricultural production yields not only in cities but also in adjacent rural areas (see also Chapter 7). Jansson & Polasky (2010) also highlight the different responses of two types of pollinators (bumbles bees and solitary bees) to changes in the biosphere (functional response diversity), pointing to the importance of urban gardens for securing pollination and seed dispersal.

2.3.3 Habitat Services

Numerous studies show that biodiversity in Europe has been declining rapidly due to the expansion and intensification of urbanization and modern agriculture. Just as for pollination, most ecosystem services tend to rely on habitat services in one way or another (MA, 2005). Urban gardens provide many habitats for plant and animal species and may be crucial for the maintenance of biodiversity. They can further contribute to the reproduction and maintenance of a wide spectrum of cultivated plant varieties (cultivars). As further

discussed in Chapter 7, management practices and plant selection of by urban gardeners are essential to enhance and maintain urban biodiversity.

Refuge for plants and animals

More than 25,000 vascular plant species in Europe are threatened by extinction (Bilz et al. 2011), and the protection of habitats for maintaining endangered species has become central in European environmental policies, such as the *EU biodiversity strategy to 2020* (see European Commission 2011). According to the *Habitats Directive* (European Commission 1992), European member states are required to actively conserve all threatened species both *in situ* and *ex situ*. Urban gardens have the potential for maintaining or even expanding populations of endangered species, and may play a vital role for *ex situ* conservation measures. For example, in Lithuania many endangered native herbaceous and woody plant species with an ornamental character (e.g. *Adonis vernalis, Anacamptis pyramidalis, Hepatica nobilis, Helianthemum alypoides, Campanula bohemica, Gladiolus felicis, Gentiana lutea, Menyanthes trifoliata, Nymphaea candida*) are highly suitable for growing in urban gardens. Some endangered native species are already cultivated because they provide edible fruits (e.g. *Trapa natans*), seasoning herbs (e.g. *Origanum cordifolium*), or medicinal plants (e.g. *Mentha spicata*) (e.g. Pourias et al. 2015). However, an important limitation for the *ex situ* conservation is the ecological characteristics of the urban garden, such as light, humidity, acidity and soil-types, which must be similar to those characterising species' natural habitats.

Box 4. Social-ecological memory in allotment gardens in Tampere, Finland

By Ari Jokinen

A century long history of the Pispala allotment garden site in Tampere (225,000 inhabitants) SW Finland can be followed by using old maps, historical data, aerial photographs and floristic analysis. The site is located two kilometres from the city centre on the shoreline of Lake Pyhäjärvi and is sheltered by a high ridge, which was colonized by industrial workers and their small wooden houses since the late 19th century. The allotment gardens

were important for the workers because the ridge slope and small yards were unsuitable for gardening. There were also periods of keeping an orchard and commercial green houses in the allotment area. Now the area is composed of nearly 300 open field plots of 10 x 10 m leased out by the city to its inhabitants. Most of the plot holders come from the surrounding historical settlement.

The allotment garden colony is exceptionally rich in plant species, resulting from historical legacies, gardening practices and fine soil conditions (Jokinen et al. 2011, complemented by floristic surveys by Matti Kääntönen and Pertti Ranta). More than 400 vascular plant species are recorded in the area, including food and ornamental species and spontaneous wild species, which is one third of the city's species pool (1,225 species, ornamentals included). Plant groups typical of the area include (1) a wide range of cultivars and probable landraces as well as experimental species from several continents, (2) remnants of traditional food plants partly naturalized in the area such as Chenopodium bonus-henricus, rare in Finland, (3) spontaneous species that belong to the old urban culture, including species like *Descurainia sophia* and *Sisymbrium officinale,* mostly disappeared elsewhere in Finland, and (4) rare seed bank species like *Hyoscyamus niger* emerging from the soil due to gardening.

The Pispala case suggests that an allotment garden may serve as a tool for retaining and increasing local landraces and genetic biodiversity, including wild historical plant species that support the life style and cultural image of the neighbourhood. As a socio-ecological system, the Pispala allotment garden shows several mechanisms that extend its temporal and spatial scale in providing ecosystem services. First, the historical evolution of the allotment garden and its interaction with a wider urban landscape has led to an active seedbank in the soil, which is a side effect of gardening practices. Tolerance of the unmanaged appearance of the garden by the public and feedback by plot holders are important. When Verbascum thapsus spontaneously emerges from the seedbank, many plot holders allow its growth and seed production for aesthetic or other reasons. Second, the number of plots increases the diversity of plot holders, many of whom are networked with relatives in the countryside and other sources of old landraces and experimental species which they bring to their plot. Third, gardening practices that are partly non-synchronized (plots are cultivated very differently, and stochastically a num-

ber of plots every year are uncultivated in part or in whole) support ecological contingency, giving room both for food production, experimentation, and spontaneous plant species.

Figure 2.vii. The Pispala allotment garden in Tampere (Finland). *Photo: Ari Jokinen*

Maintenance of genetic diversity

Most urban gardens contain wild varieties of plants as well as cultivars. Cultivars include commercial varieties but also geographically and culturally unique varieties resulting from their local reproduction and adaptation over long periods. These varieties (landraces), are crops that have been reproduced by farmers over generations in a specific geographic area. The maintenance of landraces converts urban gardens in a sort of gene bank (see also Box 6.4) of varieties that continuously adapt to the local ecological conditions and gardening practices (Calvet-Mir et al. 2011). Landraces have been deemed essential to preserve agricultural genetic diversity (e.g. Altieri and Merrick 1987), threatened by the abandonment of traditional landraces and their substitution by commercial strains since the Green Revolution

(Brush 1980; Negri 2003). Although there is still little empirical data on the role of urban gardens in landrace conservation in Europe, their importance in preserving agro-biodiversity is increasingly recognized (Barthel et al. 2010; Barthel et al. 2014). Maintaining agro-biodiversity increases the functional response diversity, for example maintaining pollination by bumblebees in the case honeybees are extinguished. This increases the resilience of an ecosystem, for example, in the face of global climate change (Calvet-Mir et al. 2012; Jansson & Polasky 2010; Barthel et al. 2014).

2.3.4 Cultural ecosystem services

Cultural ecosystem services from urban gardens are the flow of non-material benefits humans obtain from urban gardens (Chan et al. 2012) and result from human interactions with and within urban gardens. Cultural ecosystem services from urban gardens (Beilin & Hunter 2011; Guitart et al. 2012) include, nature experiences, aesthetic information and place-making, the latter more deeply discussed in Chapter 11. Sempik et al. (2005) suggest that the combination of social cohesion and interactions, contact with nature, and physical outdoor activity in urban gardens improve human health. The potential generation of cultural ecosystem services varies across different types of urban gardens; depending on social and ecological garden characteristics, geographical locations and on individual perceptions by the beneficiaries (see Camps-Calvet et al. forthcoming).

Recreation and relaxation

Most urban gardens provide important recreational benefits. Chapter 1 describes how urban gardens in Europe, in the form we currently know them, were created as sources of recreational space as well as food. For example, the first Polish allotment garden "*Kąpiele Słoneczne*" ('Sun Baths') established by the 'Society of Natural Way of Life' in 1897 consisted not only of private gardens, but also places for common recreation and sun-bathing, and was equipped with sport facilities (Pawlikowska-Piechotka 2010).

Box 5: Cultural benefits from Allotment Gardens in Salzburg, Austria

By Jürgen H. Breuste & Martina Artmann

Salzburg, Austria, accommodates 649 allotment garden plots covering an area of 28.3 ha. Since 1988 the area of allotment gardens has been reduced by 5.6 ha and 243 allotments have been lost. In a research study (Breuste and Artmann, 2014), 156 allotment gardeners in four allotment associations replied to questions regarding ecosystem services, food production, recreation, experiencing nature (learning and teaching about nature), and ecological gardening and environmental behaviour.

The majority of the allotment gardeners use the plot in summer several times (59%) or even daily (36%). Even in winter, 22% use the garden several times a week and only 29% use it rarely. On a working day in summer, the majority spends four to six hours on the plot for gardening as recreation (32%). In the allotment site "Pulvermacherweg", the majority (45%) spends more than eight hours in the garden. Only 17% of the respondents spend less than four hours there. The majority spend the whole weekend there in the summer (more than six or even more than eight hours). Fifty percent would like to reduce the maintenance activities in the allotment gardens to have more time to relax. For 64%, reduced maintenance is the leading idea regarding their gardening, accompanied by beautification (59%) and environmental sustainable design (50%).

More than 60% of the allotment gardeners learned gardening by doing, another 48% (more than one answer was possible) from other gardeners, 47% from older family members and only 38% from published information. A majority (66%) learned about nature through allotment gardening, 31% about the general relation to nature and ecological behaviour, 28% about horticulture and garden management. In this study, 78% of the respondents valued the allotment garden as an important or even very important place for the younger generation to learn about nature. The allotment garden is a place for nature observation. Birds, small mammals and amphibians are frequently observed. The majority of the gardeners (74%) call the attention of the younger generation to observe animals. If the allotment gardeners compare where they mostly make their animal observations, it is 80% on the allotment

plot, followed by forests (34%) and only 9% in urban public green spaces.
The study shows that the allotment gardens have changed in structure over the last 50 years. There is a shift from food production to recreation. Allotments have become leisure areas with interactive learning and experiential opportunities about nature and natural processes throughout the year. This has an important influence on the ecosystem services provided by them. The trend to reduce the intensity of land use in allotment gardens means also a chance to further develop other ecosystem services like habitat provision and biodiversity.

Figure 2.viii. Allotment garden in Salzburg (Austria). Photo Breuste

Human engagement with urban gardens and green spaces has shown to provide recreational benefits through the reduction of stress (van den Berg et al. 2010). Stress, in the form of excessive stimulation caused by urban environments and urban lifestyles, leads to fatigue and a decrease of vitality, as well as various health problems faced by urban inhabitants (Stilgoe 2001). Urban gardens can serve as restorative environment, providing possibilities for

relaxation and reflection (Kaplan and Kaplan 1989). Users of allotment gardens in Wales (aged 50 – 88) also showed significantly lower level of stress than their peers, who only performed indoor exercises. This is explained by the contact of garden users with plants and their psychological restoration in a natural environment, which is unavailable for the other group (Hawkins et al. 2011). Allotment gardeners, who, after stressful tasks, took care of plants, showed a faster release from stress than people who could only relax passively by reading books (van den Berg et al. 2011).

Physical activity

Physical outdoor activities are very important, especially for elderly people, the main group of users of urban gardens in most European countries (Pawlikowska-Piechotka 2010; Camps-Calvet et al. forthcoming). While simply staying in a green environment has beneficiary effects on human health and well-being, additional benefits are provided through active gardening. Park et al. (2011) demonstrate that for many elderly people urban gardens are excellent motivation to spend time outside, and to practice some physical activity. Even simple activities, like walking in the garden or watering plants can be good physical exercise (Browne 1992). Digging the soil preserves and improves human fitness, movement coordination and balance, and provide a series of health benefits, for example, lowering blood pressure**,** cholesterol levels and obesity (Dunnet & Qasim 2000).

Nature experiences

Urban gardens provide numerous opportunities for nature experiences, for example, the observation of growing plants and animals, taking care of living beings, the experience of eating fruit and vegetables grown in the garden and the experience of designing and building with natural elements. Nature experiences have been described as the "reciprocal act of growing plants and seeing plants grow" (oral gardener's statement, Barcelona, May 2013, unpublished). Recreational and mental health benefits from nature experiences are widely accepted, although still not comprehensively explained. Wilson (1985) suggests that humans have a "… natural affinity for life …" resulting from the human co-evolution with other species. However, other authors argue that whether and how people benefit from nature experiences in urban gardens also depends on their particular cultural values and the symbolic

meanings they attach to the garden as well as on personal positive and negative experiences (Eisel 2012; Kirchhoff et al. 2012). Nature experiences can be beneficial for children's personal development and educational abilities. Contact with natural environments results in stimulation of their senses, development of creativity, increased interest and attention. It may also prevent and help to cure common disorders such as Attention Deficit Disorder (ADD), Attention Deficit Hyperactivity Disorder (ADHD), aggression and nutritional problems (Taylor & Kuo 2006; Louv 2008).

Environmental learning

Nature experiences embed opportunities for environmental education and learning (e.g. Beilin & Hunter 2011). Urban gardens may foster experiential learning about local ecosystems and gardening skills. The interplay of learning, adaptation and transmission of knowledge and practices is fundamental for the long-term maintenance of biodiversity and other ecosystem services, and thus helps resilience in ecosystem service supply (Krasny & Tidball 2009). Thus, urban gardens are important for environmental education and learning for children, who ─ living in cities ─ often have reduced contact with the biosphere. School gardens and collaboration between urban gardens and schools or kindergartens are increasingly common. Urban gardens serve as learning environments providing a link between theoretical knowledge and practice through contact with plants and animals and engagement in gardening activities, which increases the awareness of their users for social-ecological interrelations.

Sense of place and social cohesion

Sense of place and social cohesion, further discussed in Chapters 11 and 12, are other social benefits (Glover 2004; Guitart et al. 2012). For example, a comparative study from the UK showed significantly greater physical and psychological benefits of allotment gardens compared with individual home gardens which was related to social interaction (Milligan et al. 2004). They may also provide an opportunity for urban immigrants from rural areas to conduct familiar activities and to grow familiar plants, providing a feeling of connectedness to their origins (Camps-Calvet et al. forthcoming). Such benefits from an engagement in urban gardening can be seen as underlying fac-

tors leading to a positive sense of place and increased place attachment (Tidball et al. 2014). A positive sense of place is strongly intertwined with and fosters social connections and support networks (Rosol 2006). The sharing of place values enables local community building, including social integration, interaction, and cohesion (Armstrong 2000; Glover 2004). Urban gardens require the active participation and engagement of gardeners (Okvat & Zautra 2014). This can increase civic empowerment, stakeholder involvement and community participation (e.g. von der Haide 2009). Social interactions are also one of the most important factors positively influencing health and life quality (Kaplan 1973). In this context, social cohesion in urban gardens is especially important for elderly people with often limited opportunities for social contacts. A reduction in loneliness is thereby directly correlated with a reduced risk of health problems, depression and the loss of cognitive abilities (de Vries 2006).

2.4 Summary and conclusions

Urban gardens provide a unique combination of productive and recreational space, which in turn provide numerous ecosystem services to urban inhabitants. Nevertheless, Chapter 6 shows that urban gardening may also negatively impact the urban environment, and Chapter 13 reminds us of potential social conflicts caused by urban gardening. Recognizing these complex socio-ecological interrelations helps to provide better understanding for the maintenance and enhancement of urban green infrastructure and ecosystem services. Flows of benefits of urban gardens are limited by the garden users' specific perceptions, and the quantitative amount of benefits might be small in cities where urban gardens only form a small proportion of the land area. However, the many possible benefits from urban gardens outlined throughout this Chapter invite a stronger recognition of the role of urban gardens within urban green infrastructure strategies, spatial planning and design. A growing number of studies also highlights the importance of urban gardens as sources of urban resilience (Andersson et al. 2007; Barthel & Isendahl 2013).

Replacement of urban gardens by built areas may only directly affect small groups of gardeners - often those unable to oppose development interests effectively. However, ecosystem services described in this Chapter benefit not only the direct users involved in gardening activities. While they may be

the main beneficiaries of food provision, recreation and social cohesion, benefits from food security, habitat for plants and animals, pollination, as well as local climate regulation, erosion prevention and water retention affect larger scales. Gardeners can therefore be described as stewards for ecosystem services, providing beneficits for a large number of urban inhabitants (Andersson et al. 2007). Seeing urban gardeners as stewards of ecosystem services and recognizing their role in the management of urban green infrastructure may strengthen their stake in policy and planning of urban land-uses.

The benefits provided by urban gardens described here are not new. Nevertheless, the ecosystem service approach provides a unifying interdisciplinary framework that allows capturing the multiple benefits from urban gardens in a robust and systematic way, offering a valuable tool to assess the multifunctionality of urban green infrastructure (Pauleit et al. 2011). Breuste (2010) has pointed out that few other green spaces provide such a collection of ecosystem services on such small areas as urban gardens. In the case of garden replacements, it should be asked if urban development is capable of providing similar benefits. Too often, the ecosystem services urban gardens provide are overlooked by urban planners and policy-makers and gardens are replaced by urban developments with easily measurable, short-term economic benefits. Describing the many ecosystem services urban gardens provide may thus contribute to a stronger recognition of their role as highly valuable land-uses and important source for urban sustainability and resilience in cities.

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Chapter 3

Assessment and valuation of ecosystem services provided by urban gardens

Insights for policy and planning

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Abstract In many European cities, urban gardens are seen as increasingly important components of urban green space networks. We adopt an ecosystem services framework to assess contributions of urban gardens to quality of life in cities. First, we identify and characterize ecosystem services provided by urban gardens. Secondly, we assess the demographic and socioeconomic profile of its beneficiaries and the relative importance they attribute to different ecosystem services. Next we dicuss the relevance of our results in relation to current policy challenges, both a the city and European level. Data were collected through 44 semi-structured interviews and a survey among 201 users of 27 urban gardens in Barcelona, Spain, as well as from consultation meetings with local planners. We identified 20 ecosystem services, ranging from food production over pollination to social cohesion and environmental learning. Among them, cultural ecosystem services stand out as the most widely perceived and as the most highly valued. The main beneficiaries of ecosystem services from urban gardens are elder, low-middle income, and migrant people. Our results indicating that urban gardens hold high societal importance was deemed highly relevant for green space planners in Barcelona, as evaluation of existing and learning for future garden programs and their promotion. Our research suggests that ecosystem services from urban gardens can play an important role in connection with several urban policy challenges in cities, such as lacking awareness and stewardship of urban ecosystems and biodiversity, lacking opportunities for recreation, and the need for social integration and environmental justice in cities. We conclude that urban gardens and associated ecosystem services can play a sifgnifficant role as nature-based solutions within urban policies aimed at enhancing quality of life in cities.

Key words Barcelona • Ecosystem services • Green infrastructure • Nature-based solutions • Urbanism • Urban agriculture

3.1 Introduction

With more than half of the world's population living in cities and a projected urban population of 60% by 2030, achieving more sustainable, livable and resilient cities stands among the greatest challenges for urban policy and planning in the 21st century (UN, 2013). Recent policy developments call for developing novel approaches to address complex and interrelated economic, social and environmental challenges (EC, 2014). A move in this direction is the growing attention paid to urban ecosystems as potential sources of nature-based solutions, i.e. solutions supported by nature that simultaneously provide economic, social and environmental benefits to address societal challenges, ideally in a resource-efficient and adaptable manner (EC, 2015).

In public policy discourse, urban ecosystems such as parks, cemeteries, green roofs, forests and gardens are increasingly portrayed as 'green infrastructure' (EEA, European Environmental Agency, 2011; DG Environment, 2013), a metaphor that emphasizes the role that green spaces in or near the built environment as sources of ecosystem services (ES) (Bolund & Hunhammar, 1999; Gómez-Baggethun et al., 2013). Urban ecosystem services are direct or indirect contributions of urban ecosystems to human well-being (MEA, 2005; TEEB, 2010). They include most prominently supporting services such as the provision of habitats for species (Gómez-Baggethun & Barton 2013), regulating services like air purification, run-off mitigation, and protection against climate extremes (Baró et al., 2014, Costanza et al., 2006), and cultural services (immaterial benefits) such as opportunities for recreation, environmental education, and spiritual enrichment (Chiesura 2004; Langemeyer et al., 2014). So-called 'green infrastructure' strategies to promote ES are gaining growing leverage in policy and planning (EC, 2013). For example, the European Commission has recently approved a Green Infrastructure Strategy that promotes the deployment of green infrastructure in the EU in urban and rural areas and maintaining multi-functional green spaces is also considered a key step for implementing the EU 2020 Biodiversity Strategy (EC, 2011a).

One element of urban green infrastructure that has attracted growing attention in the literature in recent years are urban gardens (Breuste, 2010). Urban

gardens are urban areas where horticultural activities take place. They may cover a broad range of typologies, including school gardens, therapeutic gardens, allotment gardens, home gardens, and community gardens (Lawson, 2005). The importance of urban gardens has been emphasized on the basis of their social functionality and high intensity of use (Breuste, 2010:464), their role in building resilience (Barthel et al., 2013), and their contributions to human well-being through the delivery of ES (Breuste & Artmann, 2014).

Despite growing attention to urban gardens in the scientific literature, their policy appreciation remains generally poor and the case has been made that gardens are "often, disadvantaged by planning in comparison to other green spaces" (Breuste, 2010:464). Limited policy appreciation renders urban gardens vulnerable to land-use changes from urban development. For example, Kronenberg et al. (2013) document growing pressure on urban gardens in Poland through urban development policies. Voigt (2014) describes a creeping loss of urban gardens in Vienna, Austria, from policies that favor private residential constructions over allotment garden uses. In Southern European countries, where national and regional policy frameworks to regulate urban gardens remain poorly developed (Drilling et al., 2015), urban gardens have also been documented to be highly vulnerable and lacking appreciation among policy-makers and large parts of the society (Domene & Saurí, 2007).

Loss of urban gardens also involves the loss of the many ES they provide to humans well-being. For example, previous research has noted the importance of urban gardens for the provision of food and medicinal plants (Buchman, 2009), local climate regulation (Henn, 2000), pollination (Kearns et al., 1998), pest control (Barthel et al., 2010), seed dispersal (Andersson et al., 2007), and provision of habitat for species (Breuste, 2010). Furthermore, urban gardens have been acknowledged for promoting increased social cohesion (Anguelovski, 2013), active and healthy lifestyles (Van den Berg et al., 2010), opportunities for relaxation and recreation (Breuste & Artmann, 2014), and environmental education (Shava et al., 2010). Rendering visible the contributions of urban ecosystems to human well-being through the ES they provide can be a powerful tool to raise awareness of their importance and to promote their recognition in policy (Gómez-Baggethun & Barton

2013; Pauleit et al., 2011). However, embracement of the ES approach by urban policy-makers is still weak (Kabisch, 2015; Primmer & Furman, 2012). Furthermore, most research addressing the topic have focused on limited sets of benefits from sectorial perspectives and few studies have conducted systematic and interdisciplinary assessments of ES that cover the whole range of ecological, sociocultural and economic benefits from urban gardens (cf. Dunnett & Quasim, 2000; Breuste & Artmann, 2014). In addition, the role that urban gardens and associated ES can play as nature-based solutions to address urban policy challenges ranging from social inclusion to environmental awareness remains largely unexplored.

Drawing on data from urban gardens in Barcelona, Spain, this research aims at contributing to addressing this knowledge gaps by conducting a systematic assessment of the ES provided by urban gardens and discussing our results in the context of urban policy challenges. Our specific objectives are to (1) identify and characterize ES provided by urban gardens, (2) assess the demographic and socioeconomic profile of the gardeners and the importance they attribute to different ES, and (3) to explore the role that ES from urban gardens can play as solutions for urban policy challenges.

3.2 Case Study: Urban gardens in Barcelona, Spain

Our research is based on data collected in 27 urban gardens distributed across the city of Barcelona, Spain's second largest city (Figure 1). With a population of about 1.62 million people living in the city core and over 4 million in the larger metropolitan area, Barcelona stands amongst the largest and most densely populated (16,000 inhabitants per km2) urban areas in Europe (ESPON Project, 2007; IDESCAT, 2013). Access to green spaces is barely 6.82 m² per capita (Barcelona City Council, 2013), well below the levels recommended by the United Nations (30 m2 per capita), the European Union (26 m2 per capita) and the World Health Organization (9 m2 per capita) (Khalil, 2014).

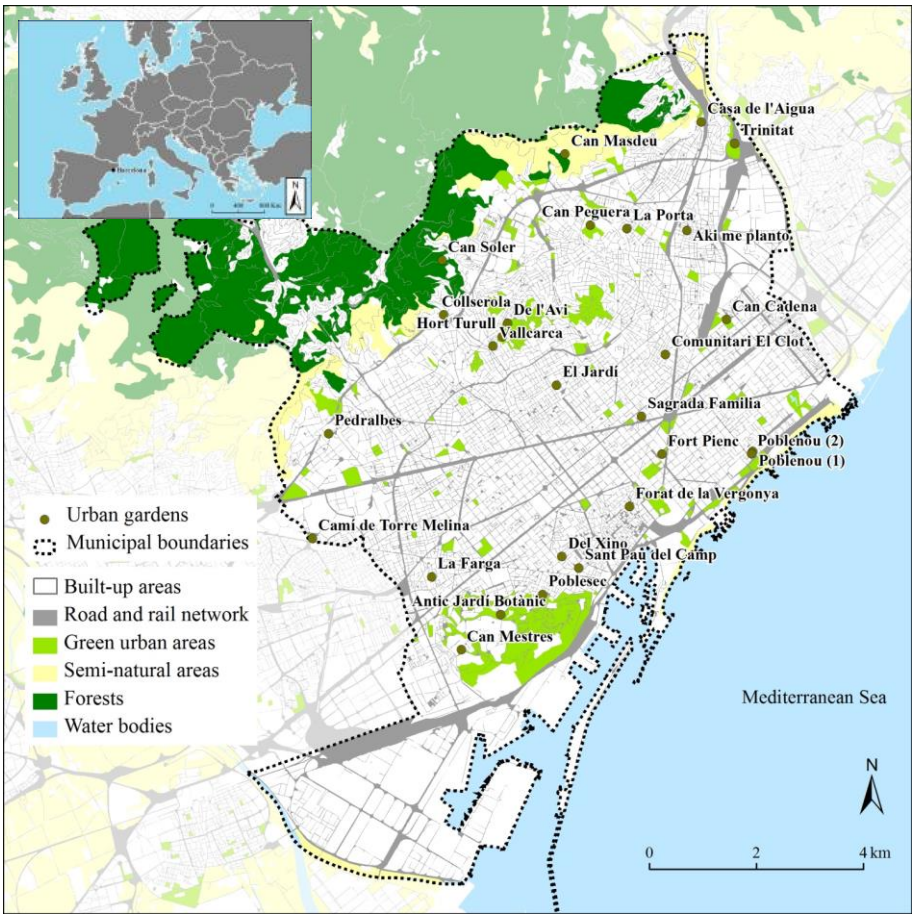

Figure 3.i. The case study area: Urban gardens in Barcelona.
Source: own elaboration based on Natural Earth data (www.naturalearthdata.com) & EEA (European Environment Agency) (2010). GMES Urban Atlas. http://www.eea.europa.eu/data-and-maps/data/urban-atlas).

3.2.1 Background

Urban gardens, which have a long tradition in Barcelona until the 1980s (Mubvami et al., 2006), decreased strongly with fast urban renewal and had been almost disappeared from the core city area by the time that Barcelona hosted the Olympic Games in 1992 (Roca, 2000). Since the beginning of the global financial crises in 2008, however, urban gardens have multiplied in many Southern European cities (Keshavarz, 2015). Barcelona has not been

an exception to this trend and, in recent years, the number of urban gardens has increased sharply. In addition, since the beginning of the economic crises in Spain during 2007-2008, bottom-up gardening initiatives, self-governed by neighborhood associations and political activists have multiplied in the city, often in connection to the social protests that shook Spain in spring 2011, known as "indignados" or "15-M" movement (Camps-Calvet et al., 2015). The Barcelona City Council, which creates public gardens since 1997, recently presented the 'Barcelona's Green Infrastructure and Biodiversity Plan', a strategic plan that recognizes urban gardens as important components of urban green infrastructure, for example on roof-tops or urban squares (Barcelona City Council, 2013:71 and 80). In 2013, the Barcelona City Council also put in place the initiative 'Pla Buits' (Empty-Spaces Plan) to promote gardening on vacant public lots (Barcelona City Council, 2015).

3.2.2 Urban gardens in Barcelona

Two main types of urban gardens exist in Barcelona. The first main type consists of gardens that are formally regulated by the Barcelona City Council. These gardens are generally divided in parcels that are individually managed by single gardeners or their families. In what follows, this type of gardens will be referred to as allotment gardens. The second main type consists of self-governed gardening initiatives where land is generally managed collectively. In what follows, this type of gardens will be referred to as community gardens. For a detailed description of urban gardens in Barcelona and their main characteristics, see Langemeyer et al. (forthcoming).

Our research covers a sample of 27 urban gardens that altogether cover a total surface of about 30 ha (Figure 1). This sample includes both formally regulated allotment gardens (n=13) and self-governed community gardens (n=13). In addition, our sample includes one collective garden managed by the Cultural Institute of Barcelona devoted to the maintenance of landraces (Institut de la Cultura de Barcelona). Our sample covers all allotment and community gardens existing within the boundaries of Barcelona municipality by the time our fieldwork was conducted. Gardens established under the 'Pla Buits' (Empty-Spaces Plan) where not yet consolidated when our field work was conducted and could thus not be considered in our study. In addi-

tion, kitchen gardens in private properties were also excluded from the study due to the difficulty of getting access to data.

3.3 Methods

Data were collected between April and October 2013. First, background information was collected to gain general understanding on urban gardens and policy processes at the study area. An initial screening of policy documents and grey literature, including newspaper articles and web-pages, was conducted to compile background information on urban gardens in Barcelona, including their geographical locations, main characteristics and number of users. We used non-participant and participant observation techniques (Bessette, 2004) spending time in the gardens and − when possible – engaging actively in gardening tasks, such as irrigation or manuring. We held semi-structured interviews with gardeners and members of 'Xarxa d'horts urbans comunitaris de Barcelona' (Network of Community Gardens of Barcelona), the association that coordinates self-governed urban gardening initiatives, to gain understanding on the gardens functioning and to identify key informants, defined here as gardeners holding recognized positions of leadership among other gardeners or having long-term experience in gardening activity. Finally, in order to gain broader understanding on the embedment of urban gardens within green space policies and Barcelona's green infrastructure strategy and to transfer knowledge and data from our study to practitioners, we organized two meetings.

3.3.1 Semi-structured interviews

Semi-structured face-to-face interviews with 44 key informants were conducted between April and June 2013 to identify and characterize ES provided by urban gardens (first specific objective) (see Annex 1). The 44 key informants interviewed included 32 male and 12 female gardeners. Interviews were conducted in all 27 gardens and lasted between 15 and 70 min. An initial list of key informants met in the gardens was subsequently enlarged using a "snowball technique", whereby interviewed informants were asked to provide contact to new informants. ES were identified using a free listing technique (Bernard, 1999; Bieling et al., 2014), whereby interviewees were asked to list benefits and contributions of urban gardens to human well-

being. Since we expected that benefits from ES delivered by urban gardens accrued to multiple scales (Hein et al., 2006), we asked gardeners to identify benefits provided at individual ("Why is this garden important for you?"), neighborhood ("Why is this garden important for the neighborhood?"), and city scale ("Why is this garden important for the city?"). We further asked informants to provide detailed explanation on the identified benefits. Interview guides were used to structure the interviews (See Annex 4). Interviews were audio recorded when interviewees gave their permission (n=31) and otherwise field notes were used to record the answers for their subsequent coding. We followed Charmaz (2006) and coded relevant text passages from the voice records and the field notes to obtain a list of the benefits provided by urban gardens. We matched stated benefits with ES types pertaining to the four major categories covered in established ES classifications: provisioning, regulating, habitat/supporting and cultural services (MEA, 2005; TEEB, 2010). When possible, benefits perceived by informants were matched with ES types that had been already described in previous ES classifications for urban areas (e.g. Bolund & Hunhammar, 1999; Gómez-Baggethun & Barton, 2013; Gómez-Baggethun et al., 2013).

3.3.2 Valuation survey

A survey has been designed to assess the perceived importance (value) of the ES identified from the semi-structured interviews and to characterize the demographic and socioeconomic profile of their beneficiaries (second specific objective). The survey consisted of closed face-to-face questionnaires among 201 gardeners, covering about 30% of the estimated 694 urban gardeners in Barcelona. The number of questionnaires per garden was defined in proportion to the number of gardeners, aiming to cover about 1/3 of the gardeners but adjusting the exact number depending on the gardener`s willingness to participate. Annex 1 shows the number of surveys realized in each of the 27 urban gardens.

The survey consisted of two main sections. The first main section comprised a socio-cultural valuation (Calvet et al. 2012; Martín-López et al. 2012) of the ES identified in the previous sampling phase through the semi-structured interviews (second specific objective). Socio-cultural valuation approaches are increasingly used in ES assessments (Kelemen et al., 2014, TEEB, 2010)

and had been previously used for the valuation of ES from home gardens in rural areas (Calvet-Mir et al., 2012). First, we checked whether the respondent recognized value in each ES, by asking: "Is this garden important for [e.g.] pollination?". In case of receiving a negative response, we proceeded to the next ES in the list. In case of a positive response we further asked the respondent to evaluate the importance he or she attributed to the ES on a Likert scale (Bernard, 1999; Calvet-Mir et al., 2012; Langemeyer et al., 2014). The Likert scale captured the degree of agreement to an affirmative sentence about the importance of the respective ES. For example, we asked: "For me, this garden is important because it provides [e.g.] medicinal plants". Responses were recorded in a scale from zero to five, where zero meant total disagreement and five meant full agreement (See Annex 5).
The second main section of the survey was designed to assess the profile of the gardeners as direct beneficiaries of the ES (second specific objective). To this end, the survey included questions regarding the sex, age, place of origin, and income of gardeners. We used this information to define the socio-economic profile of the gardeners by means of descriptive statistics.

3.3.3 Communication of results to policy makers

The first meeting to communicate our results to policy makers was held in March 2014 with staff from the Barcelona City Council's green space department and the person in charge of the 'Xarxa d'Horts Urbans de Barcelona' (Network of Urban Gardens of Barcelona). The second meeting was held in April 2014 with city planners of Barcelona City Council responsible of civic engagement and for the implementation of 'Pla Buits' (Empty-Spaces Plan). The meetings consisted in a presentation of results from the interviews and the survey, followed by an open discussion on the policy relevance of our study (third specific objective). The meetings were recorded, minutes were taken, and policy relevant passages were coded following Charmaz (2006).

3.4 Results

We structure our results in three main sections each corresponding to one of our specific objectives.

3.4.1 Ecosystem services provided by urban gardens

Two main results stand out from the interviews among key informants conducted to identify and describe ES provided by urban gardens: i) the diversity of ES perceived by gardeners and ii) the overwhelming dominance of cultural services. In terms of diversity, we identified a total of 20 ES, including two provisioning services ('food supply' and 'medicinal resources & aromatic plants'), five regulating services ('air purification', 'local climate regulation', 'global climate regulation', 'maintenance of soil fertility', and 'pollination'), one habitat service ('maintenance of biodiversity'), as well as twelve cultural ES ('learning & education', 'social cohesion & integration', 'entertainment & leisure', 'maintenance of cultural heritage', 'aesthetic information', 'relax & stress reduction', 'quality of food', 'place-making', 'biophilia' i.e. satisfaction of plant-growing, 'exercise & physical recreation', 'nature & spiritual experiences', and 'political fulfillment') (Figure 2).

Perception of the different ES (proxied here as the percentage of key informants that mentioned each ES in the free listings) ranges from 11.4% of the informants for the least widely perceived ES ('pollination') to 95.5% of the informants for the most widely perceived ES ('learning & education'). Other widely perceived ES include 'social cohesion & integration' (88.6%), 'food supply' (81.8%), 'entertainment & leisure' (77.3%), and 'maintenance of cultural heritage' (72.7%). Figure 2 shows the level of perception for all identified ES in the 44 semi-structured interviews. Annex 2 provides the complete identification and characterization of ES.

Figure 3.ii: Ecosystem services identified by gardeners. *Results based on 44 in-depth*

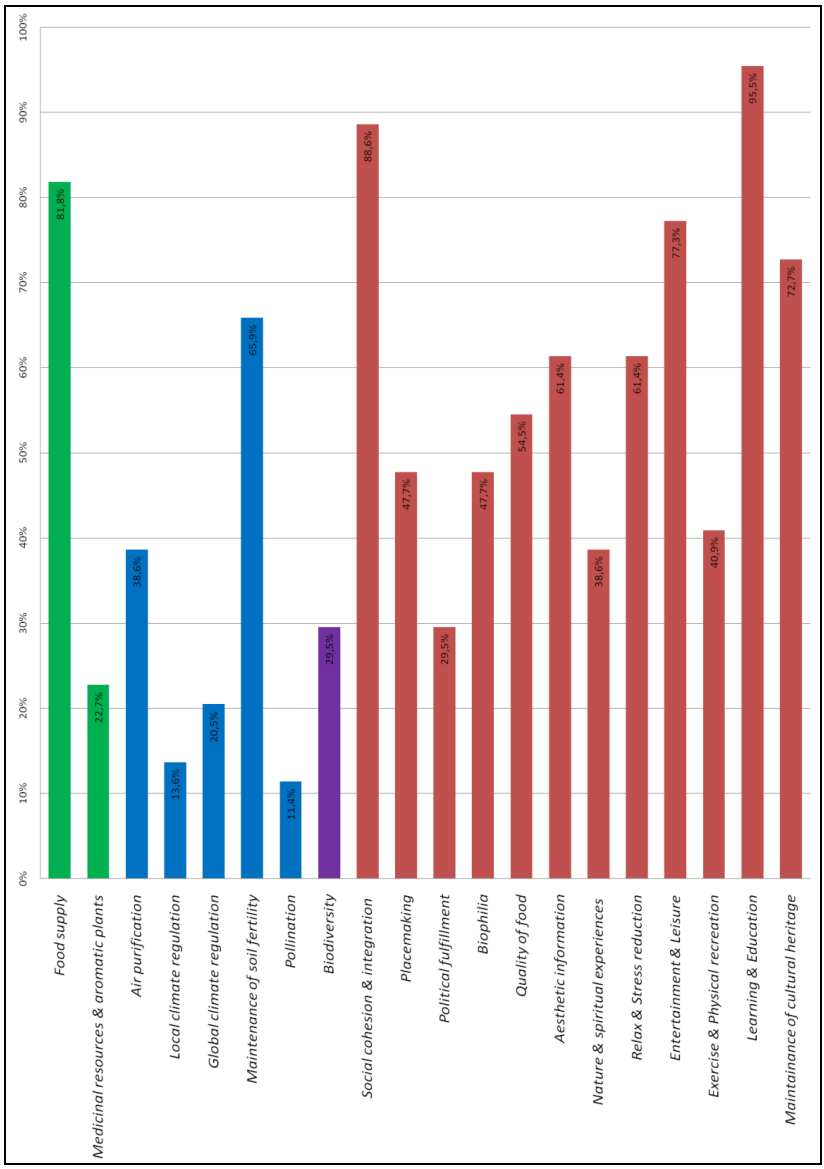

Table 3.i. Valuation of ecosystem services from urban gardens in Barcelona

Ecosystem services from urban gardens in Barcelona	Perceived as valuable (%)	Value (0 to 5)	Average value
Provisioning services			
Food supply	95.52	3.75	3.58
Medicinal resources and aromatic plants	54.23	3.40	
Regulating services			
Air purification	94.53	4.08	4.12
Local climate regulation	91.04	4.01	
Global climate regulation	84.08	3.86	
Maintenance of soil fertility	95.52	4.36	
Pollination	90.05	4.27	
Habitat services			
Biodiversity	96.02	4.26	4.26
Cultural services			
Social cohesion & Integration	99.00	4.40	4.49
Place-making	91.54	4.62	
Political fulfillment	38.81	4.14	
Biophilia	98.01	4.65	
Quality of food	95.52	4.57	
Aesthetic information	99.00	4.46	
Nature & Spiritual experiences	97.01	4.51	
Relax & Stress reduction	99.50	4.62	
Entertainment & Leisure	99.00	4.53	
Exercise & Physical recreation	95.52	4.35	
Learning & Education	100.00	4.51	
Maintenance of cultural heritage	98.01	4.55	

Based on a survey conducted among 201 urban gardeners in Barcelona (2013).

3.4.2 Valuation of ecosystem services and profile of the beneficiaries

Two main results can be highlighted with regard to the valuation of ES through the survey: i) the high overall importance attributed to ES; and ii) the prominence of cultural ES among those obtaining highest scores. Detailed information on the socio-cultural value of each ES is provided in Table 1. Aggregated values across the broader ES categories (i.e. provisioning, regulating, habitat and cultural ES) varied on the scale from zero ('very low') to five ('very high'). Cultural services obtained the highest average value with a score of 4.49, followed by habitat services (4.26), regulating services (4.12), and provisioning services (3.58). The most valued ES in each category were: 'biophilia' (4.65), 'place-making' (4.62), and 'relax & stress reduction' (4.62) amongst cultural services; 'biodiversity' (4.26) amongst habitat services; 'maintenance of soil fertility' (4.36) and 'pollination' (4.27) amongst regulating services; as well as 'food supply' (3.75) and 'medicinal resources & aromatic plants' (3.40) amongst provisioning services.

Regarding the profile of the direct beneficiaries of the ES (the gardeners), our sample included 76.6% male and 23.4% female informants. Their ages ranged between 16 to 87 years and are distributed as follows: 16-29 years (4.5%), 30-49 years (12.9%), 50-69 years (36.3%) and more than 69 years (45.3%). Four out of ten gardeners had received formal education above secondary school, whereas 58% had an equivalent or lower level of studies. Approximately 36% of the gardeners lived on a household income below 1000 € per month with an average number of 2.5 individuals per household. Informant's origin ─defined here as the place where people spent their childhood─ was distributed as follows: 31% were locals from Barcelona, 8% had migrated from other parts of Catalonia, 54% migrated from other parts of Spain (mainly from Andalusia), 4% came from other European countries, and 2% from Non-European countries. Most migrant gardeners arrived to Barcelona in the 1960s.

3.4.3 Ecosystem services and local policies

In the two meetings that were held to communicate knowledge and data from our research, urban planners showed strong interest in the results of our study. Planners from the 'Xarxa d'Horts Urbans de Barcelona' (Network of Urban Gardens of Barcelona) noted that results about ES provided by gardens provided an information basis that could be used to raise awareness about the importance of urban gardens in higher policy levels and in the face of other departments of the city council. The strategic green space planner remarked that our study is relevant because it provides "objective data […] and therefore can help to decision-making and indicate possible policy directions". The planners also noted that our results on ES values could be used to "justify" for their efforts to promote urban gardens; "rather than informing new models", - a planner stated insights from our study provide information "on how to adapt existing lines of work and to create new modalities". A planner involved in the development of 'Pla Buits' (Empty-Spaces Plan) pointed out that our results were important to them as "external evaluation" of their policies and that information on ES values could provide insights for the development of 'Pla Buits' through learning from "innovative insights from previous experiences" and also help to communicate and evaluate this policy.

3.5 Discussion

We start the discussion by acknowledging the limitations of this study. A first important limitation relates to sample selection biases. Because the sampled population consisted of gardeners (that is of the direct beneficiaries of the ES provided by urban gardens) the valuation involves to some extent a structural bias towards their positive appreciation. Hence, results obtained with regard to the diversity of ES and high level of importance attributed to most ES is not entirely surprising. If the sampled population would have included people that were not involved in gardening activities, it is likely that both the level of perception and value obtained for ES would have been lower, and that perception of some disservices or preference for other land uses would have been mentioned. While focusing on direct beneficiaries is a widely used approach in ES assessments, we recognize that results from a more diversified population sample could provide a more balanced picture of the overall importance that citizens attribute to gardens and the services they

provide. A second limitation derives from the fact that by providing a pre-written positive statement to the gardeners, the score attributed to each ES might have been be overvalued (Calvet-Mir et al., 2012).

A third limitation worth discussing concerns a potential methodological bias towards the appreciation of cultural services. While we believe that the overwhelming importance of cultural services vis-a-vis other ES categories is an important result from our study, it should be noted that the two main techniques we used to collect data (in-depth interviews and a valuation survey) may involve a bias towards this ES category. Valuation methods are not neutral tools that simply "reveal" pre-existing perceptions about ES and associated values as they also have frame effects that shape these perceptions and values. Hence, just as monetary valuation can act as an obstacle the perception of cultural phenomena and non-economic values (Chan et al. 2012), socio-cultural valuation methods based on stated preferences are likely to favor the identification of ES emerging from people's interaction's with nature over ES that are more directly associated to biodiversity and ecosystem functions (Calvet-Mir et al., 2012; Gómez-Baggethun & Martin-Lopez, 2015). As such, cultural ES are likely to receive stronger appreciation whereas in the absence of biophysical approaches and profound ecological knowledge of the urban gardens the perception of regulating and habitat ES may be more difficult (Elmqvist et al., 2013),

In the remaining of this section we discuss our results in connection to urban garden policies in Barcelona, including the role that gardens can play in (i) rising awareness about societal importance of urban ecosystems, (ii) promoting engagement in environmental stewardship (iii), creating opportunities for recreation, and (iv) enhancing social inclusion (Barcelona City Council, 2013:85). Results might also provide insights in relation to nature-based solutions to address policy challenges for European cities more broadly, including land-use changes, restoration of neglected and abandoned areas, environmental justice, and problems of social exclusion (EC, 2015).

3.5.1 Rising environmental awareness

Rising awareness of the links between ecosystems and human wellbeing has been proposed as an possible antidote to what has been referred as the 'ex-

tinction-of-experience' (Pyle, 1978) or the "global generational amnesia" (Miller, 2005) of urban populations, in terms of lacking food growing abilities and basic knowledge about human dependence on essential ecological processes (Colding & Barthel, 2013). Barthel et al. (2010) contend that restoring such ecological knowledge can be a necessary condition for stronger stewardship of life-sustaining ecosystems. It is telling that the ES from urban gardens that was most widely perceived in our study was 'learning & education'. The strong educational value of urban gardens gives basis to think that they could potentially play a stronger role in the Barcelona Green Infrastructure and Biodiversity Plan, which refer to making citizens aware of natural heritage and biodiversity-related concepts as one of its main challenges (Barcelona City Council, 2013). One result that is relevant in terms of the role that gardens may play in promoting environmental stewardship is that the highest valued ES in our study was 'biophilia', the term we have used here to refer to a feeling expressed by the gardeners related to the joy to grow plants and the satisfaction stemming with the very fact to see the "blooming of life" in their gardens (see Wilson 1984). Breuste (2010) suggests that the demand for an active relation of people with nature has been an important driver of urban gardening over the last 150 years in Central Europe. In summary, urban gardens offer citizens options for restoring a physical and cognitive connection with ecosystems and opportunities for caring and nurturing life.

3.5.2 Promoting civic engagement in urban green spaces

The European Commission states: "Cities need to be designed for all citizens and not just for the elite, for the tourists, or for the investors. People should be regarded as the key city asset and not as a demographic or social problem" (EC, 2011b:46). The green infrastructure strategy developed by the Barcelona City Council aims at promoting participation and civic engagement in the design and management of urban green spaces. That 'place-making' – expressing the importance gardeners attributed to engaging in the recovery of degraded and abandoned urban land – was the second most valued ES, indicates that gardens can play an important role also in relation to this policy objective. Friedmann (2010) defines place-making as the adverse of the processes by which places are degraded, that is, the creation and shaping of urban gardens through gardeners' practices, in combination with the

social creation of meaning and sense of place (Noori & Benson, 2015). Healey (2007) describes place-making as an increase in the quality of places and in quality of life through the cooperation of different stakeholders for a common good. In this respect, our results are consistent with Crouch's (1989) findings in the United Kingdom, indicating that urban gardens offer opportunities to ordinary citizens to decide how to shape the urban landscape in accordance with their needs, and to give meaning to the places they use.

Creating opportunities for recreation

Next to food supply, recreational purposes have historically shown to be the most important reason for urban policy-makers and practitioners to promote urban gardening (Breuste & Artman 2014; Keshavarz, 2015). Urban gardens offer a 'locus amoenus', i.e. a place to escape. The importance attributed to urban gardens' recreational function is consistent with the result that 'relax & stress reduction' was the second most valued ES in our study (scoring equal with 'place-making'). Informants expressed that gardens were places where they forgot about their problems, and where they had a chance to relax from the stressful lifestyle of the city and get away from the feeling of chronic scarcity of time.

In addition, gardeners in Barcelona pointed to multiple opportunities for 'entertainment & leisure' as another important value of urban gardens. In an economic crises-ridden country like Spain, with high rates of unemployment and poverty (the rate of unemployment in Spain in 2014 reached 26% and 55% among persons below 30 (INE, 2014a), urban gardens play an important role as non-consumptive spaces of leisure. In this regard, collectively managed gardens created through bottom-up initiatives can be interpreted as emerging forms of 'urban commons' (i.e. spaces in cities that are collectively organized and managed by the residents themselves) (De Angelis 2005; Colding & Barthel 2013; Camps-Calvet et al., 2015). For example, some gardeners noted that the leisure time they spend in the gardens replaces the spare time they otherwise would spent in a bar, "consuming health and money". The role of gardens as non-consumptive spaces of leisure can be especially important for cities ridden by gentrification and privatization of public space where access to leisure activities is increasingly commodified and restricted to those lacking sufficient purchase power, a phenomenon that has been documented for Barcelona (Anguelovski, 2013). We believe that this is again a relevant policy result. Barcelona's green infrastructure plan aims to

foster green spaces for purposes of enjoyment in less favored areas of the city, with actions such as opening green spaces belonging to public and private institutions (Barcelona City Council, 2013).

3.5.3 Promoting environmental justice

The notion of environmental justice reflects the ethical and political case for both a balanced exposure to nature's burdens (risks and pollution) and a balanced access to nature's benefits (e.g. ES) (Hofrichter 1993). While the bulk of the literature has focused on unequal exposure to pollution, unequal access to the benefits of ecosystem services is an emerging field of research (Ernstson 2013; Gomez-Baggethun et al. 2013). Our results regarding the socioeconomic profile of the gardeners suggest that the benefits provided by gardens can be particularly important for low-income people. People with higher incomes often have more access to recreational uses of nature, for example through tourism or privately owned gardens. In a comparative analysis of cities in Germany, Chile and Spain, Priego et al. (2008) report that higher social status correlates with larger amount of private urban green area, while lower-income classes make more use of publicly accessible green areas. In cities where access to urban green areas is increasingly privatized or commodified (Harvey, 1996) (a prominent example in Barcelona is the recent imposition of entrance fees to visit the emblematic Park Güell), access to urban green areas and associated ES can often become 'positional goods' (Hirsch, 1976; Parés et al., 2013) which access is limited to those with ability to pay. That the majority of beneficiaries of urban gardens reported medium to low levels of income suggests that urban gardens can offer an important alternative of access to ES among lower income groups in cities.

3.5.4 Enhancing social inclusion

A recent report by the European Commission's expert group on nature-based solutions and re-naturing cities refers to social inclusion and reduction of economic inequalities as a European-wide challenge in urban policy-making consisting in social (EC, 2015). Social isolation has been referred to as a new form of social inequality, where people have fewer opportunities to participate or to be involved in society (Machielse, 2006). Previous research has shown that deficits of social and intimate relationships resulting from isolated lifestyles in cities can lead to an experience of loneliness within densely

populated areas (Hombrados-Mendieta et al., 2012). Urban gardens offer spaces for socialization and consequently multiple opportunities for increased 'social cohesion & integration' (Milligan et al., 2004). Many beneficiaries in our sample reported that they perceived urban gardens as spaces for social interaction with other gardeners, neighbors and city inhabitants; where relations of solidarity, community cohesion and mutual support are strengthened. The importance of this facet of urban gardens has grown in the context of the Spanish economic crisis starting in 2007-2008, and solidarity networks have shown especially critical at a time when social inequalities are rising. In Spain, currently about 20% of the population is at risk of poverty due to rising unemployment rates and cuts in social welfare (INE, 2014b). The main beneficiaries of urban gardens in Barcelona are migrants and people of advanced age, with relative low income, and a low level of formal education (among them 69.15% retired and 4.46% unemployed people). The gardeners' socio-economic profiles suggest that urban gardens can play an important role towards social integration of less privileged social strata and people that are threatened by social exclusion. This result is broadly consistent with results obtained in previous studies on urban gardens in Europe (e.g. Breuste, 2010). The social inclusion of elderly and retired people is an important policy challenge for aging urban societies in Europe (EC, 2011b). Our study indicates a potential promotion of urban gardens as a nature-based solution in urban planning to promote social integration of elders.

3.6 Conclusions

Urban gardens are important sources of ES with wide potential to enhance human well-being in cities. Our results suggest that urban gardens are especially important for the provision of cultural ES, by far the most widely perceived and the most highly valued ES by our informants. The importance of cultural services relative to other ES categories may be interpreted on the grounds that the social and cultural benefits and values of urban gardens can to some extent act as nature-based solutions for some important policy challenges in urban areas, including environmental awareness rising, promotion of civic engagement in the protection and restoration of urban ecosystems, promotion of healthy lifestyles, social integration and environmental justice.

Allowing and promoting broader access to vacant areas in cities for urban gardening can be an effective nature-based solution for urban policies aiming at enhanced human well-being, social integration and healthy lifestyles. This may be done through the restoration of brownfields, by exploring possibilities of rooftop-farming, or by promoting gardening activities in urban parks − a policy that was successfully introduced in Lisbon, Portugal. We believe that the current policy momentum in Barcelona offers a great opportunity to promote urban gardens as sources of ES and nature-based solutions to several pressing challenges based by the city. With the 'Pla Buits' (Empty-Spaces Plan), the Barcelona City Council is currently experimenting with a new policy to promote the creation of urban green space in vacant areas based on civic engagement and Barcelona. Also Barcelona green infrastructure and biodiversity strategy offers a unique opportunity to further integrate an ES approach into urban policies and practical land-use planning, by considering the specific informational needs of policy-makers and planners. We hope our research will contribute to a rising awareness by science, policy and the civic society regarding the importance of urban gardens as critical nodes of cultural values and ES for cities.

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Chapter 4

Stewardship of Urban Ecosystem Services

Assessing the emergence of ecosystem service values in urban gardens

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Abstract The notion and assessment of ecosystem services is now an established part of the discourse regarding urban performance. Yet, stewardship of multiple ecosystem services in cities is still an open research frontier. Urban gardens have been highlighted for their capacity to deliver manifold ecosystem services, including food provision, pollination, biodiversity refugee and recreation. However, little is known about how ecosystem services provided by urban gardens relate to their social and physical properties. In this contribution, 20 ecosystem services from urban gardens are analysed with regard to their social and ecological foundation. The study highlights that specific urban garden types, such as allotments and community-run, show different capacities to enhance ecosystem service values. Ideas are developed from data obtained through interviews, field observations and remote sensing in Barcelona, Spain, where urban gardens are characterised with regard to various social and ecological features including gardeners' demographic profiles, property rights, management, and land-cover. This data is used to identify 'bundles of ecosystem services values' and group urban gardens with regard to these values. Relying on socio-cultural ecosystem service values developed by the authors, it uses an innovative non-metrical dimensional scale (NMDS) approach and cluster analysis to identify garden features that foster perceived values. Results show the importance of property rights and management regimes for ecosystem service stewardship and indicate potentials for green space policies and planning to boost ecosystem services in cities. Strengthening the diversity in urban green space models, including the creation of physical and institutional space for bottom-up initiatives, can positively contribute to diversify ecosystem services in cities.

Key words Stewardship • Social-ecological systems • Civic ecology • Ecosystem services • Urban gardens • Barcelona

4.1 Introduction

In an urbanizing world, increased urban resilience, resource availability and social equity are among the most pressing societal challenges in cities (EC, 2015; United Nations 2014:11). The implementation of *green infrastructure strategies* and *nature-based solutions*, i.e. "actions which are inspired by, supported by or copied from nature", are increasingly recommended to address urban challenges (EC, 2015). Urban gardens are an important part of the urban green infrastructure, referred to as the network of multi-functional green spaces in cities (Breuste, 2010). Given their multi-functionality, that is their capacity to support manifold benefits for citizens (e.g., Hynes & Howe, 2002; Guitart et al., 2012, Breuste & Artmann, 2014), they might also serve as nature-based solutions to specific societal demands. The benefits gardens and other green spaces in cities provide are often referred to as urban ecosystem services (ES) (Bolund & Hunhammar, 1999). ES provided by urban gardens include, for example, the production of food (e.g., Barthel & Isendahl, 2013; Buchmann et al., 2009), pollination (Andersson et al., 2007; Jansson & Polasky, 2010), recreation (e.g. Kaplan, 1973), environmental education (e.g. Doyle & Krasny, 2003), social cohesion (e.g., Armstrong, 2000), as well as enhanced sense of place and community (e.g., Andersson et al., 2007; Andersson et al., 2014). ES from urban gardens increase the quality of life in cities. The resulting human appraisal of urban gardens has been referred to as ES values (Braat & De Groot, 2012; TEEB, 2010).

To account for different garden properties that enable ES, we approach urban gardens in this study as coupled social-ecological systems (Barthel et al., 2010). From a social-ecological systems perspective, humans are understood as integral part of ecosystems, and ES are understood as co-produced through interrelations and feedbacks between social and ecological processes (Berkes et al., 2000; Andersson et al., 2014). This means that, when examining the foundation of ES, we are not only looking at static social and ecological components but also consider the interfaces between the social system and the ecosystem, including the social context, governance institutions as well as and physical structures and processes created or driven by humans. For example, seed dispersal and pollination depend on species abundance,

but are also enabled by specific management practices, such as the maintenance of wild flowers, and the diversification of cultivated plants (Andersson et al., 2007). Understanding crucial interfaces within social-ecological systems that favor the generation of ES may inform green space governance systems (Primmer et al., 2014). It may for example enhance adaptive capacities of actors in the governance system to maintain crucial functions for the provision of ES although external conditions change (Dietz et al., 2003; Folke et al., 2005). Knowledge about the foundation of ES may, in addition, add understanding to what motivates environmental stewardship, i.e. the civic restoration and tendering of green spaces (Krasny & Tidball, 2009[a]).

Recent literature has made substantial progress in describing and characterizing ES provided by urban gardens (Breuste & Artmann, 2014; Dunnett & Quasim, 2000; Langemeyer et al., 2015). Very few studies have however focused on the values people attach to the ES from urban gardens, i.e. the importance given to individual ES (Camps-Calvet et al., forthcoming). Only a small body of literature has started to trace the interrelation between social and ecological features as a foundation of individual ES in urban gardens (Andersson et al., 2007; Jansson & Polasky, 2010). Yet, an examination of the foundation of ES values in urban gardens and other urban green spaces is to our knowledge lacking. It has been argued that the perception and appreciation of ES values by citizens or citizen groups strongly depend on the social context (Chan et al. 2012; Scholte et al., 2015). Furthermore, benefits and values have been described as crucially dependent on local governance systems and institutions (Gómez-Baggethun & Kelemen 2008; Primmer et al., 2014), defined as formal and informal rules, and practices (Ostrom, 2009:18). Finally, ecosystem structure and processes, including human artifacts and practices, are supposed to be important determinants behind the provision of ES and related values (Andersson et al. 2007; MA, 2005; TEEB, 2010; Haase et al., 2014; Haines-Young & Potschin, 2009; Van Oudenhoven et al, 2012). Within this study, the foundation of ES values is explored through a case study of urban gardens in Barcelona. Urban gardens are first characterized in terms of their social context, governance institutions, as well as human shaped physical structures and process. Relying on a data-base of socio-cultural values, we test statistically how specific garden properties influence the valuation of ES.

4.2 Material and methods

4.2.1 Case study: Urban gardens in Barcelona

Barcelona, Spain, is one of the most densely populated cities in Europe and presents low levels of access to urban green spaces of about 6.64m² per capita (IDESCAT, 2013), compared to an average amount of available green space in European cities of 18.6m² (Fuller & Gaston, 2009). In a context of high population density and low amounts of green spaces, even small increases in the number or size of urban green spaces can noticeably enhance the societal value from the provision of ES (Gómez-Baggethun & Barton 2013). In some Northern and Central European cities urban gardens cover considerable parts of the urban surface, for example about 4.1% (1240 ha) in Leipzig, Germany (own calculation based on Stadt Leipzig, 2015[a,b]). In contrast, in Barcelona, only about 30 ha of urban gardens exist (excluding private family and school gardens), accounting for about 1 % of all public green areas and not more than 0.3 % of the city's total surface (Barcelona City Council, 2013).

Over the 20th century, most agricultural land in Barcelona has been urbanized. However, fostered by waves of rural-urban migration to Barcelona that followed Spain's late industrialization, horticultural gardens continued rising and reached their extension peak only in the 1950s and 1960s (Huertas et al., 2004). The creation of urban gardens for subsistence food production by rural migrants corresponds within a wider emergence of gardens among working-class people in industrialization periods described for North America and Northern Europe (e.g. Barthel et al., 2005). However, urban gardens have suffered from a lack of broader societal and policy recognition (Domene & Saurí, 2007), in contrast to other parts of Europe, for instance Germany, where the "Schreber"-movement enhanced the popularity of urban gardening for educational and leisure purposes (Keshavarz, 2015). Partly as a consequence of this limited societal recognition, urban gardens in Barcelona started to suffer a gradual decline that reached its bottom in the 1990s when urban development plans towards the Olympic Games of 1992 replaced most of the remaining horticultural land from Barcelona's core city area (Roca, 2000; Vendrell & Clanchet, 1992).

Over the last two decades, however, new urban gardening initiatives have emerged (Domene & Saurí, 2007). In 1997, municipal planners launched a

city-wide initiative for the restoration of urban gardens, including a gardening program that allocated allotment garden plots to retired and socially marginalized citizens (Giacchè & Tóth, 2013). More recently, a new program called '*Pla Buits' (Empty-Spaces Plan)* has promoted the use of vacant land owned by the municipality for gardening initiatives under civic management regimes (Barcelona City Council, 2015). In addition to these public planning initiatives, in recent years Barcelona – as many other cities in Europe – has witnessed the emergence of many self-governed community gardening initiatives. This form of gardening – different in its structure and organization from the allotment gardens under direct regulation by local authorities – has gained particular momentum since the beginning of the economic crisis in Spain in 2007-2008. While the crises had devastating effects, bringing about poverty and massive unemployment, gardening is one of the strategies through which people have responded to the economic crises (Camps-Calvet et al., 2015).

Our research addressed 27 urban gardens within the administrative boundaries of Barcelona city that existed in 2013, when fieldwork was conducted. Our sample includes both parceled urban gardens created under the municipal garden program and collectively managed gardens that emerged from bottom-up initiatives. Other types of urban gardens, such as home and school gardens also exist in Barcelona. However, the latter types of gardens are placed mainly in private properties that were not accessible to us for data sampling, and were accordingly not included in our study. At the time we conducted our fieldwork (April-October 2013), emerging gardens under the '*Pla Buits' (Empty-Spaces Plan)* were still at an embryonic stage; therefore, these gardens were also discarded from the assessment. We encourage however, their consideration through follow-up research on urban gardens in Barcelona as these new gardening initiatives become further established.

Aligned to the study objectives, our research followed two main steps. First, we assessed the social context, governance institutions and structure and functions of urban gardens. Second, we identified garden clusters in relation to the provision of ES values and to the underpinning social-ecological properties.

4.2.2 Characterization of urban gardens

During the initial step of our assessment, we characterized urban gardens regarding: (i) *social context*, including urban surroundings (such as highways, parks, and residential areas), garden users, and garden foundation; (ii) g*overnance institutions*, including property rights, decision-making (public regulation, user assemblies), and management (individual or collective plot tendering); as well as (iii) *structure and functions*, including size, land cover, human artifacts (such as compost-boxes, benches, and shelters), practices (such as composting, plague treatment, time spent in the garden), and activities (joint gardening, educational activities, group activities).

Following Colding et al. (2013), based on Ostrom & Schlager (1996), property rights were distinguished into the right of (a) access ("the right to enter a defined physical area and enjoy non-subtractive benefits"), (b) withdrawal ("the right to obtain the resource units or 'products' of a resource"), (c) management ("the right to transform the resource by making improvements"), (d) exclusion ("the right to determine who will have an access right, and how that right may be transferred"), and (d) alienation ("the right to sell or lease") (see table 4.1; Ostrom & Schlager, 1996: 133). Land-cover descriptions included the surface of: (a) cultivated (individual or common) plots, (b) other green spaces (such as areas with ornamental plants, lawns and trees), (c) unsealed surfaces (e.g. pebble-paths), and (d) sealed surfaces (including pavement and shelters). Garden users were distinguished by sex, age, occupation, among others (information on garden users as well as the time spent in the garden was obtained through a survey and is further described in section 4.2.3).

Methods and techniques used for the characterization of urban gardens included: A review of available written information about the urban gardens of Barcelona, including scientific and gray literature, such as web-information, newspaper articles and planning documents; participant and non-participant on-the-ground observations; and mapping of all 27 urban gardens in *Miramon* and *ArcGIS* from orthographic photographs with resolution 1:5000 obtained from the Catalan Cartographic Institute.

Table 4.i: Example of garden characteristic: Level of property rights held by the gardeners.

	Owner	Proprietor	Claimant	Authorized user	Authorized entrant
Access	X	X	X	X	X
Withdrawal	X	X	X	X	
Management	X	X	X		
Exclusion	X	X			
Alienation	X				

Source: Colding et al. (2013), based on Ostrom & Schlager (1996).

4.2.3 Assessing ecosystem services

This study relies on a list of 20 ES identified and valued in a study by Camps-Calvet and colleagues (forthcoming), partly presented in a Master thesis (Camps-Calvet, 2014). Camps-Calvet et al. (forthcoming) valued ES by means of a survey of 201 urban gardeners in the same 27 gardens characterized before (Table 4.ii). The survey embedded a stated, socio-cultural valuation approach (Scholte et al., 2015) using a 6-point Likert-scale ranking (Bernard, 2006) to elicit the agreement to an affirmative statement indicating the importance of each ES in the garden they were tendering. For example, 'this garden is important to me because it provides high-quality food', where 0 indicated total disagreement and 5 total agreement. Through the survey, we further characterized garden users with regard to gender, age, education, income, origin and migration period, and obtained information on their household size, time spending in the garden as well as potential memberships in environmental associations. For further details on the methodological approach see Camps-Calvet et al. (forthcoming).

Building upon the ES values obtained from the survey, we used a non-metrical dimensional scale (NMDS) approach and a principal component analysis (PCA) to examine similarities and dissimilarities in terms of the ES values of urban gardens; thus, examining bundles of simultaneously perceived ES, as well as trade-offs in the appreciation of ES. In addition, we categorized urban gardens with regards to the stated ES values (averaged for each garden), by means of a cluster analysis. Through a superimposition of garden properties on the PCA results, we further identified those characteris-

tics that showed a significant influence (0.005-level) on the ES value. Furthermore, properties of garden users (as explanatory variables) were related to ES values (as dependent target variables) by means of statistical multivariate analysis (least-square multiple regressions). Regressions were conducted in STATA 12, and all other statistics have been carried out in RStudio using the 'vegan'-script developed by Oksanen et al. (2013).

Table 4.ii: Ecosystem services provided by urban gardens in Barcelona, Spain.

Habitat services	Biodiversity
Provisioning services	Medicinal resources and aromatic plants Food supply (quantity) Food supply (quality)
Regulating services	Air purification Local climate regulation Global climate regulation Maintenance of soil fertility Pollination
Cultural services	Social cohesion & Integration Place-making Political fulfillment Biophilia Aesthetic information Nature & Spiritual experiences Relaxation & Stress reduction Entertainment & Leisure Exercise & Physical recreation Learning & Education Maintenance of cultural heritage

Source: Based on Camps-Calvet et al. (forthcoming) in extension of the ecosystem service classification introduced by TEEB (2010).

4.3 Results

In this section we present the different properties of urban gardens in Barcelona and the ES they sustain. For an overview of selected garden characteristics see Table 4.iii.

4.3.1 Social context

Urban surroundings

Urban gardens are found across all districts and in varying surroundings from lots integrated within residential neighborhoods, such as *Del Xino* or *El Jardí*, to gardens in mostly rural surroundings, such as *Can Masdeu* and *Can Soler*. A series of gardens are located in the direct neighborhood of urban parks, such as *De l'Avi*, *Can Mestres* and *Trinitat* among others.

Garden users

The number of gardeners ranges from five to ten in smaller gardens, like *Forat de la Vergonya*, *Poble-sec* or *Del Xino*, to over 50 gardeners in *Can Masdeu*, or the twin-garden *Poblenou 1 and 2.* About three-quarters of the urban gardeners are male and over 80% of the gardeners are above the age of 50 (about 70% are retired). Most gardeners migrated to Barcelona from other parts of Spain in the 1950s and 1960s (for further details on the gardeners' profiles see also Camps-Calvet et al., forthcoming). Garden plots in municipal gardens are exclusively and individually assigned to retired people of over 65, with one or two plots per garden assigned for social associations for collective uses, for example by pupils or prisoners. Only about 14% of the municipal gardeners are female. In average, gardeners in self-governed gardens tend to be slightly younger than in municipal gardens, with most gardeners in the range of 50-69 years. Although male gardeners are also stronger represented in self-governed gardens, female gardeners make almost up to 40%.

Foundation

A large group of gardens was established through a top-down initiative by the municipality starting with *Can Mestre* in 1997. An exception among the publicly founded gardens is the *Antic Jardí Botànic*, which was founded by the *Cultural Institute of Barcelona* (*Institut de la Cultura de Barcelona*). A second group of gardens emerged from bottom-up squatting of empty or

abandoned lots. Among them is *De l'Avi*, the oldest urban garden in our assessment and the only one that endured the Olympic Games of 1992. This garden, although now fully included in the municipal garden program, was created through a bottom-up citizens' initiative through the squatting of an abandoned private vegetable garden, belonging to a large urban residence. Contrary to other squatted gardens in the city, the creation of *La Porta* was not community-based, i.e. it was not started by a previously organized group, but by two individual gardeners who created individual garden plots on a privately-owned wasteland in front of their multi-family houses. Encouraged by their initiative other neighbors followed to create their own plots and between 2005 and 2013 approximately 40 garden plots emerged. Out of thirteen squatted gardens, nine emerged in the context of the Spanish economic crisis.

4.3.2 Governance institutions

Property rights

Gardeners in municipal gardens are *proprietors* (see Table 4.i) of single plots for a non-renewable five-years-term, including rights of *access*, *withdrawal*, *management*, and the right of *exclusion* (*cf.* Colding et al. 2013; Ostrom & Schlager, 1996). Yet, individual plots in municipal gardens cover on average only 51% (range: 30-75%) of the gardens' total surfaces. Of the remaining 49% of the garden surfaces gardeners hold a smaller bundle of property rights including the rights of *access*, and *withdrawal*, which defines the gardeners as *authorized users* of these areas. An exception is made for *De l'Avi*, where old gardeners have life-long proprietor rights over their plots, while new gardeners are assigned with a five-year contract as in other urban gardens. Yet, in *De l'Avi*, gardeners also hold the right to manage areas not included in their plots. In self-governed gardens, gardeners effectively act as proprietors, although this status might be disputed by formal land owners of squatted lots. Only a minority of squatted gardens aspired and reached legal agreements. Formal toleration from the district governments exist for *Forat de la Vergonya*, embedded within the community-based design of a public square (*cf.* Anguelovski 2013). A singular case regarding the gardeners' property rights showed the *Hort de la Masia de l'Antic Jardí Botànic*. The garden is run by voluntaries organized in a formal association

under professional guidance; as a result, the bundle of property rights defines the 20 gardeners as claimants, assigned with *access*, *withdrawal*, and limited *management* rights.

Figure 4.i: Examples of urban gardens in Barcelona. *Sources: a./b. first author's personal photographs; c./d. with permission by Marta Camps Calvet.*

a. Can Mestre founded in 1997 by the municipality.

b. Turull founded in 2004 by the municipality.

c. Can Masdeu founded in 2002 through a squatter's initiative.

d. Poblenou 2 founded in 2012 through a squatter's initiative.

Decision-making

A main differentiation of urban gardens in Barcelona can be made by their formal decision-making systems, which closely relates (although not overlaps one-to-one) to the gardens' foundation and the gardeners' property

rights. Thirteen gardens are regulated by the Barcelona City Council (*Ajuntament de Barcelona*), while the other fourteen are self-governed either through community-based associations, such as at *Antic Jardí Botànic* and *Forat de la Vergonya*, or frequent assemblies, such as at *Comunitari del Clot*. Decision-making at *Poble-sec* has been described as collective but rather informal and spontaneous, while decision-making at *La Porta* was described as informal and on an individual basis.

Management

The management and tendering of gardens was either conducted in collective plots or individual plots. Fourteen gardens were exclusively managed in individual plots, among them all gardens run by the Barcelona City Council. Three gardens, *Can Masdeu, Poblenou 1* and *2*, showed mixed forms of management where most of the area was tendered individually and smaller parts collectively. Ten gardens including *Aki me planto* and *Forat de la Vergonya* were fully managed collectively.

4.3.3 Structure and processes

Size & Land-cover

The size of gardens ranges between 274m^2 and 9125m^2. At the time of our observations, between 30% and 80% of the gardens' surfaces were used for the cultivation of food plants, most commonly tomato, lettuce, pepper, eggplant, carrot, cabbage, onion, strawberry, spinach, cauliflower, beans, and potatoes (order has no specific significance). Only at *El Jardí* (20%) and *Del Xino* (0.05%) smaller areas were used for the production of food. A clear exception in terms of land-uses is the *Antic Jardí Botànic*, where no aliments were cultivated, and where cultivated areas served the reproduction and maintenance of local, traditional horticulture varieties, i.e. landraces. Municipal gardens are divided into plots (between 7 and 51 plots per garden) with a size of 25m^2 to 40m^2. In municipal gardens, the green space department is responsible for all green patches not included in the individual plots. They mainly consist of small patches with highly managed shrubs and lawns, in some gardens complemented by fruit trees, aromatic or flower beds.

Table 4.iii: Characteristics of multi-functional urban gardens in Barcelona

Urban garden	***District***	***Foundation***	***Decision-making***	***Property rights***	***Plot manage.***	***No. workers***	***Surface***				
							Total (m2)	*Food (%)*	*Ornam. (%)*	*Paths/lawn (%)*	*Sealed (%)*
De l'Avi	Gràcia	1987 (bottom-up)	Municipal (hierarchical)	Proprietor	Individ.	13	887.70	0.60	0.07	0.32	0.01
Hort Turull	Gràcia	2004 (top-down)	Municipal (hierarchical)	Auth. users / proprietor	Individ.	17	883.39	0.60	0.02	0.00	0.38
Casa de l'Aigua	Nou Barris	2007 (top-down)	Municipal (hierarchical)	Auth. users / proprietor	Individ.	30	1546.64	0.73	0.02	0.25	0.00
Trinitat	St. Andreu	2008 (top-down)	Municipal (hierarchical)	Auth. users / proprietor	Individ.	62	3590.32	0.60	0.06	0.31	0.03
Can Soler	Horta-Guinardó	2003 (top-down)	Municipal (hierarchical)	Auth. users / proprietor	Individ.	22	2288.58	0.50	0.27	0.63	0.20
Collserola	Sarriá-San Gervasi	2008 (top-down)	Municipal (hierarchical)	Auth. users / proprietor	Individ.	12	921.36	0.55	0.05	0.37	0.03
Camí de Torre Melina	Les Corts	2009 (top-down)	Municipal (hierarchical)	Auth. users / proprietor	Individ.	31	2649.42	0.75	0.03	0.20	0.02
Pedralbes	Les Corts	2008 (top-down)	Municipal (hierarchical)	Auth. users / proprietor	Individ.	20	4001.97	0.30	0.40	0.30	0.00

Sagrada Familia	Eixample	2007 (top-down)	Municipal (hierarchical)	Auth. users / proprietor	Individ.	20	1187.06	0.65	0.28	0.00	0.07
Can Cadena	St. Martí	2003 (top-down)	Municipal (hierarchical)	Auth. users / proprietor	Individ.	25	2722.67	0.30	0.25	0.40	0.05
Sant Pau del Camp	Ciutat Vella	2005 (top-down)	Municipal (hierarchical)	Auth. users / proprietor	Individ.	7	443.27	0.30	0.10	0.50	0.10
Can Mestres	Sants-Montjuïc	1997 (top-down)	Municipal (hierarchical)	Auth. users / proprietor	Individ.	51	9125.37	0.35	0.15	0.45	0.05
Can Peguera	Nou Barris	2010 (top-down)	Municipal (hierarchical)	Auth. users / proprietor	Individ.	14	1218.62	0.35	0.10	0.45	0.10
Antic Jardí Botànic	Sants-Montjuïc	2008 (top-down)	Association (horizontal)	Claimants	Collective	20	2067.89	NA	(0.59)*	0.40	0.01
Poblenou 1	St. Martí	2011 (bottom-up)	Assembly (horizontal)	Proprietor (tolerated)	Individ. (partly coll.)	20	798.87	0.40	0.20	0.30	0.10
Poblenou 2	St. Martí	2012 (bottom-up)	Assembly (horizontal)	Proprietor (tolerated)	Individ. (partly coll.)	70	1291.89	0.70	0.05	0.25	0.00
Can Masdeu	Nou Barris	2002 (bottom-up)	Assembly (horizontal)	Proprietor (tolerated)	Individ. (partly coll.)	60	6571.77	0.85	0.03	0.10	0.02
La porta	Nou Barris	2005 (bottom-up)	Informal (individual)	Proprietor	Individ.	40	1065.07	0.80	0.05	0.15	0.00

Vallcarca	Gràcia	2012 (bottom-up)	Assembly (horizontal)	Proprietor (tolerated)	Collective	15	495.77	0.55	0.07	0.38	0.00
Aki me planto	St. Andreu	2003 (bottom-up)	Assembly (horizontal)	Proprietor (tolerated)	Collective	20	201.97	0.40	0.30	0.30	0.00
Fort Pienc	Eixample	2010 (bottom-up)	Assembly (horizontal)	Proprietor	Collective	10	556.12	0.60	0.05	0.35	0.00
El Jardí	Gràcia	2012 (bottom-up)	Assembly (horizontal)	Proprietor (tolerated)	Collective	7	1056.85	0.20	0.05	0.75	0.00
Comunitari del Clot	St. Martí	2009 (bottom-up)	Assembly (horizontal)	Proprietor (tolerated)	Collective	20	148.30	0.75	0.05	0.20	0.00
Poble-sec	Sants-Montjuïc	2011 (bottom-up)	Informal (horizontal)	Proprietor (tolerated)	Collective	5	609.57	0.30	0.30	0.40	0.00
Del Xino	Ciutat Vella	2009 (bottom-up)	Assembly (horizontal)	Proprietor (tolerated)	Collective	7	600.66	0.05	0.85	0.10	0.02
Forat de la Vergonya	Ciutat Vella	2006 (bottom-up)	Association (horizontal)	Proprietor	Collective	5	273.90	0.80	0.20	0.00	0.00
La Farga	Sants-Montjuïc	2010 (bottom-up)	Assembly (horizontal)	Proprietor (tolerated)	Collective	10	463.05	0.60	0.01	0.09	0.30

** Cultivated areas at Hort de la Masia de l'Antic Jardí Botànic serve the purpose of reproduction of land-races.*

Garden descriptions based on an assessment of multi-beneficiary and multi-purpose urban horticulture gardens, conducted between April and September 2013, through remote sensing and ground observations as well as interviews with gardeners and local authorities.

Human artifacts

In all municipal gardens, apart from the *De l'Avi,* the management is undertaken by the municipal green space department, which creates strong similarities between the garden's built facilities, including individual composts for each plot, relaxation areas with tables, benches and chairs, lockers, bathroom, tools, water dispensers and water supply. The conduction of management leads to a large variety of built facilities in the different gardens. While most self-governed gardens possess basic facilities, including compost, a simple shelter for tools, tables and chairs, others embed rudimentary greenhouses (e.g. at *Fort Pienc*), covered relaxation areas (*Poble-sec*), or even basic kitchen facilities (*Del Xino*). Some squatted gardens use high-beds due to known or suspected soil pollution, for example *Hort del Xino*, which reduces the available space for horticultural cultivation.

Practices & activities

A common rule for municipal gardens is the prevention of pesticide, herbicide and chemical fertilizer uses, and the implementation of organic horticultural practices. Although no formal sanction mechanism is given, the rule is widely followed and enforced through informal control mechanisms between gardeners. Throughout the year most gardeners visit the garden at least every second day, usually for around three hours. Although common activities, such as joint work, fests, and assemblies are rare, a continuous exchange of practices (e.g., in the use of manure), and varieties (e.g., a successfully introduced pea-variety was quickly adopted in the neighboring plots) takes place between gardeners. However, differences in plant varieties are small since seeds and seedlings are mostly obtained from commercial distributors. Some exceptions observed included varieties of potatoes, beans and tomatoes, introduced by migrant gardeners from their regions of origin (most gardeners are migrants from other parts of Spain, who migrated to Barcelona between 1940 and 1980).

Gardeners in self-governed gardens also widely stick to organic horticultural practices, including the use of manure and composted organic waste for fertilization, and various specific techniques for the prevention and treatment of pests and plagues, e.g. combination of plant species. Many gardeners also experiment with gardening techniques inspired by biodynamic agriculture, as well as, traditional agricultural practices, which are applied by older people

with rural origins. Practices are generally orally agreed upon in gardeners' assemblies and enforced through mutual control mechanisms. Garden visits are less frequent than in the municipal gardens but with strong differences across the gardens, while the time spent in the garden at each visit is also about three hours. Common activities, such as the annual distribution of manure (observed at *Can Masdeu*), joint meals, educational events and open workshops were reported for most self-governed gardens.

Table 4.iv: Bundles of ecosystem services provided by urban gardens

Ecosystem Service	*NMDS1*	*NMDS2*	*r2 Pr(>r)*	*Signif.*	
Maintenance of biodiversity	0.87260	0.48844	0.0673	0.375	
Aromatic medicinal plants	0.89321	0.44964	0.3334	0.008 **	
Food supply (quantity)	0.32577	-0.94545	0.552	0.001 ***	Food supply (bundle)
Food supply (quality)	0.01263	-0.99992	0.3892	0.011 *	
Maintenance of soil fertility	0.28327	-0.95904	0.2108	0.111	
Air purification	-0.67694	0.73604	0.1317	0.202	
Local climate regulation	-0.24887	0.96854	0.3043	0.028 *	Regulation (bundle)
Global climate regulation	-0.10107	0.99488	0.069	0.441	
Pollination	-0.09765	0.99522	0.4557	0.001 ***	
Political fulfillment	0.66395	0.74778	0.72	0.001 ***	
Social cohesion	0.54208	0.84032	0.2307	0.069 .	Fulfillment (bundle)
Place making	0.43641	0.89975	0.3753	0.008 **	
Natural & Spiritual experiences	0.30194	0.95333	0.3896	0.009 **	
Biophilia	-0.99814	-0.06096	0.528	0.001 ***	
Esthetical information	-0.90639	0.42244	0.5377	0.002 **	Mental recreation (bundle)
Relaxation & Stress reduction	-0.95392	0.30005	0.416	0.005 **	
Entertainment & Leisure	-0.97346	0.22888	0.5326	0.001 ***	
Exercise & Physical recreation	-0.75060	-0.66075	0.6876	0.001 ***	
Learning & Education	-0.51842	0.85513	0.2295	0.064 .	
Maintenance of cultural heritage	0.58700	-0.80958	0.1559	0.147	

*Results from a non-metrical dimensional scale (NMDS) approach identifying ES bundles in across 27 urban gardens in Barcelona, based on beneficiaries' values. Significance levels: ***0, **0.01, *0.05; P values based on 999 permutations.*

4.3.4 Benefits and values

Bundles of ecosystem service benefits

Urban gardens in Barcelona provide different bundles of ES (Foley et al., 2005), that means synergies are given between the values attached to different ES. Our results shown in Table 4.iv depict four main bundles: a) *food supply*, b) *regulation*, c) *fulfilment*, and d) *mental recreation*. The food supply bundle includes 'quality' and 'quantity food supply', and the 'mainte-

nance of soil fertility'. The regulation bundle includes 'pollination', 'local and global climate regulation' and 'air purification'. The fulfilment bundle involves the appreciation of 'political fulfilment', 'social cohesion', 'place-making', and 'natural & spiritual experiences'. Finally, the mental recreation bundle includes 'aesthetical information', 'relaxation & stress reduction', as well as 'entertainment & leisure'.

Other values of ES that are often perceived together are the 'maintenance of biodiversity' and the provision of 'aromatic & medicinal plants', while values held for 'biophilia', 'exercise & physical recreation' and 'learning & education' did not show clear interaction with any other ES. Trade-offs, i.e. ES that partially exclude each other, are less clearly identifiable by the methods used and should rather be interpreted as tendencies. Such trade-off tendencies (Table 4.iv) can be described between the food supply bundle and the fulfilment bundle, as well as between the bundle of mental recreation and the 'maintenance of biodiversity' and 'aromatic & medicinal plants'.

Perception of ecosystem service values

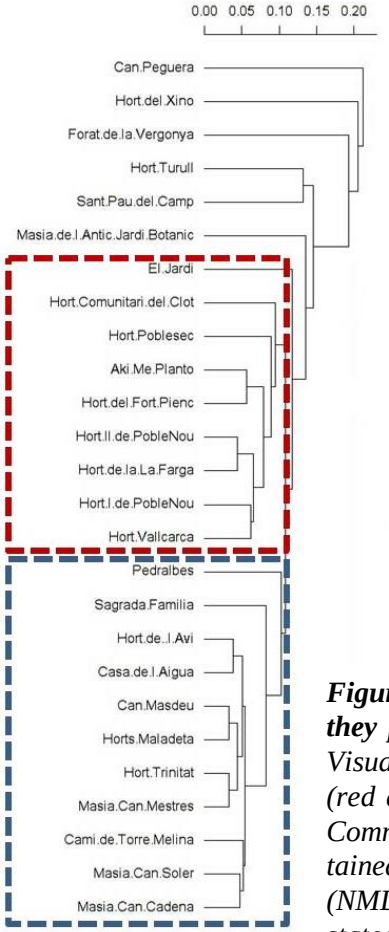
Gardens can be divided into two large groups, shown in Figure 4.ii as cluster A and B, regarding stated ES values. ES values characterizing cluster A are summarized by the fulfillment bundle, with emphasis on 'political fulfillment', such as the resistance to predominant models of urban development (Camps-Calvet et al., 2015). This cluster of gardens is characterized by small garden sizes and number of workers, and exclusively includes gardens resulting from squatting of vacant land. The vast majority (eight out of nine) of these gardens were founded between 2009 and 2013 (except *Aki me planto* founded in 2003), after the beginning of the economic crisis in Spain. All gardens are self-governed by horizontal decision-making processes, mostly through assemblies, and gardens were informally tolerated, i.e. the gardeners were practically proprietors of the gardens. However, the proprietor status can be precarious due to a lack of formal agreements with the authorities and with public or private land owners. Seven out of nine gardens in the cluster were tendered collectively in absence of individual plots (the twin gardens *Poblenou 1* and *2* are an exception; these were collectively tendered areas, maintained in parallel with individual parcels).

Cluster B is positively related to the higher appreciation of 'exercise & physical recreation' and 'biophilia', understood as the human satisfaction of seeing plants growing (Camps-Calvet et al., forthcoming; Wilson 1984). In addition, gardens in this cluster are highlighted for their importance for ES summarized in the food supply bundle, as well as those bundled as mental recreation. Cluster B exclusively includes larger gardens (with twenty or

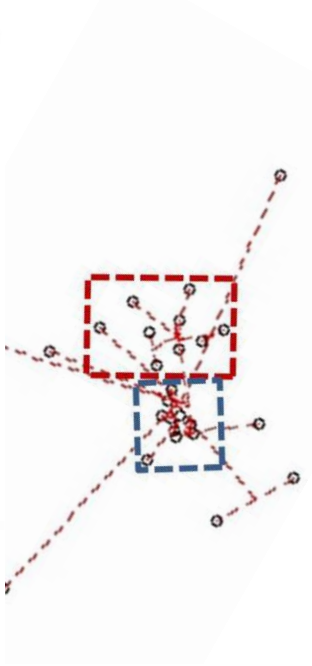
more gardeners) that were founded before 2009, the beginning of the economic crisis in Spain. The cluster includes nine municipal gardens with hierarchical decision-making processes and the self-governed gardens *Can Masdeu* and *La Porta. Can Masdeu* was the only garden in this cluster that used assemblies for decision-making, while *La Porta* had no formal way of decision-making, decisions were mainly taken individually. It stands out, that all gardeners except in the two self-governed gardens held formal guarantees of proprietor rights (usually guaranteed for five years) over their respective plots. Yet, even though gardeners' proprietor rights at *Can Masdeu* were not formalized, the gardeners' property rights seem to be more stable than in most other self-governed gardens due to toleration by the district authorities. A similar situation was given at *La Porta* where the local district government tolerated the garden as interim land-use (in the meantime, this status has been disputed and the gardens future is currently unclear). All gardens in cluster B were divided into individually tendered plots and managed as allotments (*Can Masdeu* embeds, in addition, a small collectively managed area). The remaining six gardens could not be clearly grouped regarding the ES values they provide.

Garden properties that significantly influenced the appreciation of ES are related to the garden's social context, governance as well as structure and processes. The determining criteria ($P \leq 0.005$) for the valuation of ES are the garden size, the property rights, management, the number of workers and the foundation year. In addition, Table 4.v shows that specific characteristics of garden users influence the perception and appreciation of ES including: (i) sex, whereby women valued ES higher than men ($P \leq 0.001$); (ii) formal education, whereby people with lower formal education valued ES higher than people with higher education ($P \leq 0.05$); (iii) income, whereby individuals with lower incomes valued ES higher than individuals with higher incomes ($P \leq 0.1$); (iv) gardeners' origin, whereby local people valued ES higher than migrants ($P \leq 0.1$); (v) migration period, whereby migrants who arrived to Barcelona before 1980 provided higher scores ($P \leq 0.05$), (vi) and time spend in the garden, whereby the time spent in the garden is positively related with higher valuation of ES ($P \leq 0.05$). Other characteristics of gardeners, including age, number of persons living in the household and the engagement with environmental associations, according to our data, had no explanatory power for differences in the valuation of ES across gardeners.

Cluster dendogram



NMDS



Garden characteristics

- Emergence 2009-2013 (except *Aki Me Planto*: 2003)
- Civic governance
- Tolerated informal proprietors (on squatted land)
- Collective plot management (except *Poblenou 1 and 2*)
- Predominantly above 60 years

- Emergence pre-crisis (2002-2009)
- Municipal governance (expect Can Masdeu & La Porta)
- Auth. users of gardens (expect Can Masdeu & La Porta)
- Formal proprietors of plots (except Can Masdeu)
- Individual plot management (small collectivelly manged areas in Can Masdeu)
- 20 or more workers per garden
- 40% female gardeners, 60% ,male gardeners

Ecosystem service values

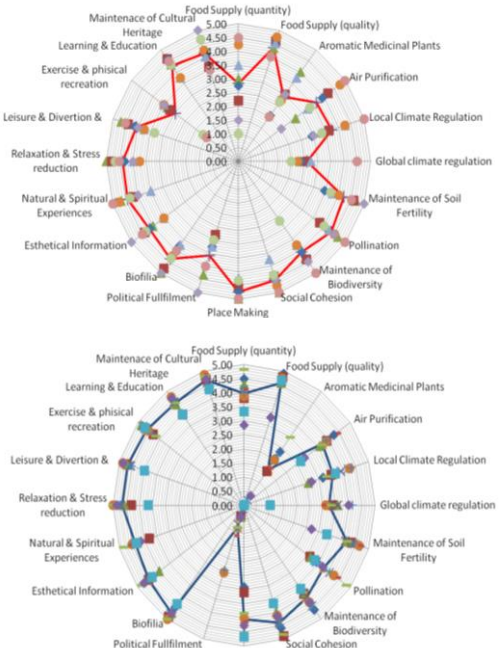


Figure 4.ii: Common social-ecological characteristics of urban gardens and the ecosystem services they provide.*Left: Cluster dendogram showing two main clusters (red and blue frame). Centre left: Visualization of a non-metrical dimensional scale (NMDS) showing the two main clusters A and B (red and blue frame), it might be interpreted as a top view of the cluster dendogram. Centre right: Common characteristics of gardens within the main two clusters A and B (red and blue frame), obtained through superimposition of social-ecological characteristics on non-metrical dimensional scale (NMDS). Right: Ecosystem service values in the two main clusters (red and blue frame), based on stated preferences in a survey among 201 urban gardeners (2013).*

Table 4.v. Appreciation of ecosystem services from urban gardens by user properties

Property	Criteria	Correlation with ES value	Coefficient (standard error)	P>|T|
Sex	Women	+	*-0.33 (0.08)*	*0.00****
	Men	−		
Age		=	*0.00 (0.00)*	*0.69*
Education	Lower than secondary level	+	*-0.20 (0.10)*	*0.05**
	Higher than secondary level	−		
Income	Lower income	+	*-0.00 (0.00)*	*0.10**
	Higher income	−		
Origin	Not born in Barcelona	−	*0.21 (0.11)*	*0.07**
	Born in Barcelona	+		
Migration period	After 1980	−	*0.28 (0.13)*	*0.04***
	Before 1980	+		
Number of people living in the household		=	*-0.05 (0.04)*	*0.21*
Daily time spent in the garden	Less than 2 hours	−	*0.20 (0.10)*	*0.04**
	More than two hours	+		
Affiliation to environmental association	Given Not given	=	*0.03 (0.10)*	*0.74*

*Significance levels (P>|T|): ***0.01, **0.05, *0.1*

Garden users properties as explanatory demographic variables in relation to ES values based on Likert scale rankings as outcome variables (aggregated across all samples, internal consistency: Chronbach alpha = 0.89). Explanatory variables included three continuous variables: (i) age, (ii) number of people living in the household, and (iii) income (monthly income in a household divided by the number of people living in the household); and six binary variables: (i) sex (0= woman, 1= man), (ii) education (0= lower, 1= higher than secondary level) (iii) origin (0=not born in Barcelona; 1=born in Barcelona), (iv) migration period (0= arrived to Barcelona after 1980, 1= before 1980), (v) time spent in the garden (0= less than 2 hours; 1= more than two hours), and (vi) affiliation to environmental associations (0= No; 1=Yes) . Conducted as multivariate regression analysis (N=171 after dropping some observations for lacking information) using STATA 12.
Foundation of ecosystem service values

4.4 Discussion

Most studies have assessed the value of ES from urban green spaces as ecological values, such as carbon sequestration and cooling potentials by plants and trees or habitats for species (Haase et al., 2014). While these assessments are important to understand the ecological boundaries of urban green spaces that provide ES, socio-cultural values are also needed to address the human demand for specific ES. Information about both is crucial to advise urban governance in steering the creation and maintenance of green spaces in cities. Lacking understanding of the foundation of ES values, may lead to urban green space planning that does not match human demands. Consequently, the livability of cities might be lower, and human demands may increase the pressure on ecosystems elsewhere. Our study provides an innovative methodological approach to explore the foundation of ES values. While ecological properties seem to be crucial for the potential provision of ES, a major finding of this work is that ES values - which probably to a substantial degree incentivize stewardship practices - are both produced as well as perceived, qualitatively differently with regard to the social context and governance institutions of green spaces in cities.

4.4.1 ES values related to the social context

The perception of values has been shown to partly relate to the characteristics of garden users', thereby confirming previous findings by Dunnett &

Quasim (2000). For example, female socialization has shown as positively influencing the awareness of benefits from nature, this has been related to the different female role in agro-ecological labour, expertise and knowledge (Martín-López et al., 2012). The stronger appreciation of ES by female garden users stands in sharp contrast to the low number of female gardeners in Barcelona. This result might rebut our assumption that ES values incentivize environmental stewardship. However, figures in Northern Europe are nearly opposite with regard to the sex of gardeners (Barthel et al., 2010). This might indicate institutional or cultural barriers impeding females from engaging in urban gardening in Barcelona. In either case, future research is encouraged to address the role of female gardeners and the implication of gender involvement more thoroughly. Results also indicate that a lower income also stipulates the appreciation of ES from urban gardens; indicating that social groups that lack economic purchase power, often retired and jobless person, have stronger incentives for engaging in environmental stewardship (Camps-Calvet et al., forthcoming).

Our study also found indicative signs that gardens that existed for longer tend to contribute to a different set of values than younger gardens. Results indicate a considerable shift in ES values demanded from urban gardens in Barcelona for the year 2009 ─ the beginning of the economic crisis in Spain. Results showed, for example, stronger appreciations of biophilia and individual fulfillment within gardens founded before 2009. It has been argued that the specific situation of economic crisis present in Barcelona in recent years enhanced a politically motivated civic garden foundation (Camps-Calvet et al, 2015). It is also worth highlighting that in post-crisis gardens (cluster A) the political ideal of food sovereignty and the knowledge of food production were far more important than the actual quantity of produced food. The emergence of urban gardens in Barcelona during the economic crises is, thus, not explained with the need for enhanced food supply. The limited smaller size of cluster A compared to cluster B gardens and limited available area for food production reflects this.
Tidball (2012) explains the "community-based ecological restoration" in moments of crisis as an urge to express human's affinity with nature through creation of restorative environments, allowing for a reconnection to the "… ecological self and sense of ecological place …" (Tidball & Stedman, 2013). Results show that political fulfillment and place-making, expressing both contestations to the predominant economic system as well as a request stronger community resilience in cities towards volatile dynamics in global financial systems (Camps-Calvet et al., 2015) were predominantly demanded by the design of cluster A gardens, created after the economic crises. These

gardens can thus be interpreted as places where adaptive capacity in the face of the economic crisis is built. These gardens may thus be seen as seeds for adaptation and transition as well as technologies used to make claims for a just and sustainable city (Dempsey et al., 2011; Fainstein, 2010; Kabisch & Haase, 2014). Or put in other words, as niche innovations (Schot & Geels, 2008), serving as places for experiments with new and diverse forms of value articulation, decision-making, social practices, for a transition towards an ecosystem based urban planning agenda (Bendt et al., 2013).

In contrast to the post-crisis gardens, gardeners in older gardens were more inclined to develop place specific knowledge and values with a bearing on food production, both in terms of quality and quantity, the exchange of such knowledge through learning and education, as well as its maintenance build into cultural heritage. Analogously, we observe high values for political fulfillment and 'place-making', as the (collective) creation of meaning in relation to the garden's physical and social design (Noori, & Benson, 2015), in gardens that emerged after 2009, when the economic crisis began. Results akin to this observation have been found for urban gardens in Berlin by Bendt et al. (2013), who highlighted that social practices and social learning as well as political engagement had stronger importance in younger gardens, and described an individualization in older gardens, where gardeners tend to be more closed down to the wider urban society. This finding might point towards a more general pattern between the values perceived in younger and older gardens. However, it might also indicate a potential trade-off that needs further research before advising urban policies that aim to boost both civic stewardship of local ES, and simultaneously support more inclusive forms of green areas in cities (*cf.* Bendt et al., 2013).

4.4.2 ES values related to governance institutions

Our results demonstrate links between property rights held by gardeners and ES values. Especially the strong value for place-making, often the base for sense of place and community (cf. Raymond et al., 2010; Noori, & Benson, 2015) in cluster A gardens indicates a beneficial relation between extended property rights and inclusive urban green spaces. Since cities are usually loci of social diversity (Zanoni & Janssens, 2009), we argue here that green spaces with property rights that are inclusive to a rich variety of lifestyles, gender, ethnicities and different age-groups, are rendered especially relevant for environmental stewardship among heterogeneous urban populations (Colding & Barthel, 2013). Gardeners who hold proprietor rights have the possibility to learn how to adapt the garden's physical and institutional design with regard to ES they appreciate most. From the perspective of adap-

tive ecosystem governance (Boyd & Folke, 2011), creating a feedback-loop that allows for an alteration of the social-ecological properties of urban gardens to changing human demands, depends on the capacity of institutional actors to consider citizens ES values (Dietz et al., 2003). For example, gardeners in the self-managed gardens *Horts de Can Masdeu* and *Hort de la Porta* (cluster B) seek for physical and mental recreation and enhanced food production, to this enhance these ES allotment gardens with individual plot management are created. Oppositely, gardens (in cluster A) are designed for civic inclusion and include collective garden management with horizontal decision-making processes, in favor of social cohesion, place-making and political fulfillment. In contrast, in the remaining cluster B gardens, run by the municipality where gardeners have reduced ability to decide on and design the social-ecological garden structure, this feedback is not given.

In terms of theoretical context, we suggest that our exploration herein provide new insights on the role of 'urban green commons' (Colding et al., 2013), as a noteworthy link to and foundation for future research in the field of transitions thinking for a sustainable development (e.g. Geels & Raven, 2006; Grin et al., 2010). Such transitions and the required niche innovations (Schot & Geels, 2008) have been receiving much attention of late. However, technological innovations within, for instance, energy technologies and infrastructure (e.g. Smith et al., 2005; Boyd & Juhola, 2014) seem to have gained more interest than green infrastructure and innovative nature-based solutions found in this study. Based on this shortcoming, Seyfang & Haxeltine (2012) suggest that social–psychological aspects such as identity building and sense of community within wider societal shifts need more theoretical consideration and development.

Following Tidball´s argumentation (2012), the provision of institutional and physical space constitutes a main challenge for urban planning in achieving adaptive governance and management capacities. On the one hand, allowing for bottom-up gardening initiatives embeds legal obstacles, on the other hand publicly managed gardens lack institutional flexibility to adapt to changing and pluralistic civic demands. This may be especially challenging in demographically dense cities such as those in Mediterranean Europe and Asia. In this context, the shift in urban garden policies by Barcelona's planners from the municipal garden program towards the '*Pla Buits' (Empty-Spaces Plan)* is an interesting case of promoting land stewardship in dense cities that deserves further research, since it might indicate a pathway to provide both institutional space for civic management and physical space for interim stewardship of vacant land. For Barcelona our study indicates that gardens embedded in the municipal garden program constitute a concrete potential to

introduce experimental co-creation structures by extending gardeners management rights beyond the individual garden plots.

4.4.3 Limitations

Six gardens (*Antic Jardí Botànic, Hort Turull, Sant Pau del Camp, Can Peguera, Del Xino,* and *Forat de la Vergonya*) could not clearly be correlated with a larger cluster regarding the ES values perceived. This may be partly related to methodological shortcomings. Due to the small number of gardeners in some of these gardens, only a limited number of surveys were executed, which makes results sensitive to outliers, and demands careful interpretations. However, deviating results in these gardens may also be related to peculiarities in garden properties that are not captured by our data collection or statistical approach. The latter may include, the particular emergence of *Forat de la Vergonya* out of (violent) contestations, the claimant rights exclusively held at *Antic Jardí Botànic*, or the particular land-cover at *Del Xino* that barely lacked any aliment production. The socio-cultural valuation of ES underlying our results showed a limited appreciation of regulating and habitat services (Camps-Calvet et al., forthcoming), which might indicate a methodological bias in Likert-scale rankings of multiple ES. Regulating and habitat ES are generally more complex and difficult to understand than provisioning and cultural ES, and might thus lack stronger appreciation by lay people in a survey method where detailed ecological information cannot be provided.

4.5 Conclusion

The provision of ES in cities is among the great challenges of an ever more urbanizing world in the 21st century. The capacity of urban green spaces to provide ES is limited. However, even small patches of green spaces, such as urban gardens in Barcelona, are important pieces in a larger network of green spaces in cities and worldwide. Creating awareness for the capacity of urban green spaces to provide ES may support their stronger recognition in urban governance. The green spaces governance, as our study has shown, is crucial for enabling ES stewardship. From the perspective of civic ecology (Krasny & Tidball, 2009[b]) "the sustainable city does not only weave nature into its physical landscape, but also into the everyday practices and experiences of its citizens" (Bendt et al., 2013:29). Previous research has put emphasis on assessing the capacity of the ecological structure of urban green spaces to provide ES. Yet, the benefits and values related to ES, which motivate environmental stewardship, are not singularly determined but the eco-

logical properties of urban green spaces, but co-created through social-ecological interactions. Our study shows that a more holistic understanding and consideration of ES values is required to derive practical advices urban governance.

For example, a major finding from our study is that there are some significant determinants of ES values, such as the number of workers, property rights, and management regimes. These can be influenced or modified by judiciously designed policies. Furthermore, we suggest that diversity in the management of urban gardens may broaden their relevance as innovative stewardship arenas for ES by enabling broader citizen groups to intertwine gardening practices with wider sets of issues (cultural, political, and spiritual). Hence, successful stewardship policies of cities must take into account that cities often hold cosmopolitan mindscapes rich in terms of world-views, and values, and hence opportunity structures for stewardship should be tailored to fit micro-scale specific circumstances.

Thinking of humans as integrated, interacting and often shaping natural systems is still not yet fully adapted within ecosystem thinking and ES research; even less established is the consideration of cities as social-ecological systems in urban theory. We believe that stronger interdisciplinary collaboration between the social and ecological sciences is beneficial to better understand the generation of ES from urban green spaces and inform policies that sustain their delivery. Cities are rapidly developing both from socio-demographical as well as biophysical perspectives, and difficulties in coping with changing demands for ES can be assumed a common challenge in urban planning; thus, requiring flexibility and tolerance to diversity in urban policy, planning and management practices. Our study underlines the previously described capacity for civic engagement in the management of urban green areas by highlighting the potential bottom-up emergence of urban gardens, as adaptive nature-based solutions, to changing demands for ES.

Cities are connected to, and dependent on the biosphere that faces uncertain changes. Involving civic stewardship groups have been highlighted as a promising way to build creative capacity to such uncertainties (Colding & Barthel, 2013; Andersson et al., 2014). Civic stewardship, for example practiced in urban parks in Berlin, requires a shift in urban policy, where power and rights are shared with the users and civic stewards of urban ES (Colding et al., 2013). Lacking civic management experiences in Barcelona and other Mediterranean cities, stewardship approaches to green areas consisting in joint co-creation by professionals and laypeople might be a promising approach to experimentally implement the creative potential that cities hold. As with urban services which are co-created in other realms such as in art, in

local markets and in a vivid street-life, urban services which like ES, can enhance the livability of cities.

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Chapter 5

Contrasting values of cultural ecosystem services in urban areas

The case of Park Montjuïc in Barcelona

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Abstract Urban green infrastructure attracts growing attention for its potential as a nature-based strategy to improve quality of life through the provision of ecosystem services. In this paper, we value cultural ecosystem services in relation to land-uses and management regimes of urban green infrastructure. Through a survey among 198 beneficiaries of the largest urban park in Barcelona, Spain, we assessed cultural ecosystem services in monetary and non-monetary terms in relation to land-uses and management regimes. Results from our research suggest that monetary and non-monetary valuations capture complementary information, and show that values of cultural ecosystem services change across different green infrastructure assets and management regimes. For example, 'environmental learning' generates low monetary values but high non-monetary values. Stronger place values were related with low management intensity, while values for tourism increase with land-uses embedding cultural facilities. We discuss monetary and non-monetary values in the light of urban green infrastructure strategies and indicate potentials for urban planning and management to proactively alter the provision of cultural ecosystem services through specific configurations of land-uses and management intensity.

Keywords Cities • Urban ecosystem services • Valuation • Green infrastructure • Spain

5.1 Introduction

The concept of urban green infrastructure is increasingly used to capture the multi-functionality of urban green and blue spaces, such as parks, gardens, forests, rivers and lakes in or near built areas that are managed for producing ecosystem services and benefits to city inhabitants (Bolund & Hunhammar, 1999; Gómez-Baggethun & Barton, 2013; Sandstrom, 2002; Tzoulas et al., 2007). The concept green infrastructure emphasizes a holistic and multi-functional understanding of interconnected green spaces across various scales, and comprising different degrees of human transformation (Ahern, 2011; Pauleit et al., 2011; Tzoulas et al., 2007). Ecosystem services from urban green infrastructure include, for example, food production in gardens and air purification and temperature regulation by forests – but perhaps most importantly in the urban context are a variety of cultural services, values and benefits (Konijnendijk et al., 2013). Cultural ecosystem services, like recreation, aesthetic appreciation, spiritual experiences, sense of place and social cohesion, enrich human life with meanings and emotions and contribute to enhance the physical and mental health of city inhabitants (Altman & Low, 1992; Chiesura, 2004; Gómez-Baggethun et al. 2013; Maas, 2006; Peters et al., 2010; TEEB, 2011). Valuation of cultural ecosystem services is a way to understand and demonstrate the importance of non-material benefits from nature that matter to humans that can, therefore, be used to inform planning of green infrastructure (Chan et al., 2012). Because people allocate very different meanings to nature, various methods and approaches have been used for the valuation of cultural ecosystem services in urban areas, ranging from the use of monetary valuation techniques like hedonic pricing, contingent valuation, choice experiments and travel cost methods (e.g., Jim and Chen, 2007; Teknomo, 2005), to non-monetary methods based on observational studies, stated well-being, self-reported physiological health, time allocation and preference ranking approaches(e.g., Chiesura, 2004; Maas, 2006). Ecosystem services and benefits of urban green infrastructure result from a combination of biophysical and social factors, including land-uses, management regimes and access regimes (Andersson et al., 2007; Barthel et al., 2005; Pickett et al., 2008). Yet, knowledge about the linkages between land-uses, management regimes and the production of ecosystem services is

still limited, as is the understanding of the trade-offs between the provision of competing services (de Groot et al., 2010; TEEB, 2010). This study illustrates how the valuation of cultural ecosystem services can be used to inform urban planners and policy-makers on how to enhance the social benefits of urban green infrastructure. To this end, we use monetary and non-monetary approaches to value cultural ecosystem services provided by urban green spaces, and assess effects of land-uses and management regimes in ecosystem service values. Our research is based on the case study of Park Montjuïc, the largest and most visited urban park in the city of Barcelona, Spain.

5.2 Materials and methods

5.2.1 Case study: park Montjuïc in Barcelona, Spain

Barcelona is located in Northeast Spain and is – with 1.62 million inhabitants living on about 100 km^2 (IDESCAT, 2013) – one of the most densely populated cities in Europe. Given the limited availability of green space per capita (less than 7 m^2/inhabitant), Barcelona´s City Council is putting strong emphasis on enhancing the quantity, quality and ecosystem services of green space, as a part of the Barcelona green infrastructure and biodiversity plan 2020 (Barcelona City Council, 2013). The importance of Barcelona ′s green infrastructure for producing ecosystem services is recognized both by the local authorities and by recent scientific studies (Chaparro & Terradas, 2009; Baró et al., 2014). However, the potential for increasing the amount of green spaces in Barcelona is ultimately limited due to the city ′s compact structure and because of the surrounding hills and sea creating a natural geographical boundary. This situation poses high pressure and conflicting demands on existing green spaces, involving major challenges for decision-making on green space planning and management.

The Park Montjuïc covers an inner city hill at the South of the city, and is central within the Barcelona ′s green infrastructure strategy, given that it attracts about 16 million visits per year (Barcelona City Council, 2010). With an area of approximately 338 ha (Barcelona City Council, 2010), Park Montjuïc is by far the largest urban park and the second largest green area in Barcelona (Figure 5.i). Park Montjuïc is covered by a mosaic of green spaces, including 85% of lawns, gardens, parks, forests and other green infra-

structure, while the remaining 15% is covered by built infrastructure including public facilities and roads (Langemeyer, 2012).

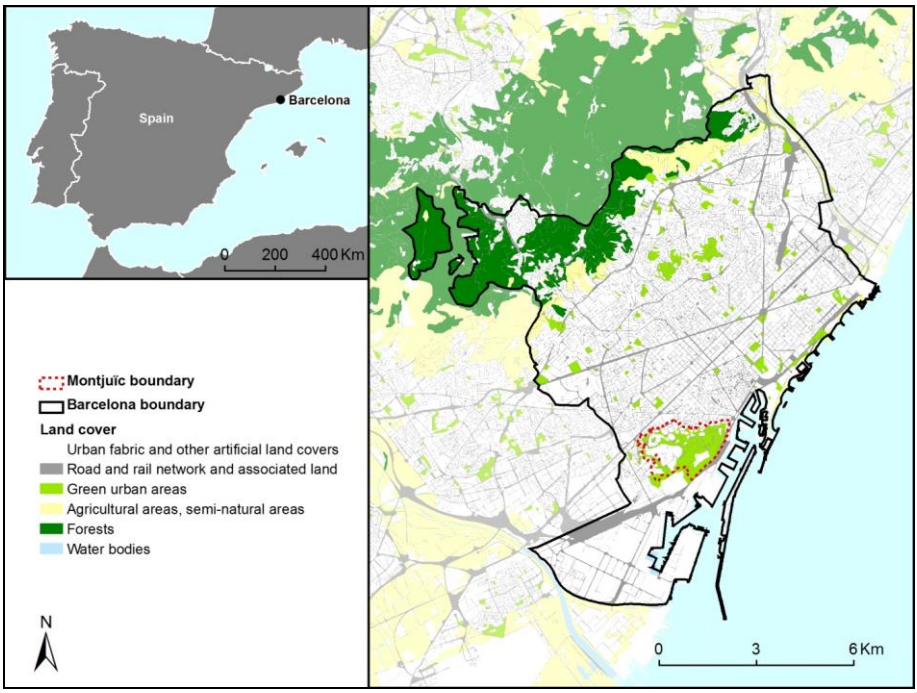


Figure 5.i. Spatial description of Park Montjuïc in Barcelona, Spain. *From Langemeyer (2012), based on ICC (Catalan Cartographic Institute) datasets, Corine land-use maps, and Ecological Map of Barcelona (Burriel et al., 2006).*

The specific urban planning instrument MGPM (Modification of the general metropolitan plan for the area of the Montjuïc mountain) that recognizes Park Montjuïc as a "distinct and singular planning unit" within the city ′s general plan (Barcelona City Council, 2010), was finally approved in June 2014. The plan manifests Park Montjuïc ′s outstanding character as open space with natural interests and defines four new planning zones according to morphological and land-use characteristics (Barcelona City Council, 2010). The new zoning is shown in Figure 5.ii (bottom) and includes the following categories: a. 'Classical Park', enclosing areas close to urban neighborhoods, such as many historical parks and cultural facilities where cultural and recreational uses are highlighted; b. 'Sports Park', embedding

sport facilities (including Olympic facilities), with a focus on sports uses; c. 'Natural interest', located at the sea front and the higher parts of Park Montjuïc is establishing

5.2.2 Background information

Background information was compiled to identify and characterize major ecosystem services and benefits provided by Park Montjuïc ′s green infrastructure, and to gain understanding of the main planning and management issues affecting Park Montjuïc in the context of Barcelona ′s green infrastructure strategy. We also gathered land-use maps and management databases for the study area (Barcelona City Council, 2010; Barcelona City Council, 2012; Burriel et al., 2006). We reviewed scientific publications, the gray literature and planning documents addressing ecosystem services and/or green space planning and management at Park Montjuïc, and consulted 18 local experts from different disciplines (including urban planning, environmental health, psychology, biology and geography) and institutions (including the Urban Ecology Agency of Barcelona, the Barcelona City Council, local universities and an environmental NGO) through in-depth interviews. Although regulating ecosystem services, like the provision of habitat for species, air purification and urban temperature regulation by Barcelona ′s green infrastructure have recently gained interest among local policy makers (Barcelona City Council, 2013; Chaparro & Terradas, 2009) and scientists (Baró et al., 2014), the literature review and expert consultations emphasize that the main function attributed to Park Montjuïc in Barcelona ′s green infrastructure strategy is related to the provision of cultural services, values and benefits (Barcelona City Council, 2013; Boada and Capdevila, 2000; Núñez et al., 2004). Over the last century, the land use and management focus at Park Montjuïc has shifted from provisioning ecosystem services (such as construction material, food production and fresh water) to cultural ecosystem services (Roca, 2000). Accordingly, the recently published planning instrument MPGM, puts strong emphasis on cultural ecosystem services and highlights the benefits for physical and mental recreation, esthetics and tourism provided by Park Montjuïc (Barcelona City Council, 2010).

5.2.3 Valuation of cultural ecosystem services

To assess values of cultural services associated with the green spaces of Park Montjuïc, we conducted a survey among 198 beneficiaries—defined here, as visitors to the park—in May 2012 (see Supplementary Material S1 for an excerpt from the questionnaire). The survey was conducted to collect data for a master thesis (Langemeyer, 2012) and contained two parts. The first part was designed to assess monetary values associated with cultural ecosystem services, and the second part was designed to assess non-monetary values. Monetary valuation was conducted using an Individual Travel Cost Method (ITCM). ITCM is a standardized approach to determine the monetary surplus value of visits to recreational sites (Dixon & Hufschmidt, 1986; Martín-López et al., 2009) that has been previously applied to determine cultural and recreational values of urban parks (More et al., 1988; Teknomo, 2005). The individual travel cost to reach the site was calculated for every visitor, based on the stated transport costs and an opportunity cost for the travel time – both derived from the survey. The survey assessed the travel time to and from the park, and the costs incurred to reach the study site – i.e. in the case of non-residents, the money and time spent to travel from their accommodation to the study site and back. The best way to calculate the opportunity cost related to travel time is object of an ongoing discussion since Cesario (1976) and McConnell & Strand (1981). Following these authors, the opportunity cost for leisure activities is generally chosen within a range from 0.3 to 0.6 of the hourly wage (e.g., Hein et al., 2006). Accordingly, the travel time in our study was determined as hourly wages multiplied by a factor 0.5. Hourly wages were calculated based on the average net household income within the sample divided by an estimated number of 134 working hours per family per month (assuming one fulltime-working person per household). The calculation of the individual travel cost is given by

$$TC_i = TCs_i + 0.5\frac{I_{mean}}{tW}\, tT_i \qquad \text{Eq. (1)}$$

where, TC_i is the individual's i travel cost, TCs_i is the individual stated travel cost (transport), I_{mean} is the mean family income per month (across all samples), tW is the number of working hours per month, and where tTi is the individual travel time. Finally, we estimated a demand curve for the number of visits subject to individual travel cost to obtain an average monetary sur-

plus value attached to each visit to the park. The monetary values resulting from ITCM were based on an opportunity cost for travel time of 9.30 USD per hour, derived from the net average household income within the sample of 2492.27 USD per month. Based on recent classifications of urban ecosystem services (TEEB, 2011; Gómez-Baggethun et al. 2013), we distinguished four different types of cultural ecosystem services: (1) 'recreation, and spiritual and mental health' (in the following referred to as 'recreation'), (2) 'tourism', (3) 'aesthetical appreciation and inspiration' (in the following 'aesthetical appreciation'), and (4) 'spiritual experiences and sense of place' (in the following 'place values'). From the insights we obtained in the consultations to local experts, we added a fifth category, labeled here (5) 'environmental learning' (Bendt et al., 2012; Krasny and Tidball, 2009). Because we were interested in distinguishing the monetary value associated with each cultural ecosystem service, we weighted the individual travel cost TC_i using results from a Pebble Distribution Method (PDM) (Colfer, 2005; Sheil et al., 2003) given in Eq. (2), and we estimated an average surplus value per visit for each of the five cultural ecosystem services in our sample.

$$TCn_i = TC_i\ PDn_i \qquad \text{Eq. (2)}$$

where, n is the type of cultural ecosystem service, TCn_i is the individual's i travel cost associated to each cultural ecosystem service type n, and where PDn_i is the individual pebble-distribution value of cultural ecosystem service type n (in %). The PDM was combined with the ITCM in the questionnaire by asking respondents about their motivation to visit Park Montjuïc. The respondents were asked to think of their visiting motivation within six different categories; five of which presented the previously described set of ecosystem services ('recreation', 'tourism', 'aesthetical appreciation', 'place values' and 'environmental learning'). A sixth type of motivation (labeled 'cultural activities') accounts for visiting motivations that were not directly related to Montjuïc 's green infrastructure, such as expositions and concerts provided by cultural facilities located within Park Montjuïc. The reason to add this sixth category was to avoid a positive bias in values by correcting for motivations to visit the area unrelated to ecosystem services. Visiting motivations may overlap between these categories and, hence, respondents were asked to distribute 10 small stones (pebbles) on a panel with six pic-

tures representing the six motivation categories. The distribution of pebbles, thus, indicated the weight of the visiting motivation across the six categories. Non-monetary valuation of ecosystem services was conducted through preference ranking methods based on constructed measures using Likert-scales (Bernard, 1999; Kelemen et al., 2014) within the same survey. Likert-scale rankings have been suggested and used for non-monetary ecosystem service valuation, translating qualitative statements into quantitative measures along ordinal scales (Calvet-Mir et al., 2012; Castro et al., 2013; Martín-López et al., 2012; Kelemen et al., 2014). However, its application requires careful consideration and acknowledgment of some intrinsic limitations, such as a limited quantitative interpretability, overlaps between ecosystem service categories, and bias due to the limited group of respondents, the affirmative formulation of the survey question or the respondent ′s intention to please the interviewer (Calvet-Mir et al., 2012). Rankings were based on the degree of agreement (on a scale from 1='I totally disagree', to 10='I totally agree') to an affirmative statement about the importance (value) of a given cultural ecosystem service, such as 'Park Montjuïc is important because it serves as an area for recreation' (see Supplementary Material). Average Likert-scale values were calculated across all samples. For a better comparison of the values obtained from the two valuation approaches, we conducted a standard minimum–maximum normalization following Eq. 3:

$$x' = \frac{(x - x_{\min})}{(x_{\max} - x_{\min})} \qquad \text{Eq. (3)}$$

where, x' is the normalized value, x is the initial value, x_{min} is the minimum value among all values, and x_{max} is the maximum value among all values.

5.2.4 Variation of values with land-use types and management

We used a two-layered mapping approach to integrate information about the way land-use types and management regimes correlated or not with the assessed values (Figure 5.ii). The first layer describes land-use types at the study site divided into four classes (Burriel et al., 2006): 'cultural facility', 'parks and gardens', 'semi-natural', and 'sports facility'. The second layer

We mapped values of cultural ecosystem services using a Geographical Information System (ArcGIS 10). The places where surveyed beneficiaries had been met were used as spatial proxies of the sites where benefits from cul-

tural ecosystem services are realized. Then, we overlaid the map of ecosystem service values with the map of land-uses and management regimes. Average values for cultural ecosystem services were finally calculated based on the intersection of sample points with each layer class.

Table 5.i. Green space management intensity

Level	***Description***	***Spaces and features***	***Management cost*** *[USD/m^2/year]*
A – High	Intensive maintenance, subject to the characteristics of the space or its location.	Parks, gardens, squares and flowerbeds in the public highway that are historical, theme-based or emblematic, as well as inner block courtyards in the *Eixample* district (of Barcelona)	3.07
B – Medium / Standard	Medium maintenance, especially subject to high frequentation.	Parks, gardens, places and flowerbeds in the public highway	2.26
C – Low	Less intensive maintenance, below medium or standard maintenance given the types of plantations or a reduced frequency of use.	Parks, gardens, squares and flowerbeds in the public highway	0.84
D – Minimal	Very low intensity maintenance seeking to ensure that vegetation preserves its wild characteristics.	Parks and gardens	N/A
E – Preventive	Maintenance actions carried out mandatorily or by law in order to prevent forest fires.	Plots	N/A

Adapted from the Barcelona green infrastructure and biodiversity plan 2020 (Barcelona City Council, 2013). Average management costs between 1999 and 2002, no data available for more recent years, no data available (N/A) for management levels D and E (Personal communication 14/10/2014, by Montserrat Rivero Matas, Green Spaces and Biodiversity, Environment and Urban Services - Urban Habitat, Barcelona City Council). Currency conversion: 1 € = 1.28 USD (average midpoint rate for the week of Monday, May 14, 2012 to Sunday, May 20, 2012).

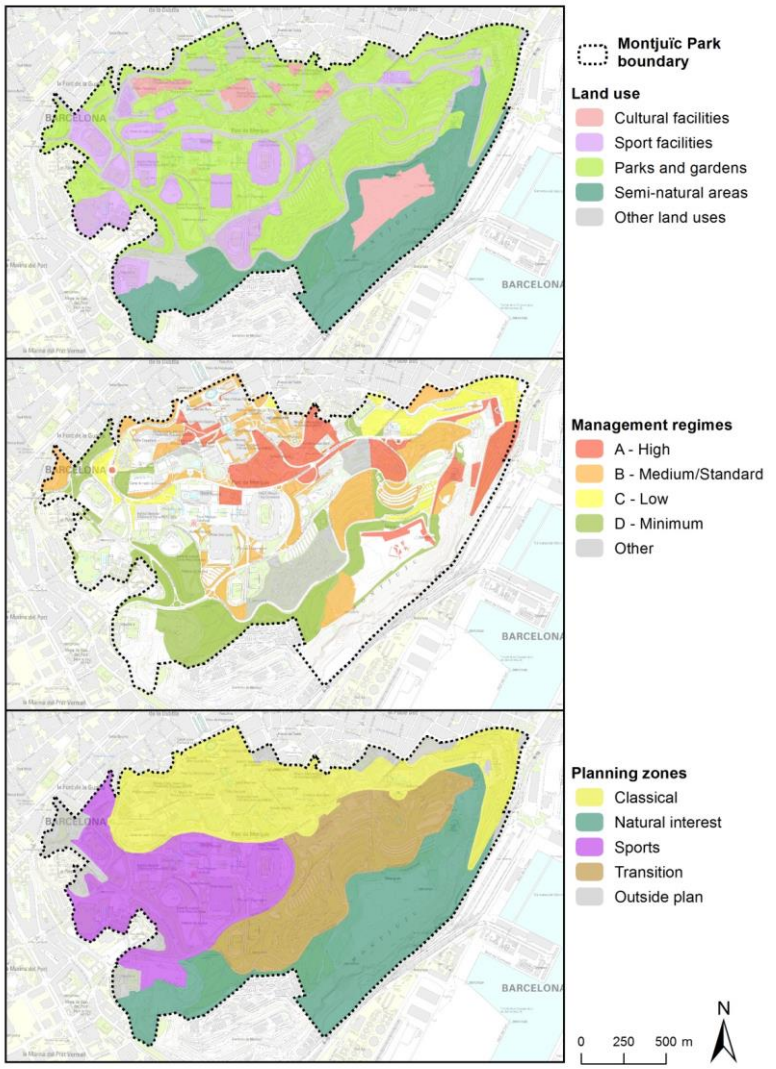


Figure 5.ii Land-use and management regimes at Park Montjuïc *Land-use map based on the classification from the Ecological Map of Barcelona (Burriel et al., 2006); 'other land-uses' refers land that is not covered by vegetation, such as streets and parking lots. Management regimes are derived from the Green Space Maintenance Database provided by the Barcelona City Council (2012). This database covers areas managed by the Barcelona City Council's green space department. Areas labeled as 'other' have a separate management plan and do not fall under the five general*

categories; at Montjuïc these areas include the botanic garden and Barcelona's public plant nursery 'Tres Pins'. Planning zone map based on the Modification of the general metropolitan plan for the area of the Montjuïc mountain (MPGM) (Barcelona City Council, 2010). The new planning instrument changes the delimitation of Park Montjuïc. Areas in the category "outside plan" have previously been treated as parts of Park Montjuïc but have been excluded from it in the new plan (concerning mostly residential areas).

5.3 Results

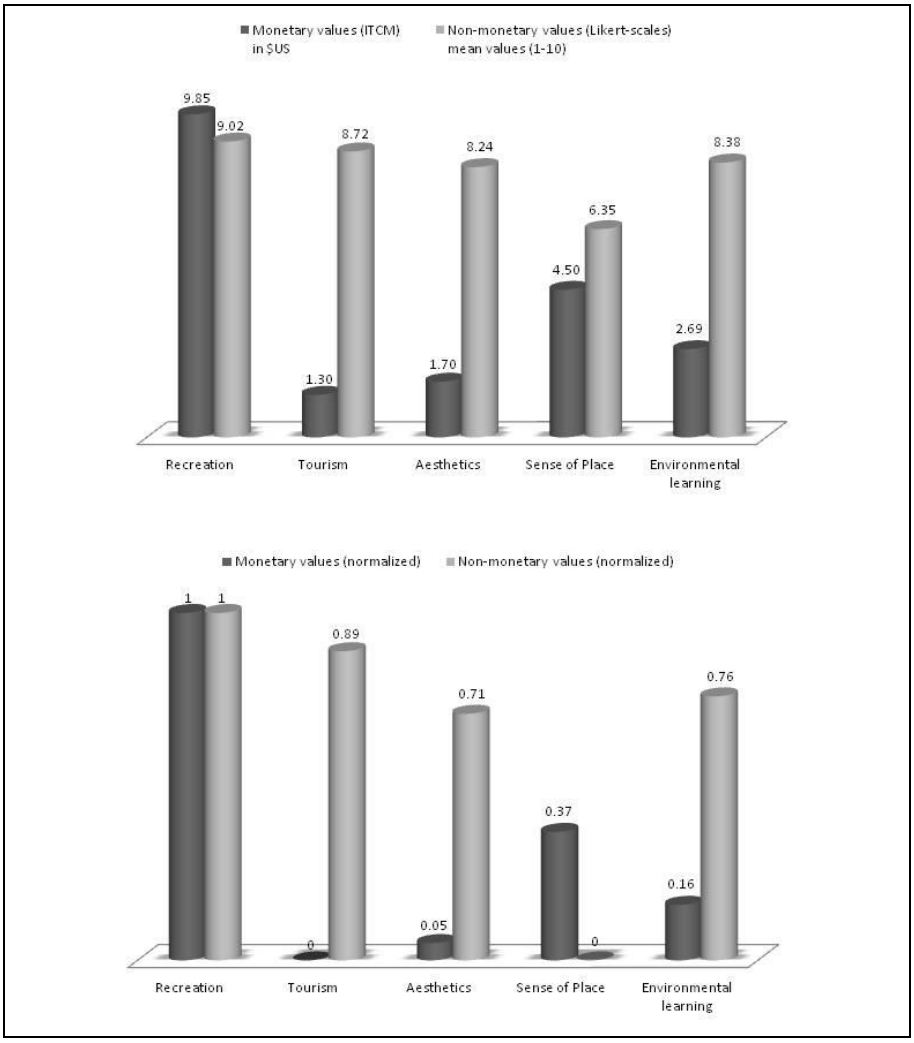
5.3.1 Values of cultural ecosystem services

Monetary and non-monetary values of cultural ecosystem services at the study site are presented in Figure 5.iii. The average monetary (surplus) value from cultural ecosystem services amounted to 4.54 USD per person per visit. Monetary values obtained for the five cultural ecosystem services – representing reported motivations to visit the park – were estimated at 9.85 USD per visit for 'recreation', 4.50 USD for 'place values', 2.69 USD for 'environmental learning', 1.70 USD for 'aesthetical appreciation', and 1.30 USD for 'tourism'. Non-monetary values on the Likert scale (ranking from 1 to 10) were highest for the service 'recreation', with an arithmetic mean value (μ) of 9.02 and standard deviation (σ) of 1.45. 'Tourism' obtained the second highest value (μ=8.72; σ=1.87), 'environmental learning' was ranked third (μ=8.38; σ=1.97), followed by 'aesthetical appreciation' (μ=8.24; σ=1.92) and 'place values' (μ=6.35; σ=2.99).

Figure 5.iii. Monetary and non-monetary values of cultural ES

Adapted from Langemeyer (2012) and based on TEEB (2011) ecosystem service categories. Exchange rate for monetary values: 1 € = 1.28 USD (average midpoint rate for the week of Monday, May 14, 2012 to Sunday, May 20, 2012; http://www.oanda.com). Monetary values are the average surplus value per visit for five cultural ecosystem services, i.e. values given would be reached if a person has a hypothetical single-purpose motivation to visit the park based on one service, while the total average would represent the benefit obtained by an average person from our sample when visiting the park. For non-monetary values (measured on Likert-scales, from 0 = low to 10 = high) means (μ) are shown. Normalization followed:

$x'=(x-x_{min})/(x_{max}-x_{min})$, where x´ is the normalized value, x is the initial value, x_{min} is the minimum value among all values, and x_{max} is the maximum value among all values.



5.3.2 Effects of land-use s and management regimes on ES

Ecosystem service values and land use types

The highest monetary values per visit of 7.45 USD and 7.39 USD corresponded to the land-use classes ‘semi-natural’ and ‘sport facility’, respec-

tively; a medium value of 4.93 USD was linked to ‘parks and gardens’; and a low value of 2.58 USD corresponded to the land-use ‘cultural facility’.
In the non-monetary valuation, high values for the service ‘recreation’ intersected with the land-use classes ‘semi-natural’ areas and ‘sport facility’, medium values corresponded to ‘parks and gardens’, and low values to ‘cultural facility’. Likert scale values for ‘tourism’ were high for the land-uses ‘semi-natural’, ‘cultural facility’ and ‘parks and gardens’, while they were notably lower for the land-use ‘sports facility’. ‘Aesthetical appreciation’ rendered higher values for the ‘cultural facility’ and ‘parks and gardens’ classes, and lower values for ‘sport facility’ and ‘semi-natural’ land-uses, while noting that values obtained for the different land-use classes varied only 1.17 points. Small variations were also observed for the Likert-scale ranking of ‘place values’. It obtained higher values for areas devoted to ‘parks and gardens’, about average values for areas classified as ‘semi-natural’, and lower values for ‘cultural facility’ and ‘sport facility’ land-uses.

Ecosystem service values and management regimes

With regard to the relation between values and management regimes we obtained the lowest monetary values per visit for ‘medium/standard’ management intensities (5.19 USD), a value of 5.38 USD for areas under ‘high’ level of management. The highest values (6.21 USD) were obtained for the areas with ‘minimum’ level of management. Non-monetary values for ‘recreation’ only showed a very small overall variation of 0.61 value points on the Likert-scale across management regimes (where ‘medium/standard’>‘high’> ‘minimum’); differences were even smaller (less than 0.38 points) in the values obtained for ‘tourism’ (‘high’≈‘minimum’>‘medium/standard’). Only slightly larger differences were observed for ‘aesthetical appreciation’ (‘minimum’>‘high’>‘medium/standard’), while only ‘environmental learning’ and ‘place values’ showed a stronger positive variation corresponding to the ‘minimum’ management regime (‘minimum’>‘medium/standard’≈‘high’).

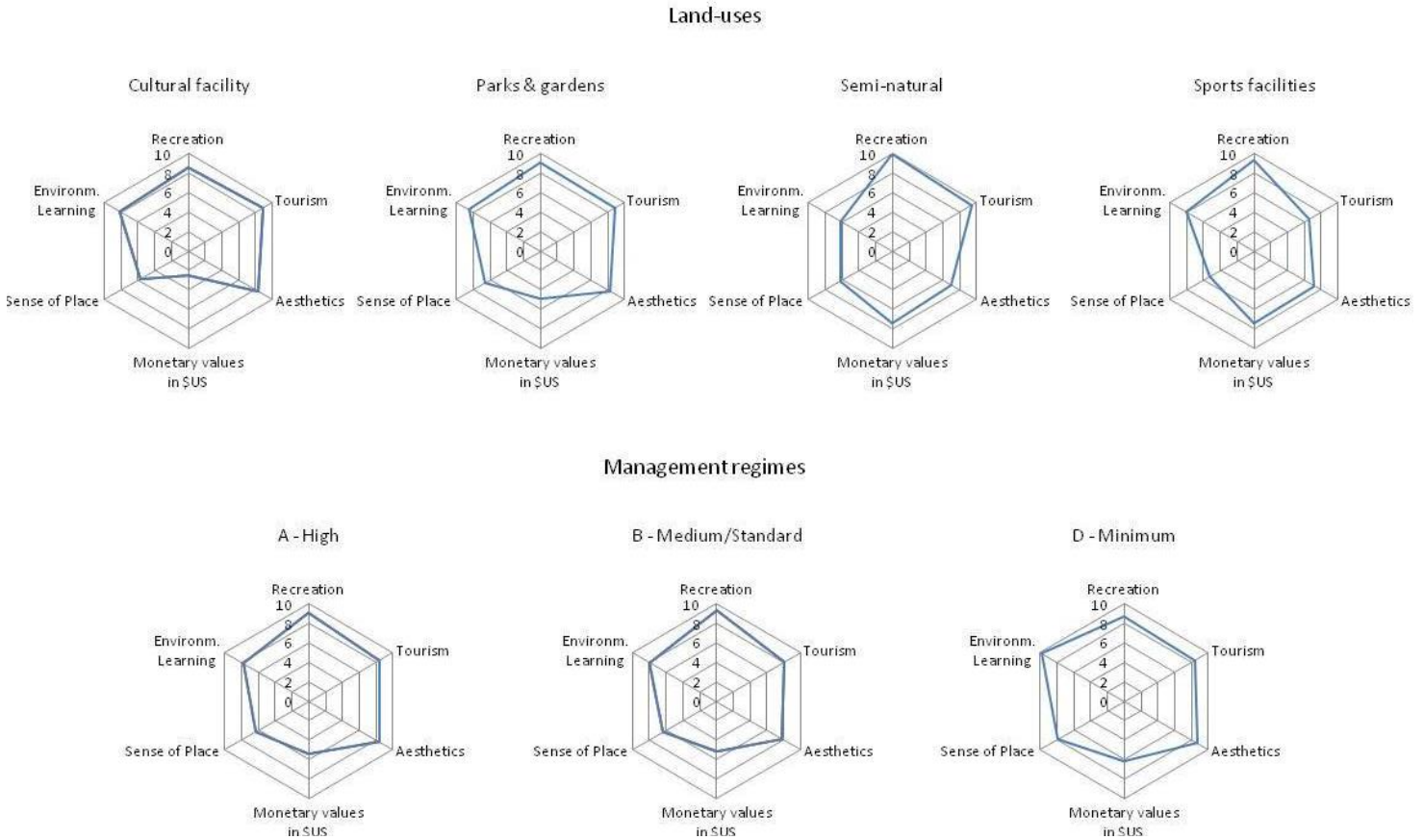


Figure 5.iv. Values of cultural ecosystem services related to land-uses and management regimes. *Based on the Ecological Map of Barcelona (Burriel et al., 2006) and Green Space Maintenance Database (Barcelona City Council, 2012). Monetary values are based on the exchange rate: 1 € = 1.28 USD (average midpoint rate for the week of Monday, May 14, 2012 to Sunday, May 20, 2012). Non-monetary values result from Likert-scale rankings range from 0 = low to 10 = high. Number of intersecting samples in land-use classes: Cultural facilities (n=41), Parks & Gardens (n=141), Semi-natural (n=5), Sports facilities (n=10). Number of intersecting samples in management classes: High (n=44), Medium/Standard (n= 33), Low (n=0, not shown in the figure), Minimum (n=8), Preventative (not given at Park*

Table 5.ii. Values of cultural ecosystem services related to land-uses and management regimes

n	*Land use*	*Non-monetary values*										*Monetary values*	
		Recreation		*Tourism*		*Aesthetical appreciation*		*Place values*		*Environm. Learning*		*(USD)*	
		μ	*σ*	*μ*	*σ*	*μ*	*σ*	*μ*	*σ*	*μ*	*σ*	*μ*	*σ*
41	Cultural facility	**8.66**	*1.39*	**8.90**	*1.45*	**8.37**	*1.60*	**5.71**	*3.30*	**8.15**	*1.70*	**2.58**	*1.30*
141	Parks & gardens	**9.07**	*1.45*	**8.80**	*1.77*	**8.33**	*1.90*	**6.62**	*2.80*	**8.55**	*1.87*	**4.93**	*2.72*
5	Semi-natural	**10.0**	*0.00*	**9.40**	*0.80*	**7.00**	*2.40*	**6.20**	*2.40*	**6.20**	*3.71*	**7.45**	*3.65*
10	Sports facilities	**9.30**	*1.55*	**6.50**	*3.20*	**7.20**	*1.60*	**5.30**	*2.00*	**8.00**	*2.24*	**7.39**	*1.42*

n	*Management*	*Non-monetary values*										*Monetary values*	
		Recreation		*Tourism*		*Aesthetical appreciation*		*Place values*		*Environm. Learning*		*(USD)*	
		μ	*σ*	*μ*	*σ*	*μ*	*σ*	*μ*	*σ*	*μ*	*σ*	*μ*	*σ*
44	A - High	**9.05**	*1.31*	**8.36**	*2.16*	**8.39**	*1.76*	**6.27**	*3.07*	**7.75**	*2.68*	**5.38**	*2.51*
33	B - Medium or Standard	**9.36**	*1.44*	**8.00**	*2.58*	**7.76**	*1.80*	**6.32**	*2.80*	**7.96**	*2.47*	**5.19**	*1.91*
0*	C - Low	-	-	-	-	-	-	-	-	-	-	-	-
8	D - Minimal	**8.75**	*1.98*	**8.38**	*2.60*	**8.63**	*1.70*	**7.88**	*1.60*	**9.75**	*0.43*	**6.21**	*3.13*
0**	E - Preventive	-	-	-	-	-	-	-	-	-	-	-	-

** no intersection with our sample points; ** management class not given at Montjuïc*

Based on the Ecological Map of Barcelona (Burriel et al., 2006) and Green Space Maintenance Database (Barcelona City Council, 2012; Barcelona City Council, 2013). For all values means (μ) and standard deviations (σ) are given. Monetary values are based on the exchange rate: 1 € = 1.28 USD (average midpoint rate for the week of Monday, May 14, 2012 to Sunday, May 20, 2012; Source: http://www.oanda.com). Non-monetary values result from Likert-scale rankings range from 0 = low to 10 = high.

5.4 Discussion

5.4.1 Complementary values in cultural ecosystem services

Monetary and non-monetary techniques to assess values of cultural ecosystem services allow assessing divergent not always consistent results. For example, divergent monetary and non-monetary values were observed for 'tourism' and 'place values' as well as for 'aesthetical appreciation' and 'environmental learning'. Such conflicting results across value dimensions are consistent with previous findings (e.g. Martín-López et al., 2014); the type of methods chosen, the design of the survey, the questions applied and metrics used may define to a large extend which specific values are captured. In our study, for the monetary valuation, the beneficiary's motivation to visit Park Montjuïc was requested, whereby use values were assessed. In contrast, the non-monetary valuation approach asked for the general importance beneficiaries attach to the study site for the provision of a specific ecosystem service. Besides personal use-values, this question embedded notions of moral values such as the consideration of needs by others. Looking for example at 'environmental learning', the use-value of this service expressed in monetary values in our study was of minor importance for the survey respondents. Yet, high non-monetary values were articulated for this service expressing the respondents' acknowledgment of the importance of 'environmental learning' at Park Montjuïc (for example for children) even if their individual visiting motivation does not include educational benefits. Divergent monetary and non-monetary values were not observed for all ecosystem services assessed: The values for 'recreation' were consistent under both approaches. However, our results indicate that monetary and non-monetary valuation approaches provide complementary information about the importance of cultural ecosystem services, suggesting the need to account for a pluralism of values as the necessary evaluative space for ecosystem service assessments (Chiesura & Martínez-Alier, 2010; Gómez-Baggethun & Barton, 2013; Martínez-Alier et al., 1998) as well as supporting recent calls for integration of different methods and disciplinary perspectives (Gómez-Baggethun & Ruiz-Pérez, 2011; De Groot et al., 2006; TEEB, 2010). This is a crucial insight if monetary or non-monetary valuation of ecosystem services is meant to provide useful information for urban planning and man-

agement. Overlooking important value dimensions of ecosystem services when assessing green infrastructure strategies can lead to misinformed decision-making and, thus, to ineffective planning and management. For example, in our case study‘tourism’ obtained a low monetary value but a high non-monetary value. If the tourist benefits of Park Montjuïc green infrastructure had only been assessed in monetary terms, the (unquestioned) importance of Park Montjuïc for ‘tourism’ would have been downplayed. It should also be acknowledged here that monetary valuation of urban ecosystem services bears a risk of misinterpretations. With an average surplus value per visit of 4.54 USD per person per visit and the information that Park Montjuïc receives about 16 million visits per year (Barcelona City Council, 2010), an overall value in monetary terms is easily calculated. Such an overall use value would be low compared to the monetary benefits from imaginable scenarios of real-estate developments at Park Montjuïc. It would also be inadequate as a measure of the total value of Park Montjuïc because it neglects other types of ecosystem services and indirect use values, such as those provided by biodiversity that are difficult if not meaningless to measure in monetary terms. Instead, the monetary values derived in this study are, for example, more suitable to justify public costs embedded in the management and maintenance of urban green infrastructure. Complementary valuation approaches and integrated assessments also reduce the sensitivity to assumptions and limitations embedded in specific methods. For example, in our study the monetary valuation by ITCM neglected the potential substitutability of services by other parks, and showed a high sensitivity for the definition of the opportunity cost for travel time. A critical assumption underlying both valuation approaches is the definition of beneficiaries as park-visitors, whereby distant benefits from, for example, aesthetical appreciation are neglected.

5.4.2 Informing land-use planning and green space management

Linking values of cultural ecosystem services spatially to planning and management provides insights in the benefits associated with different green infrastructure types. It may thereby provide additional information for urban green infrastructure strategies as well as concrete planning, such as currently defined for Barcelona and Park Montjuïc in the Barcelona green infrastructure and biodiversity plan 2020 (Barcelona City Council, 2013) and the

Modification of the Metropolitan Master Plan for the Montjuïc Mountain Area (Barcelona City Council, 2010), respectively. For this study, the spatial links of ecosystem service values rely on the assumption that park-visitors obtain the benefits motivating their visits at the specific place surveys were conducted. A limitation of this approach is that it does not capture mobility of beneficiaries as an important variability factor. However, because we observed that respondents frequently referred to their immediate surroundings when answering questions regarding ecosystem services values, we assume this criterion is a useful proxy to make values spatially explicit. Urban green infrastructure can play an important role in strengthening the social cohesion by enhancing place identity and place attachment (Altman & Low, 1992; Peters et al., 2010; Stedman et al., 2006). Our results suggest a potential to increase such 'place values' by implementing 'parks and gardens' and 'semi-natural' land-uses with 'minimum' management intensities. Intensively managed green spaces often produce lower 'place values', possibly because they hinder public engagement (Baumgärtner & Jessen, 2011). In contrast, accessible public green space under low management intensities may encourage social activities and thereby strengthening social cohesion. Given that management costs decrease with decreasing management intensity (Table 5.i), for areas designated to Barcelona's 'low' and 'minimum' management classes, such increase in 'place values' could at the same time mean a reduction in public green space management costs. Our results further suggest that lower management levels can also favor benefits related to 'environmental learning' an explicit goal of Barcelona's green infrastructure and biodiversity plan (Barcelona City Council, 2013). Green areas with less management may provide more opportunities for plant and animal observation thereby increasing the understanding of natural processes, such as plant growing. A potential to lower the management intensity to foster 'place values' and 'environmental learning' values is especially given for 'parks and gardens' land-uses in close proximity to residential areas – i.e. within the newly created 'classic zone' that currently mainly embeds areas of 'high' management (Barcelona City Council, 2010). A robust accounting for values of cultural ecosystem services in relation to current land-uses and management intensities as well as future plans can satisfy the policy need for information about synergies and trade-offs between ecosystem services under alternative green infrastructure types (De Groot et al., 2010). It can also con-

stitute an important step forward in the understanding of the social and ecological factors behind the generation of ecosystem services in urban areas (Andersson et al., 2007; Barthel et al., 2010), providing additional evaluative capacity for urban policy-makers and practitioners to assess green infrastructure strategies (Potschin & Haines-Young, 2012). On the one hand, unraveling linkages between values and land-uses provides guidance about the ecological structure of urban green spaces favoring cultural benefits. On the other hand, ecosystem service values related to land-uses and management regimes enhance the understanding of policy-making to actively alter cultural benefits and increase the adaptive capacity to meet social demands in the city with green infrastructure strategies.

5.5 Conclusions

Our study shows how assessments of ecosystem services can inform about the status of urban green infrastructure and increase the evaluative capacity to inform urban green infrastructure strategies. In line with previous studies combining different methods for ecosystem services valuation (e.g. Martín-López et al., 2014), the occurrence of divergent results in our study suggests the necessity for combined, hybrid or integrated assessments of different value dimensions. Integrated approaches of, for example, monetary and non-monetary valuation, provide a more comprehensive picture because they capture different and often complementary values attached to urban ecosystems services. To guarantee comparability between different assessments and to provide sound advice to urban policy-making, general agreement on standardized methodological approaches is necessary. In this context, our results call for a stronger consideration and justification of the kind of values assessed, such as use and moral values. Making values of cultural ecosystem services spatially explicit allows for an evaluation of green infrastructure strategies in terms of trade-offs and synergies in the provision of ecosystem services. We would like to encourage future research to strengthen the linkages between values of cultural ecosystem services and urban green infrastructure types. A spatial association of values promises to help detecting the combination of social and ecological factors defining the production of ecosystem services – such as proximity, accessibility, types of vegetation cover and management regimes. As our study shows, such information may allow for an adaptation of the urban green infrastructure to social needs and in-

crease the benefits provided by urban ecosystems through, for example, reduced management intensities. Such adaptations will not only increase the contribution of green infrastructure to quality of life in cities but, may, also permit a more efficient and effective green space management.

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Chapter 6

Bridging the gap between ecosystem services and land-use planning

An exploration of multi-criteria decision analysis

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Abstract Land-use planning is an important arena for the governance of ecosystem services in cities. Its strong influence on the structure of ecosystems, and can enhance or impinge upon the benefits provided, including air purification, urban cooling, and recreation. The ecosystem service approach has helped to attract increasing attention to these benefits, yet ecosystem services remain poorly considered in urban governance. In this study, we address this gap by advancing a framework that integrates ecosystem service into policy processes. We further examine multi-criteria decision analysis (MCDA) as a practical tool to conduct an integrated valuation of ecosystem services. Our framework, the 'ecosystem service policy cycle', has been developed from the integration of conceptual models of the 'ecosystem service cascade' and the classical 'policy cycle'. It bridges the conceptual gap that still separates ecosystem service assessments from effective ecosystem governance. We use theoretical insights from this framework and practices from an urban planning case study to examine state-of-the-art knowledge on integrated ecosystem service valuation through MCDA. Based on this review a generalized frequency of steps for the integrated valuation of ES by MCDA is developed, including problem definition, stakeholder engagement, definition and weighting of ES criteria and prioritization of alternatives. Results highlight the potential of MCDA to support ES governance in cities through informing urban land-use planning. Its advantages over other planning tools lie in the capacity to accommodate different value dimensions, such as ecological, socio-cultural and economic, and plural values held by multiple stakeholders. Observations suggest that no standard framework for ES governance can be found, and that evaluation approaches need to be tailored to specific governance contexts.

Key words Cities • Ecosystem services • Urban governance • Multi-criteria analysis • Urban planning • policy evaluation

6.1 Introduction

Urban populations demand growing quantities of ecosystem services (ES), defined as the contributions that ecosystems make to human well-being (Haines-Young & Potschin, 2009), in form of food, drinking water, clean air, and recreation (Guo et al. 2009). At the same time, urbanization is an important driver of land-use change and biodiversity loss (McDonald & Marcotullio, 2011). In a context of generalized decline of ES (MA, 2005), governing ES to satisfy increasing demands for ES in cities stands among the biggest challenges for the urbanizing human society in the 21st century (Elmqvist et al., 2013; TEEB, 2010; Wilkinson et al., 2013). Space in cities is limited and the demand for ES from green spaces is typically much higher and divers in urban than in rural areas (Gómez-Baggethun et al., 2013).While scientific knowledge on ES from urban green spaces is growing (Haase et al., 2014), ES are still lacking stronger integration into urban governance (Ahern et al., 2014; Kabisch, 2015; Primmer & Furman, 2012). A stronger integration of ES in governance requires shifting the research attention from assessment and valuation of ES towards its implementation within urban decision-making (Primmer et al., 2015; Rinne & Primmer, 2015). The governance of urban green spaces, that is the institutional arrangements, structures and processes by which people in societies make decisions and share power (Folke et al., 2005; Lebel et al., 2006), is characterized by multiple levels of formal and informal decision-making. Yet, ultimately, the loss, preservation and restoration of green spaces and associated ES strongly depends on the importance they are given by prevailing land-use planning – one of the most important governance arenas for ES in cities (Primmer & Furman, 2012).

The emerging knowledge on ES and related benefits and values challenges the urban planning system, including existing mind-sets and technical procedures (Rinne & Primmer, 2015). The integrated valuation of ES, including the conflicting relation between different value dimensions and values held by different stakeholders, has been pointed out as a promising approach to inform urban governance at different levels towards safeguarding, improving and restoring highly valuable green spaces (Gómez-Baggethun & Barton, 2013). In promotion of green spaces within and around cities, such as parks, forests, gardens, watersheds, greened lanes as *green infrastructure* (GI) (Pauleit et al., 2011), we assume advantages of an integrated valuation of ES

for urban planning to be twofold: First, an integrated valuation of ES is important to raise awareness for the multiple benefits of and the costs involved in green space losses (Elmqvist et al. 2015; Gómez-Baggethun & Barton, 2013). Second, an integrated approach to the assessment of ES may help to prioritize land-uses with regard to ES values and trade-offs, including between values of different social groups as well as between ecological, socio-cultural and economic value dimensions (Elmqvist, 2011; Langemeyer et al., 2014). Practical assessment frameworks and tools informing about ES values in land-use planning are growing in demand (Koschke et al., 2012; Karjalainen et al., 2013). However, a stronger operationalization and integration of ES into land-use planning and other institutions characterizing urban governance is still in its infancy (Kabisch, 2015; Primmer & Furman, 2012).

Two of the most widely used decision-support tools to inform urban land-use planning are *environmental impact assessment* (EIA) and *cost-benefits analysis* (CBA) (Chen & Jim, 2008; TEEB, 2010). These tools have played a critically important role in the practical integration and evaluation of environmental concerns in urban land-use planning. However, both approaches show difficulties in integrating ES knowledge, especially related to the 'plurality of values' (Gómez-Baggethun & Martin-Lopez, 2015). For example, EIA is characterized by its primary focus on ecological values, with emphasis on planning impacts on water, climate, habitats and protected species. It makes limited consideration to socio-cultural and economic values people attribute to urban green spaces, which are crucial in urban contexts (Haase et al., 2014). To the contrary, CBA is exclusively based on the assessment and comparison of economic, monetary values. It is therefore limited in its capacity to integrate ecological values without direct use for humans, often related to supporting and habitat ES, as well as socio-cultural values related to intangible ES, such as spiritual experiences and sense of place (Chan et al. 2011). The epistemological assumption in CBA of substitutability between ecological, socio-cultural and economic values constitutes a strong reductionism that may blind ecological complexity and obscure the plurality of values ecosystems provide (Martinez-Alier et al., 1998; Noorgard, 2010; Parks & Cowdy, 2012). The commensuration of values along a single measurement unit (money) in CBA seems therefore insufficient to integrate ES knowledge into urban planning and decision-making.

In response to the limitations in current approaches, multi-criteria decision analysis (MCDA) has been proposed as a tool for an integrated valuation of ES; primarily due to its capacities to analyze trade-offs, to consider incommensurable value dimensions, and to integrates values held by different stakeholders (Costanza et al., 2006; Gómez-Baggethun & Martin-Lopez, 2015; Paetzold et al., 2010; Saarikoski et al., 2014, Sijtsma et al., 2013). Its application to ES assessments has been very limited to date, especially in urban planning (e.g. Grêt-Regamey et al., 2013; Sanon et al., 2012; Srdjevic et al., 2013). MCDA may not solve all problems highlighted for EIA and CBA, and might raise new problems, such as those related to non-transparency, risks of manipulation and lacking democratic representation (*cf.* Munda, 2008; Saarikoski et al., 2014; Spangenberg, 2001). Therefore, a differentiated examination of MCDA for an integrated valuation of ES seems required.

On these grounds, this paper aims at examining the potential and limits of MCDA as a tool for an integrated valuation of ES to support urban planning. First, we present a framework, which conceptually integrates ES into policy processes building on the ES cascade model (Haines-Young & Potschin 2009) and the policy cycle (Lasswell, 1956). Secondly, we illustrate this framework along the land-use planning process taking place to determine the after-use for Airport Tempelhof in Berlin, Germany. Thirdly, we review and discuss state-of-the-art knowledge on MCDA for an integration of ES in decision-making. We conclude by highlighting shortcomings and advantages of MCDA in supporting an integrated valuation of ES and recommend its future testing.

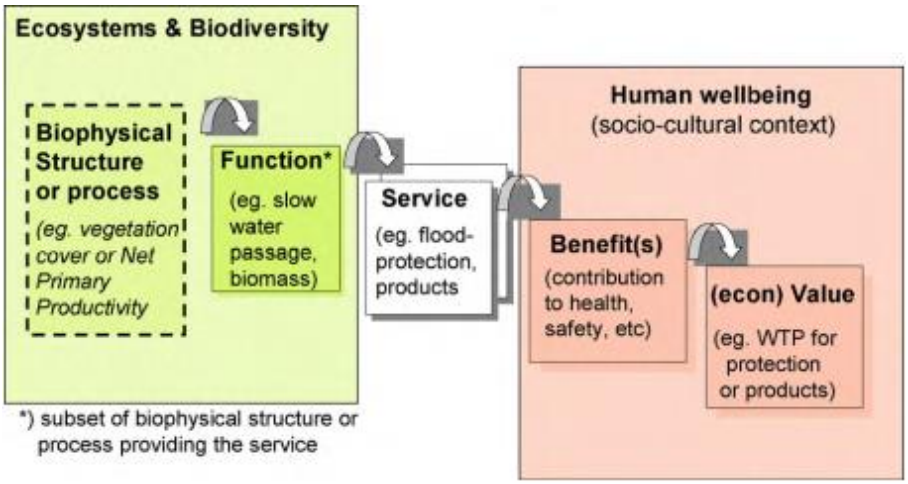
6.2 Bridging the gap between ES and policy

6.2.1 The ecosystem services cascade

The ecosystem service cascade (Haines-Young & Potschin, 2011) is a widely used model which illustrates the links between ecosystems and human wellbeing through the generation of ES. The cascade is widely consistent with other commonly used conceptualizations such as ES-provision-demand-models (e.g. Paetzold et al., 2010) or ES-potential-flow-models (e.g. Schröter et al., 2014).

The cascade model consists of five main elements: *ecosystem structure*, *ecosystem processes* (or functions), *ecosystem services*, *benefits* and *values*. Ecosystem structure depicts a static composition of physical components of an ecosystem, while processes describe the dynamic interactions between these components (TEEB, 2010). Together they represent the *supply side* or capacity of an ecosystem to provide ES (Paetzold et al., 2010; Schröter et al., 2014). Benefits and values represent the human system or *demand side*; where benefits describe the material and non-material contribution of ecosystems to human wellbeing, and values express the human appraisal of these benefits (Braat & De Groot, 2012; TEEB, 2010). ES are feedbacks from the ecosystem to the human system and bridge the supply and demand sides of this scheme (Paetzold et al., 2010).

Figure 6.i. Ecosystem Services Cascade-Model (Potschin & Haines-Young, 2011).
This conceptualization is widely used in ecosystem service research; it introduces ecosystem services as a feedback from ecosystems (characterized by its biophysical structure and related processes and functions) to human wellbeing in from form of benefits and values.



While the ES cascade provides a comprehensive picture of the links between ecosystems and human values, Braat & De Groot (2012) note that the cascade model makes limited consideration of positive and negative feedbacks

from the human system to the ecosystem. In urban ecosystems, that are usually far from naturalness, policy and planning may be crucial determinants in biophysically shaping ecosystem structure and processes, and thus of the potential generation of ES. Furthermore, human values, as the ultimate step of the ES cascade, ideationally influence the policy agenda. These biophysical and ideational feedbacks between the social to the ecological system deserve further attention.

6.2.2 The Policy cycle

The policy cycle, initially introduced by Lasswell (1956), is an idealized model to describe the stages of policy processes that has been widely used in environmental decision-making (e.g. Sarkki et al., 2013). The original policy cycle is illustrated in five stages: a) agenda setting, b) policy development, c) decision-making, d) policy implementation, and e) policy evaluation. *Agenda setting* is "the process by which problems and alternative solutions gain or lose public and elite attention" (Birkland, 2007:63). *Policy development* consists of "identifying and/or crafting a set of policy alternatives to address a problem" (Sidney, 2007:79). *Decision-making* is the selection of a policy alternative guided to reach specific objectives. *Policy implementation* is the execution of a policy or plan and *policy evaluation* defines a systematic assessment of the effects of a policy in the face of its objectives (Jann & Wegrich, 2007). Land-use policies and planning imply long-term effects on ecosystems and the environment, which may have irreversible consequences for human-wellbeing. Therefore, policy evaluations are conducted as *ex-ante* policy assessments, that is before a final decision on a policy alternative is taken; in many countries and decision-contexts, such ex-ante policy assessments are mandatory, for example in form of EIA (e.g. European Commission, 2012).

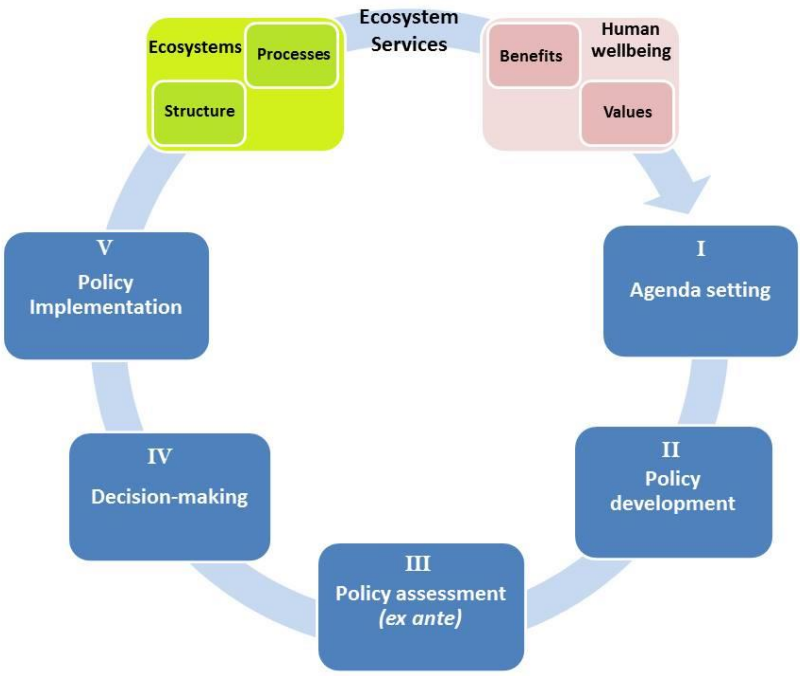
6.2.3 Ecosystem services in governance

A combination of the ES cascade and an adapted policy cycle can enhance our understanding of the links between ecosystems, human wellbeing and governance. The *ES-Policy-Cycle* (Figure 6.ii) describes an idealized policy process of (I) agenda setting, (II) policy development, (III) policy assessment, (IV) decision-making, (V) and policy implementation. The implementation of policies, for instance in form of changed land-uses, affects the bio-

physical capacity of ecosystems to provide ES. Thereby it enhances or decreases the flow of benefits supporting human wellbeing. We propose the *ES-Policy-Cycle* as a cyclical model assuming that values attached to ES may raise public and elite attention and influence the policy agenda (Gómez-Baggethun & Barton, 2013). To our understanding, such informational and ideational feedback can reinitiate the policy-process, and create a closed feedback loop of adaptive ecosystem governance (Boyd & Folke, 2011). The proposed ES-Policy-Cycle can be understood as an "ideal-type of rational planning and decision-making" (Jann & Wegrich, 2007:44) rather than a descriptive model of real-world governance, which often develop along different and unexpected paths as they adapt to contingencies and practicalities.

Figure 6.ii. The Ecosystem-Service-Policy-Cycle: Idealized land-use planning process.

The Ecosystem-Service-Policy-Cycle is a conceptual model to link the ecosystem service concept to policy-making; it combines the policy cycle (adapted from Lasswell, 1956) with the ES cascade model (Potschin & Haines-Young, 2011).



The informational feedback of ES benefits and values is particularly hampered in real world land-use planning, due to the fact that benefits and values are not sufficiently considered in common assessment tools, such as EIA and CBA. An integrated valuation of ES including benefits and values, alongside structure and processes, may fill this gap (Karjalainen et al., 2013), and has been stated as a "logical and necessary element of the sustainable development policy cycle" (Braat & De Groot, 2012:11). The following section will introduce a case of urban planning to exemplify these theoretical thoughts.

6.3 The case of Airport Tempelhof

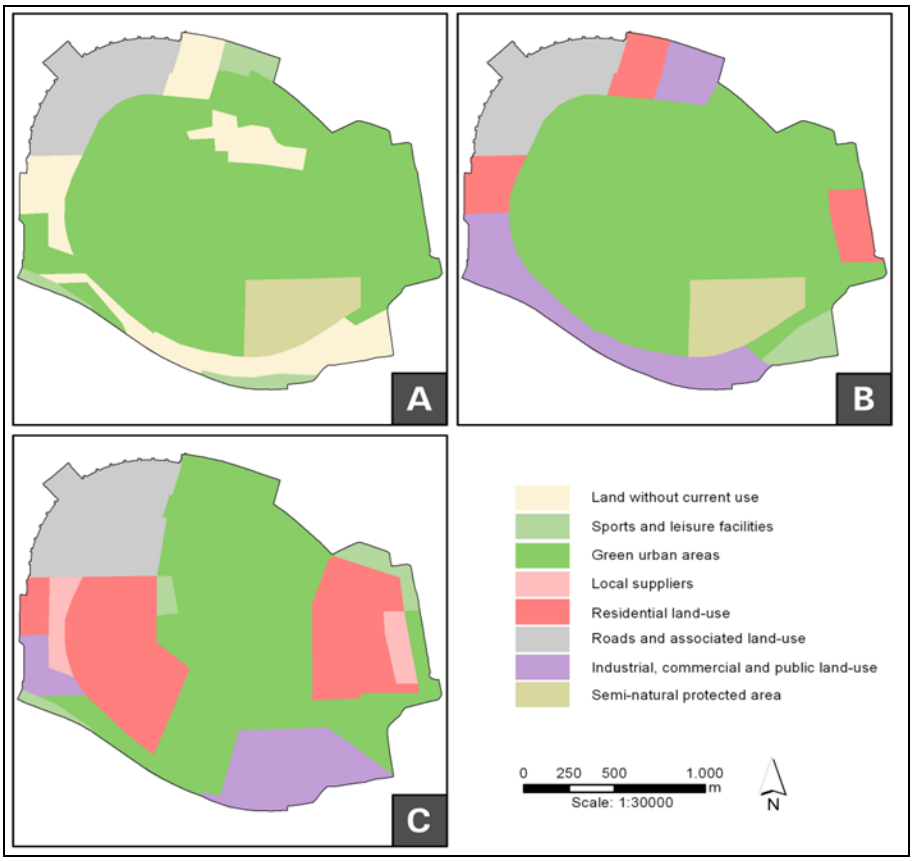
The land-use planning at Airport Tempelhof after its closure in 2008 provided an important challenge to urban governance in Berlin (Germany). With approximately 300 ha, Airport Tempelhof was to become the largest inner-city green space in Berlin (Berlin Senate, 2010). The land-use planning at Tempelhofer Feld serves us as an example to project the different stages of the ES-Policy-Cycle onto a real-world governance situation and underlines our argumentation for the need of an integrated valuation of ES. The after-use of urban transport areas is a recurrent planning situation in cities (Kabisch & Haase, 2014). Other examples include the inner-city airports Floyd-Bennett-Field (New York) closed in 1971, Airport Tegel (Berlin) expected to close in 2016, and Bromma Airport (Stockholm), where a possible closure is the subject of controversial debates.

The process to decide for an after-use of Airport Tempelhof can be summarized as follows: Following the decision to close the airport, defined in the city's zoning-plan in 1994 (*Flächennutzungsplan*, Berlin Senate, 1994), the search for an after-use of the area was set on the policy agenda, (stage I). The zoning-plan builds the legal frame for all lower scale planning instruments. In 2009 a new zoning that announced large transformations of land-uses at Tempelhofer Feld, shown in Figure 6.iii (alternative C), was approved by the Senate. This approval took place despite the after-use policy elaborated by the *Berlin Senate's* administration as a specific Masterplan for Airport Tempelhof between 2003 and 2009 (stage II), including public information and consultation of neighbors (*cf.* Kabisch & Haase, 2014). In the period 2009-2013 an assessment of the Masterplan was conducted in accordance with EIA and national and regional nature protection acts (stage III).

This standard policy assessment included the evaluation of potential impacts of the Masterplan on soil, water, (local) climate, plants & animals, landscape, recreation & cultural goods as well as an estimation of impacts on flora, fauna and habitats, particularly on that of the strongly protected *Skylawk* (Berlin Senate, 2013).

Figure 6.iii. Planning alternatives for the after-use of Airport Tempelhof, Berlin

The planning alternatives (adapted from Metzke, 2012) represent the main land-uses under three competing proposals for an after-use of Airport Tempelhof.



***A**. This land-use alternative was elaborated based on the Masterplan presented in September 2013 (Berlin Senate, 2013). It aimed at maintaining green space in the central part of the site, while allowing for a peripheral*

residential and commercial development. This alternative was rejected by the voters within a city-wide referendum held on 25 May 2014 (Landeswahlleiterin Berlin, 2014).

B. *This alternative represents the 100% Tempelhofer Feld law as proposed by the citizens' initiative (Bürgerinitiative 100% Tempelhofer Feld) (THF 100, 2014). It was broadly seeking to maintain the status quo in land-use patterns as given in 2013. This land-use alternative has been selected by Berlin citizens within a city-wide referendum held on 25 May 2014.*

C. *This alternative is based on an excerpt of Berlin's zoning plan (Flächennutzungsplan, Berlin Senate, 2009), which reflected the official planning goal for Airport Tempelhof by the Senate of Berlin from 1994 until a separate Masterplan (A) was put in place in 2013 (Berlin Senate, 2013). It embeds considerable transformation of green areas into residential, cultural and commercial land-uses including in the central parts of Airport Tempelhof.*

From the perspective of the ES-Policy-Cycle, policy assessments by standard EIA cover the first two steps of the ES cascade (assessing impacts on structure and functions), but leave the citizen perspective related to the impacts unconsidered. Karjalainen et al. (2013) contend this as a general limitation of classical EIA.

Still in 2009, in parallel to the top-down land-use planning by the Berlin Senate, citizen groups started to organize in order to demand wider access to and use of the former airport's green space. The emergence of this bottom-up initiative can possibly be seen in response to challenges of tactical governance described for Berlin, including the engagement with citizens and communication of informal strategies to local actors (Kabisch et al., 2015). In May 2010, authorities opened access to the area and promoted various interim land-uses, including areas for sports and leisure, and community gardening (Berlin Senate, 2010). In 2013, the legal decision-making (stage IV) took place by the Senate of Berlin in form of approving a separate Masterplan (see Figure 6.iii, alternative A) for the area of the former airport (Berlin Senate, 2010; Berlin Senate, 2013). This Masterplan was moderate compared to the land-use changes announced in the 2009 zoning-plan (*Flächennutzungsplan*, Berlin Senate, 2009) and included some of the established interim-uses. However, it still stipulated the conversion of 64 to 75 ha

(diverging estimations by Berlin Senate and citizen's initiative) of green space into residential and industrial land-uses and the transformation of about 22 to 50 ha into private gardens, sports areas and a water retention pool, reducing or transforming previous green spaces by about 29% to 41% (www.thf100.de; Berlin Senate, 2013).

Yet, before the Senate's Masterplan was implemented (stage V), a citizen's initiative (*Demokratische Initiative 100% Tempelhofer Feld e.V.*) presented an alternative after-use plan (stage II) (see Figure 6.iii, alternative B). Its emphasis was on the protection of landscape, cultural-historical and recreational values (THF 100, 2014). The alternative plan further opposed any conversion of green spaces into built infrastructure and demanded the maintenance of all interim land-uses developed since the airport's closing (THF 100, 2014). Based on these objectives, the citizen's initiative challenged and finally overthrew the Senate's after-use plan in a city-wide referendum (stage IV). From the perspective of the ES-Policy-Cycle, we may see this decision as predominantly taken under the consideration of the values expressed by local stakeholders about ES, as expressed for example in their demands for wider recreational and esthetics benefits. However a formal ex-ante policy assessment (stage III) of the long-term impacts on ecological values and to guarantee a sustained flow of ecosystem services was not conducted for this plan. Ecological monitoring processes and participatory approaches are currently used for *ex-post* evaluation of the implemented policy.

The ES-policy-cycle helps us to gain a systematic understanding of the governance of Tempelhof Airport. The case further illustrates the importance of a thorough (*ex-ante*) policy assessment. This was lacking for the finally approved land-use plan, meaning that potential negative impacts in the future stayed unconsidered in the decision-making. Vice versa, we assume that the engagement and communication with local actors and citizens was not sufficient (*cf.* Kabisch, 2015). As a consequence, the important loss of values citizens associated with the proposed land-use changes under the zoning-plan and the Masterplan remained undetected and unconsidered. We suggest that for a thorough policy assessment ecological values, such as derived from an EIA, are to be put in relation to citizens' benefits and values. In this, we believe, an integrated valuation of ES may help to open the evaluative space for decision-making, considering gains and losses in human benefits

and values alongside impacts on ecological structure and processes (Karjalainen et al., 2013; Paetzold et al., 2010). Or said differently, we believe that, in cases like Airport Tempelhof, an integrated valuation of ES might reduce the risk of conflicting situations and enhance the governance quality and legitimacy.

6.4 Multi-criteria decision analysis of ES

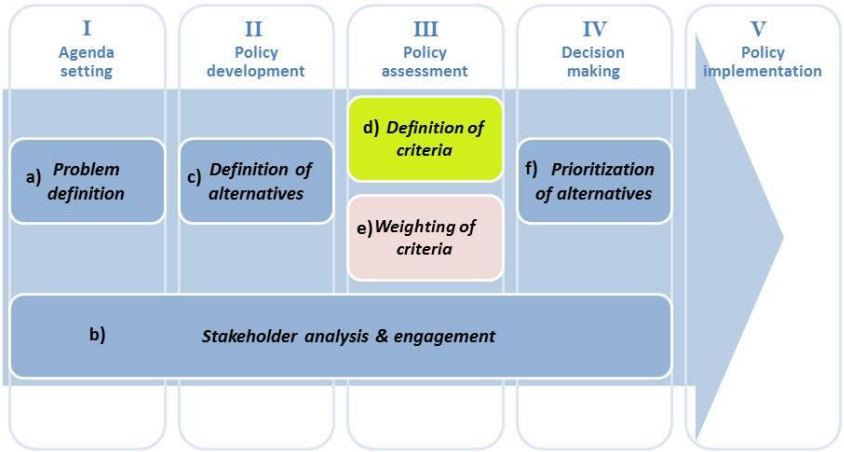
This section introduces MCDA as a potential tool to integrate ES values into the policy-cycle. We developed the ES-Policy-Cycle as a theoretical framework to highlight feedbacks between ES and governance. The framework suggests that ideational feedbacks of ES can positively influence governance outcomes. However, such information is often lacking in real-world planning processes, such as seen for Airport Tempelhof. Multi-step MCDA approaches that systematically assess ES along the cascade-model may serve as a tool to fill this informational gap; thereby demonstrating a possible way to operationalize the ES-Policy-Cycle and to support urban planning.

MCDA is defined as a (multi-step) process that includes a set of methods to structure and formalize decision-making in a transparent and consistent manner (Munda, 2008; Myšiak, 2006). MCDA has been suggested to support ecosystem governance by evaluating policy and planning based on the generation of ES; from this approach, ES are considered as *evaluation criteria* measurable through ES indicators, and human values attached to the criteria as *weights*, describing their relative importance (De Lange et al., 2012; Saarikoski et al., 2014). Given its capacity to operationalize value plurality, MCDA is supposed to be capable to integrate ES knowledge into to decision-making and governance (Dendoncker et al. 2013). In this study, we conducted a review of state-of-the-art knowledge in the use of MCDA for ES assessments, to examine the potential and limits of MCDA as a tool for the integrated assessments of ES in land-use decision-making, such as the one described for Airport Tempelhof.

Generally, ES assessments by MCDA include a serious of steps (Marttunen, 2010; Munda 2008:39), which we relate to the different stages of the ES-Policy-Cycle, shown in Figure 6.iv. The six steps include: I.a) Problem definition (including scale and scope), I.b) stakeholder analysis & engagement, II.c) definition of policy/planning alternatives, III.d) definition and assessment of ES criteria and corresponding indicators, III.e) selection and

weighting of ES criteria, and IV.f) prioritization of alternatives. The latter step involves the selection of an aggregation rule defining the mathematical procedure for the systematic comparison of alternatives (*cf.* Munda, 2008). Different aggregation rules embed dissimilar epistemological approaches especially to trade-offs between criteria, i.e. "the possibility of offsetting a disadvantage on some criteria by a sufficiently large advantage on another criterion" (Munda, 2008:71). We distinguish between *analytical-hierarchy-process*, *(multi-attribute) value-function-based* approaches (strong trade-offs), and *pair-wise-comparison* (weak trade-offs) (Munda, 2008:71ff).

Figure 6.iv. Idealized multi-criteria decision analysis process for ecosystem service assessments.
Based on a review of 32 MCDA studies of ecosystem services a generalized sequ*ence of steps has been developed, inspired by Marttunen (2010) and Munda (2008:39).*



We conducted a review of state-of-the-art knowledge in the use of MCDA for ES assessments. Therein, we examined how different case study authors dealt methodologically with the six MCDA steps related to the ES-policy-cycle described above. The review is based on a systematic screening of peer-reviewed articles by title, abstract and keywords conducted in SCOPUS and the ISI Web of Knowledge. To maintain a clear boundary and repeata-

bility of the study selection, we excluded non-scientific literature from our review. We identified 64 studies published between 2004 and 2013. For the screening, we used all combinations of the search terms “multi-criteria”, “multicriteria”, "multiple criteria" with the search term “ecosystem services”, "environmental services", and “ecological services”. Next we conducted a qualitative review of all studies, whereby the initial number of 64 was reduced to 32 publications (see Table 6.i); attempting to cover a representative sample of study cases in which ES assessments were conducted using MCDA. The following section highlights and discusses the main results from the review for the integrated assessment of ES by MCDA.

6.5 Results and discussion

Studies using MCDA for ES assessments have increasingly emerged since the Millennium Ecosystem Assessment (MA, 2005) set ES firmly on the global scientific and policy agenda. Most studies address rural ecosystems such as streams (e.g., Karjalainen et al., 2013), agricultural areas (e.g., Jannoyer et al., 2011) and forests (Sell et al., 2006; Locatelli et al., 2008). Only three studies are located in urban environments (Grêt-Regamey et al., 2013; Sanon et al., 2012; Srdjevic et al., 2013). A tabular summary of the main results from the review is given in Table 6.i.

6.5.1 Agenda setting

Problem definition (scale & scope)

The initial step of ES assessment by MCDA is the definition of the problem in its scope and scale. All reviewed studies start from a clearly defined problem, for example, in a case study from Belgrade (Serbia) the selection of a management plan for an urban forest park (Srdjevic et al. 2013); or the prioritization of geographical sites, for example, for the clearing of invasive species in the Western Cape (South Africa) (Forsyth et al. 2012). The problems addressed can be divided into two major groups: 1. Evaluation of alternative policies, plans or management practices (e.g. Oikonomou et al. 2011; Sanon et al. 2012; Srdjevic et al. 2013), and 2. Selection of geographical sites, for example, in choosing the most suitable (and cost-effective) sites for restoration or protection measures (e.g. Crossman et al., 2009; Gutierrez et al., 2012). The first approach, where different policy options are compared,

would correspond to the planning situation at Airport Tempelhof. The second approach can, for example, be used to steer urbanization processes, for instance through highlighting the most valuable areas for ES that demand preservation.

Reviewed studies apply MCDA to problems defined at different spatial scales, from (urban) biotope design (e.g. Grêt-Regamey et al., 2013) to global (wood) markets (Sell et al. 2006 and 2007). However, limitations are given for multi-scale assessments, possibly related to the stated need for clear problem definitions and boundaries demanded for MCDA applications (Munda, 2008). Sanon et al. (2012) provide an approach that might help to overcome this constraint, introducing various stakeholders and their specific objectives in the representation of multiple spatial scales. However, this aspect still demands further research attention. As urban green areas only cover a small share of city's demand for ES (Baró et al., 2014), planning for ES delivery to cities requires prioritizations across spatial scales, i.e. which ES are to be produced *in-situ* (within the city), locally, regionally, and globally (*cf.* Kabisch & Haase, 2014). For example, the provision of drinking water is generally a matter at regional scale, while for instance carbon storage must be considered at global scale.

Stakeholder analysis & engagement

The second stage in MCDA approaches to ES assessments regards the involvement of stakeholders. A stakeholder analysis and involvement is conducted in about 3/4 of the reviewed studies (Table 6.i). This reflects that stakeholder engagement is not necessarily conducted in MCDA. However, Srdjevic and colleagues (2013) in line with many MCDA scholars underline the importance of stakeholder involvement and suggest a thorough stakeholder analysis. From the example of Airport Tempelhof we see an urgent need for standardized protocols to assess and integrate stakeholder values into the policy-cycle and governance (Gould et al., 2015; Kabisch, 2015). The engagement with stakeholders, including local actors and citizens, needs to become a continuum in the policy process starting in the agenda setting and influencing all stages until the decision-making phase. Standardized protocols need to make sure that also diverging values held by minorities, such as migrants and elders, are taken into account in urban land-use planning (Kabisch & Haase, 2014). The reviewed studies demonstrate a potential

to combine MCDA with deliberative approaches; building on the assumption that human objectives are produced within a social group and a specific 'institutional and cultural context' (TEEB, 2010). Deliberative approaches were used to engage with stakeholders at different stages of the policy process (e.g. Zia et al. 2011). For example, Cork & Proctor (2005) use a deliberative approach to (i) create a common understanding of the problem, (ii) to develop alternatives, and (iii) to ES criteria related stakeholder values. Through the deliberative approach, individual ideas changed noticeably and common objectives consolidated.

6.5.2 Policy development

Definition of alternatives

As in the study by Cork & Proctor (2005), the definition of alternatives in MCDA often reflects stakeholder objectives. Spatially explicit alternatives are used in about half the reviewed studies. For example, the small-scale approach by Grêt-Regamey et al. (2013) uses alternatives based on combinations of ecological features, such as lawns, trees and water elements. Out of these features, land-uses best fitting the stakeholders' objectives are crafted. Developed for the design of an urban park in Masdar City (Abu Dhabi), this approach is suitable for small-scale decision situations were stakeholders' interest are not expected to be conflictive. Decisions and problems that demand the selection of geographical sites, such as the clearing of invasive species (Forsyth et al. 2012), and the spatial prioritization of restoration investments (Crossman et al. 2009; Gutierrez et al. 2012), introduce geographical locations as alternatives. In this approach, alternatives are usually represented by single pixels and evaluated in large numbers within geographic-information-systems (GIS) (*cf.* Crossman et al., 2009; Mitsova et al., 2011).
In contrast, in the evaluation of policies and planning, as applicable for Airport Tempelhof, alternatives are usually represented as spatially differentiated alternatives, for example in form of land-use change alternatives (e.g. Birkel et al., 2012). Within this type of studies, policy and management alternatives are often defined in a way that each alternative represents the objectives of a specific stakeholder (e.g. Cork & Proctor, 2005; Karjalainen et al., 2013); this usually implies a limited number of more elaborated policy alternatives (De Lange et al., 2012).

Table 6.i: Applied MCDA studies integrating ecosystem services

Stage in the policy cycle		***I. Agenda setting***		***II. Policy development***		***III. Policy assessment***		***IV. Decision-Making***	
Reference* *(by year of publication)*	***Ecosystem*** *(Location)*	***a) Problem definition***		***b) Stakeholder analysis & engagement***	***c) Definition of alternative***	***d) Evaluation criteria***	***e) Weighting***	***f) Alternatives prioritization***	
		Scope	*Scale*					*Aggregation rule*	*Trade-offs*
Curtis 2004	Rainforest (Australia)	Assessment of total economic value	Landscape	Expert engagement, Delphi panel	Ecosystem goods and services	Processes & benefits (*inter alia*)	Experts weighting of ecosystem goods and services (Delphi panel)	AHP	Strong
Cork & Proctor 2005	Rural landscape (Australia)	Assessment of land management practices	Region	Conducted, deliberative approach	Management alternatives	Processes & benefits	Stakeholder preferences (deliberative approach)	PWC	Unclear
Sell et al. 2006	Tropical forests (unspecified)	Assessment of land management practices	Global	Conducted, questionnaire	Management alternatives	Processes & benefits, i.a	Stakeholder preferences (Likert-scale ranking)	N.A.	N.A.
Sell et al. 2007	Tropical forest (unspecified)	Assessment of land management practices	Global	Conducted, questionnaire	Management alternatives	Benefits /values	Stakeholder preferences (holistic choice approaches)	AHP	Strong

Locatelli et al. 2008	Tropical forest (Costa Rica)	Evaluation of PES scheme	Region	Conducted, Expert panel, stakeholder interviews	Policy alternatives	Local development criteria	Stakeholder preferences (trade-off valuation)	AHP (integrating fuzzy set theory)	Weak - strong
Corsair et al. 2009	Stream (OH, USA)	Assessment of restoration options	Landscape (Basin)	Conducted, method not specified	Policy alternatives	Processes & benefits	Criteria valuation by experts and managers (subjective scoring system)	Value function (linear aggregation)	Strong
Crossman et al. 2009	Rural landscape (Australia)	Investment prioritization	Landscape & Site	Conducted, expert panel	Geographical locations (spatial explicit)	Structure /processes	Expert weighting	Value function (linear aggregation)	Strong
Hajkowicz & Collins 2009	Agricultural land (Tasmania, AUS)	Site/program selection for stewardship policy	Site	Conducted, stakeholder panel	Geographical locations / management alternatives	Processes & benefits	Selection ar weighting of crite by stakeholder pan	Value function (ideal point)	Strong
McCartney & Houghton-Carr 2009	Wetland (Tanzania, Zimbabwe and Swaziland)	Assessment of land-use suitability	Region	Not conducted	Land-use alternatives	processes & benefits	No weighting conducted	Value function (linear aggregation)	Strong
Zerger et al. 2009	Farmland (Victoria, Australia)	Assessment of management actions	Local	Conducted, stakeholder workshop	Land-use alternatives (spatial explicit)	Structure /processes	Participatory weighting	AHP	Strong
Zhang & Lu 2010	Peatland (Tibet, China)	Determination of total economic (land-	Region	Conducted, approach not explained	N.A.	Processes & benefits	Participatory weighting	AHP	Strong

		scape) value							
Bryan & Kandulu 2011	Rural watershed (South Australia)	Assessment of water resource management	Basin	Conducted, survey, community forum	Management alternatives	Processes & benefits	Selection of criteria in stakeholder survey; iterative weighting process in community forum	Value function (linear aggregation)	Strong
Jannoyer et al. 2011	Agriculture (Martinique and Guadeloupe)	Selection of cover plants to increase ES in orchard farming	Local	Not conducted	Management alternatives	Processes	No weighting conducted	Value function (ideal point)	Strong
Mitsova et al. 2011	Urban-rural landscape (OH/KY/IN, USA)	Assessment conservation policies	Region	Not conducted	Land-use alternatives (spatial explicit, cellular automate)	Structure /processes & benefits	No weighting conducted	Value function (Ideal point, cellular automate)	Strong
Oikonomou et al. 2011	Rural watershed (Lesbos, Greece)	Assessment of conservation management	Local	Conducted, Institutional analysis, participant observation, in-depth interviews	Management alternatives	Processes	Participatory weighting of alternatives (not of criteria)	PWC (NAIADE)	Weak
Seidl et al. 2011	Forest ecosystems (Alps, Austria)	Adaptation of sustainable forest management	Region	Conducted, workshop	Management alternatives	Processes, i.a.	Expert weighting	Value function (linear aggregation)	Strong
Zia et al. 2011	National Park (Tanzania)	Assessment of national park management	Local / Nation./ Intern.	Conducted, deliberative approach	Management alternatives	Processes & benefits, i.a.	Participatory weighting	Value function (linear aggregation)	Strong

Birkel et al. 2012	Tropical forest & watershed (Costa Rica)	Policy assessment (Payments for ES)	Basin	Not conducted	Land-use alternatives (spatial explicit)	Structure / processes	No weighting conducted	Value function (ideal point)	Strong
De Lange et al. 2012	Rural Agulhas Plain Region, (Western Cape, South Africa)	Assessment of the bio-energetic use of invasive species	Region	Conducted, scenario development	policy alternatives (spatial explicit)	Processes & benefits, i.a.	Stakeholder preferences	AHP	Strong
Forsyth et al. 2012	Rural catchments (Western Cape, South Africa)	Site prioritization for invasive species clearing	Region	Conducted, stakeholder workshop	Geographical locations (spatial explicit)	Structure / processes & benefits	Stakeholder preferences	AHP, PWC	Strong
Gutierrez et al. 2012	Forest landscape (San Marcos, Guatemala)	Prioritization of restoration site	Local	Limited	Geographical locations (spatial explicit)	Structure / processes & benefits	Expert weighting	Value function (ideal point), PWC	Strong
Koschke et al. 2012	Rural landscape (Saxony, Germany)	Regional development planning	Region	Conducted, stakeholder workshop	Planning alternatives (spatial explicit	Structure / processes & benefits	Different weighting approaches are tested	Value function (linear aggregation)	Strong
Lopez-Toledo 2012	Foerst Landscape (Yucatan, Mexico)	Assessment of conservation potential	Site	Not conducted	Geographical locations	Processes & benefits, i.a.	No weighting	Value function (ideal point)	Strong
Newton et al. 2012	Rural landscape (Dor-	Assessment of habitat restora-	Region	Conducted, online survey	Management alternatives	Values	Local stakeholders preferences	Value function (linear	Strong

	set, UK)	tion			(spatial explicit)			aggrega-tion)	
Sanon et al. 2012	**Urban flood plain (Vienna, Austria)**	**Assessment of flood plain restoration**	**Local**	**Conducted, multi-scale institutional analysis**	**Poli-cy/planning alternatives**	**Structure /processes**	**Stakeholder pref-erences (trade-off valuation)**	**Value func-tion (ideal point), PWC (TOP-SIS)**	**Strong**
Schwenk et al. 2012	Rural forests (Ver-mont, USA)	Assessment of forest man-agements	Region	Not conducted	Management al-ternatives (spatial explicit)	Structure / processes	Researcher prefer-ences (sensitivity analysis)	Value func-tion (Boole-an overlay)	Strong
Shang et al. 2012	Rural land-scape (USA)	Assessment of forest man-agement	Region	Not conducted	Management alternatives (spatial explicit)	Structure / processes	No weighting	PWC (PROME-THEE)	Strong
Fontana et al. 2013	Mountain landscape (Alps, EU)	Assessment of ES under dif-ferent LUC sce-narios	Region	Conducted, ques-tionnaire	Land-use change alternatives	Processes & benefits	Stakeholder prefer-ences (trade-off valuation)	PWC (PROME-THEE)	Strong
Grêt-Regamey et al. 2013	**Urban park (Masdar City, Abu Dhabi)**	**Assessment of landscape de-sign**	**Site**	**Limited**	**Park features (spatial explic-it)**	**Structure / process-es**	**Ruler system**	**Value func-tion (linear aggrega-tion)**	**Strong**
Jackson et al., 2013	Rural water-shed	Decision-support on landscape man-agement	Local	Conducted, not specified	Land-use alter-natives (spatial explicit)	Structure / processes	No weighting conducted	Value func-tion (Boole-an overlay)	Strong
Karjalainen et al. 2013	River (Finland)	Environmental impact assess-ment	Local	Conducted, delib-erative approach	Management alternatives	Benefits / values	Participatory weighting	N.A.	N.A.
Srdjevic et	**Urban forest**	**Selection of**	**Site**	**Conducted, de-**	**Planning alter-**	**Structure**	**Participatory**	**AHP**	**Strong**

al. 2013	**park (Belgrade, Serbia)**	**management plan**	**liberative approach**	**ap- natives**	**/ process-es**	**weighting**

Abbreviations & Explanations: AHP – Analytical Hierarchy Process, CBA – Cost-Benefit-Analysis, LUC – Land-use change, N.A. – not applicable, PES – Payments for ecosystem services, PWC – Pair-Wise Comparison (e.g. NAIADE - Novel Approach to Imprecise Assessment and Decision Environments, PROMETHEE - Preference Ranking Organization METHod for Enrichment Evaluations), TEV – Total economic value, Value function (Linear Aggregation Rule / Weighted Linear Summation / Simple Additive Weighting, Ideal Point, e.g. TOPSIS - Technique for Order Preference by Similarity to Ideal Solution). Non-conflicting and conflicting objectives as defined by Costanza et al., 2006; information on trade-offs is derived from the levels of 'compensability' according to Munda 2008:109. Urban studies are highlighted in bold. *Additional references in this table (included in the review) that are not enclosed in the main bibliography can be found in Supplementary Material A.

6.5.3 Policy assessment

Definition of criteria

Reviewed studies use, at least *inter alias*, ES as evaluation criteria. A general observation can be made, that most studies only account for a small fraction of ES (e.g. Grêt-Regamey et al., 2013; Schwenk et al., 2012). We assume the limited number of ES considered in reviewed studies are mainly reasoned in a lack of context-specific ES data (Paetzold, 2010), which may indicate an important challenge for conducting ES assessments through MCDA, especially in cities where ES assessments are only recently gaining stronger importance (Haase et al., 2014).

Within spatially explicit MCDA, criteria and related indicators are directly linked to the ecosystem structure, for example, in form of land-use and land-cover data (e.g. Jackson et al., 2013; Koschke et al., 2012) or green space features (e.g. Grêt-Regamey et al., 2013). Spatially explicit descriptions of the structure are the base to account for spatial heterogeneity in the supply of ES. For example, Jackson et al. (2013) simulate potential ES provisions based on elevation, land-use and soil characteristics; Seidl et al. (2011) additionally include climate data. In addition, cellular automates allow to simulate spatially explicit changes of ES potentials over time (Mitsova et al., 2011).

Studies which are not spatially explicit usually derive evaluation criteria from ecosystem processes. For example, Cork & Proctor (2005) use evaluation criteria based on sediment filtration, erosion control, water quality, water discharges, as well as the potentials for the generation of cultural ES, while Seidl et al. (2011) and Schwenk et al. (2012) use a forest and occupancy model for terrestrial birds, respectively, to estimate policy impacts on ES. Assessments of ecosystem processes may involve considerations of non-linear changes (Mitsova et al., 2011), risks, uncertainties, and for policy evaluation a determination of safety boundaries (e.g. Locatelli et al., 2008). From a theoretical viewpoint, it has been argued, that stronger uncertainties and severe possible risks related to policy impacts can be addressed by increased transparency and broader integration of stakeholders, expertise, experience and viewpoints in decision-making (Funtowicz & Ravetz, 2003).

Selection and weighting of criteria

The selection and weighting of evaluation criteria is the most common way human benefits and values are considered in decision-making. Studies like that by Cork & Proctor (2005) involve multiple stakeholders in the selection of evaluation criteria, other studies rely on the judgment of experts (e.g. Schwenk et al., 2012). Weights attached to evaluation criteria are commonly derived as ES values (e.g. Locatelli et al., 2008; Sell et al., 2006; Sell et al., 2007), albeit the use of weights is not necessary in MCDA and some studies neither apply weights nor consider ES values (e.g. Mitsova et al., 2011; Shang et al., 2012). However, for an integrated valuation of ES, the attachment of weights to the evaluation criteria can be considered an approved and intuitive way to operationalise ES values. In most studies values are derived from socio-cultural valuation techniques, including Likert-scale-rankings (Sell et al., 2006), holistic choice approaches (Sell et al., 2007), trade-off valuation (Locatelli et al., 2008), often embedded in deliberative group exercises (Cork & Proctor, 2005).

From the viewpoint of the ES-policy-cycle, the selection of evaluation criteria can conceptually be interpreted as the definition of benefits, i.e. which ES provide benefits to humans in the specific governance context. The focus on human benefits and values is an inherent limitation in an ES approach that defines human wellbeing as the ultimate goal. In this context, the study by Karjalainen et al. (2013) provides useful insights in the comparison between expert- and citizen-based approaches to criteria selection. While citizens were more focused on short-term benefits, previously described as 'end point' problem (Sijtsma et al., 2013), experts tend to account more strongly for ES as future assets and insurance values (Gómez-Baggethun et al., 2013).

6.5.4 Decision-making

Prioritization of alternatives

Reviewed studies use three different approaches for the comparison and prioritization of alternatives. (i) *Analytical hierarchy process,* for example applied by Sell et al. (2006; 2007) and Srdjevic et al., (2013) is used to structure the decision-making processes, use rankings of objectives, criteria and values to prioritize one alternative. (ii) *Pair-wise comparison* applied in four studies (e.g. Fontana et al., 2013; Oikonomou et al., 2011), evaluates always

two alternatives 'side-by-side' for each of the criteria until a full ranking of all alternatives is provided. (iii) *Value-function* based aggregation rules are used in most of the studies in particular those conducting spatial explicit assessments (e.g. Jackson et al., 2013; Schwenk et al., 2012). Value-function approaches are (similar to CBA) based on the epistemological assumption that a single optimal alternative can be found; and alternatives are either compared by *linear aggregation*, i.e. the sum of all (normalized) ES values (e.g., Corsair et al., 2009; Koschke et al., 2012), or by *ideal point approaches*, which use the sum of (normalized) differences between the actual and an ideal criteria performance (e.g. Jannoyer et al., 2011; Mitsova et al., 2011; Sanon et al., 2012).

A critical consideration in the selection of a suitable aggregation rule concerns the assumption of trade-off relationships between ES (Saarikoski et al., 2014). Most studies, namely those applying value-function-based approaches, allow for strong trade-offs, where low provision of one ES can be fully compensated by the high performance of another. Such compensatory approaches are not appropriate where "categorical non-commensurability" (ibid.) is given. Incommensurability can result from from cultural values, such as place attachment, religious and spiritual benefits whose losses cannot be compensated by increasing other ES (Martinez-Alier et al., 1998) or due to ES that are vital for subsistence, such as drinking water supply (e.g. Sanon et al., 2012). Even if citizen values are considered, trading-off incommensurable values may undermine the acceptance of green governance causing social opposition. Where such conflict can be expected, for example at Tempelhof Airport, pair-wise-comparison approaches are more promising. Especially the NAIADE-approach, applied in the study by Oikonomou et al. (2011), was designed to account for trade-off relations in a transparent manner (Munda, 2008) and can benefit from further empirical testing.

6.6 Concluding remarks

By introducing the ES-policy-cycle as a conceptual framework for an integrated assessment of ES, our study aims to contribute in bridging the gap between ES assessments and urban governance. On the one hand, the human capacity to govern urban ES and to impact human wellbeing through the biophysical shaping of ecosystems and the provision of ES was theoretically underscored. On the other hand, the lacking communication of ES benefits

and values in standard policy processes that characterize green space governance in many cities was emphasized using the case of Airport Tempelhof. In search for an operational tool to integrate lacking informational feedback on ES in policy processes, the review of MCDA approaches to ES assessments suggests alleged advantages over CBA and classical EIA.

Our study underscores a strong potential of MCDA for urban policy assessments for its capacity to integrate ecological and socio-economic values, as well as different stakeholder preferences across social groups, spatial locations, and temporal dynamics. Most of all, the review has proven the capacity of MCDA to integrate ecosystem structure and processes alongside human benefits and values thereby covering the various stages of the ES cascade. The case of Airport Tempelhof underlines that a better integration and understanding of stakeholder values is needed in policy assessments, still standardly conducted by EIA. Reviewed studies show a clear potential to achieve an integration of stakeholder values through selecting and weighting of ES criteria. From our results, deliberative approaches can be highlighted as an approved technique to involve stakeholders in MCDA that may facilitate the consolidation of objectives in a way that may even help to solve initial conflicts and create adaptive learning processes among stakeholders.

However, MCDA is not a silver-bullet to all decision-making situations and has, as EIA and CBA, its specific limitations. For example, results indicate potential limitations for MCDA in dealing with multiple scales of ES supply and demand. Reviewed studies further highlighted a need for a clear problem definition, but the example of Airport Tempelhof demonstrates that real world agenda setting is often not as straightforward as assumed in the policy cycle, and especially urban planning is characterized by multiple different stakeholders and interests, which may dispute the scope of a problem. In addition, integrating ES into planning is not a technical issue only; it further needs to be embedded in existing practices and institutions (Rinne & Primmer, 2015). After the referendum around Airport Tempelhof new participatory approaches to urban green space governance are currently explored in Berlin. MCDA based ES assessment might serve in this context to open up discussions on stakeholder values.

Said this, special attention in the application of MCDA for ES assessments is demanded in the prioritization of alternatives, and the selection of an aggregation rule. Value-function-based approaches most commonly used in the

reviewed studies are easily conducted and provide an intuitive way to policy assessments. However, they can be criticized for trading-off incommensurable values and for lacking democratic foundation due to the potential underrepresentation of minority objectives, thus bearing the risk of reduced social acceptance of a selected policy alternative. Pair-wise-comparison approaches, such as NAIADE, still widely unexplored in ES assessments, seem better suited to address incommensurability-relations between stakeholder values, but also to make allowance to non-negotiable objectives, such as species and habitat protection, which might conflict with stakeholder demands.
Overall, our study claims that MCDA could provide a nuanced tool to integrate ES into urban governance. At least, we believe, it is worth further testing to inform real world planning processes.

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Annex 1. Urban gardens assessed in Barcelona

Interviews were conducted with key informants in each garden, where contacts could be established during this stage of the fieldwork (April to June 2013). The number of surveys in each garden was conducted (July to October 2013) in approx. proportion (1/3) to the estimated number of gardeners, constraint by the gardener`s willingness to participate.

Urban garden	**District**	**Interviews**	**Survey samples**	**Gardeners (approx.)**
Camí de Torre Melina	Les Corts	2	7	34
Can Peguera	NouBarris	1	1	17
Collserola	Sarrià-St.Gervasi	2	0	15
De l'Avi	Gràcia	1	6	18
Hort Turull	Gràcia	2	2	22
Can Cadena	St. Martí	4	12	33
Can Mestres	Sants-Montjüic	2	29	60
Can Soler	Horta-Guinardó	2	10	27
Pedralbes	Les Corts	1	3	23
Sagrada Família	Eixample	2	7	25
Sant Pau del Camp	CiutatVella	2	4	12
Trinitat	St. Andreu	1	22	65
Casa de l'Aigua	NouBarris	2	8	33
Antic Jardí Botànic	Sants-Montjüic	2	7	20
Can Masdeu	NouBarris	2	29	70
Poblenou (1)	St. Martí	2	5	20
Poblenou (2)	St. Martí	2	16	70
Aki me planto	St. Andreu	1	4	20
Comunitari del Clot	St. Martí	0	3	18
Del Xino	CiutatVella	3	1	7
Forat de la Vergonya	CiutatVella	2	2	4
Fort Pienc	Eixample	2	4	10
La Farga	Sants-Montjüic	0	4	9
Poble-sec	Sants-Montjüic	2	2	5
Vallcarca	Gràcia	0	3	10
El Jardí	Gràcia	0	2	5
La Porta	NouBarris	2	8	40
	Total	**44**	**201**	**694**

Annex 2. Identification and characterization of ecosystem services

Results based on 44 in-depth interviews with urban gardeners conducted in Barcelona in 2013.

Ecosystem services	Description	Gardeners perception (examples)
Provisioning services		
Food supply	Urban gardens provide food.	"Can catch something in these times." "Productive relation, food is a basic need. self-sufficiency"
Medicinal resources & aromatic plants	Resources of the urban gardens are used as traditional medicines and some plants are used as aromatic resources.	"Rosemary for colds and disinfectant." "Snail ejects mosquito bite." "Aromatic plants to infusions, to cook, to smell."
Regulating services		
Air purification	Urban gardens contribute to decontaminate and reduce pollution in the city.	"Plants absorb wastes of the air: clean air." "Decontaminate."
Local climate regulation	Regulate microclimatic conditions through humidity and shading.	"Plants create a microclimate."
Global climate regulation	Plants of the urban gardens regulate carbon in atmosphere, through sequestrate carbon and increase the presence of oxygen in the atmosphere.	"Plants eat carbon and expel oxygen" "Green lung"
Maintenance of soil fertility	Recovers, maintains and increases soil fertility as well as external waste of the urban garden is decomposed, this process permit to close the nutrient cycle.	"Recovering ground capacity." "Increase soil fertility and minimize impact on the land." "House and manure waste." "To transform waste, to close the cycle, to bring wastes that provide nutrients."

Pollination	Some specific plants of the urban gardens are an input to increase the abundance of pollinators.	“Many flowers to attract pollinators”
Habitat services		
Biodiversity	Urban gardens maintain or increase a wide range of species and provide habitat or refuge to biodiversity.	“To create diversity. If there is more variety of plants it is most probably that more predators come, everything has a balance.” "Biotope, mosaics, diversity of habitats, more birds, more insects"
Cultural services		
Social cohesion & Integration	Connecting structures between people and between communities.	“Place where people meet and they relation with others.” “Help to solve the problem of loneliness in the city.”
Place-making	Some type of urban gardens allow create or rehabilitate places and population can interact and decide how they want to make the places or rehabilitate spaces.	“Place where people can develop initiatives, not only contemplation such as a park.” “To bring life to vacant plots”
Political fulfillment	Contributes to food sovereignty, autonomy or others political ideas.	“More conscience of local consumption” “Come back to a less consumer life” “If all the people worked in gardens it would contribute to food sovereignty”
Biophilia	Users of urban gardens obtain a satisfaction of creation and plant-growing.	“Illusion to watch grow plants.”
Quality of food	Gardeners perceive that the food produced in the urban gardens has a higher quality.	“Enjoy the flavours that food gives us.”
Aesthetic information	Landscape benefits and aesthetic information provided by urban gardens.	“I love the form of nature in miniature.” “They come to see this garden, to savor with the view.” “Beautiful place.”

Nature & Spiritual experiences	Urban gardens permit the reconnection between urban people and nature.	"I feel like I'm in the forest." "To see biological processes of the nature, without maternal process of the nature we will be lost, it is wonderful."
Relax & Stress reduction	Disconnection, relax and stress reduction, the garden allowed to relax the stress of the city.	"I feel good and quiet, to relax the stress, quietness, to take away the stress of the city."
Entertainment & Leisure	Urban gardens allow distraction, leisure and entertainment and /or as a hobby. And act as decommodified spaces that offer non-consumptive activities.	"It occupies time; there is always something to do." "Distraction and entertainment." "Entertainment, I'm retired and I stay all the morning in the garden instead of to spend time and money in the bar."
Exercise & Physical recreation	Garden tasks implies doing exercise, keeping fit and physical health.	"I do exercise; you bend over without realizing it. You jump from one site to another."
Learning & Education	Pedagogical opportunities in terms of horticultural practices, intercultural exchange and learning about environmental processes.	"When ancients die I don't know what's going to happen, garden is a site for people to learn." "To share ideas and practices of the garden. Exchange with others." "Many days we come with our grandchildren to see where beans come from."“Cultural learning between different cultures through the practices of the garden." "The garden is a laboratory of agricultural experimentation."
Maintenance of cultural heritage	Preserve our cultural heritage and remember the personal origins.	"To recover ancient knowledge" "They can return to his origins and they enjoy doing it."

Annex 3. Profile of urban gardeners in Barcelona

Based on a survey conducted among 201 urban gardeners in Barcelona (2013).

Sex							
Female				***Male***			
23.4 %				76.6 %			
Age							
15-29	***30-49***		***50-69***		***>69***	***No answer***	
4.5 %	12.9 %		36.3 %		45.3 %	1.0 %	
How often do you go to the garden?							
	Every day	***Every second day***	***Twice a week***	***Once a week***	***Twice a month***	***Once a month***	***< Once a month***	***No answer***
Summer	38.3 %	33.3 %	15.9 %	10.0 %	1.5 %	0.0 %	1.0 %	0.0 %
Winter	21.9 %	26.4 %	23.9 %	17.4 %	2.5 %	0.0 %	1.0 %	7.0 %
How long do you spend in the garden?								
	>30'	***30-60'***	***1-2h***	***2-3h***	***3-4h***	***4-5h***	***>5h***	***No answer***
Summer	0.5 %	1.5 %	15.4 %	34.8 %	23.4 %	14.4 %	9.0 %	1.0 %
Winter	0.5 %	5.0 %	25.9 %	28.4 %	18.4 %	9.0 %	5.5 %	7.5 %
Origin								
Barcelona	***Catalonia***		***Spain***		***Europe***	***Out of Europe***	***No answer***	
31.3 %	8.5 %		53.7 %		4.0 %	2.0 %	0.5 %	
Migration of immigrant gardeners to Barcelona								
1930-1939	***1940-1949***	***1950-1959***	***1960-1969***	***1970-1979***	***1980-1989***	***1990-1999***	***2000-2009***	***2010-2013***
1.5 %	13.9 %	21.9	29.2 %	13.9 %	5.8 %	5.1 %	8.0 %	0.7 %
How many people live in your home?								
1	***2***	***3***	***4***	***5***	***> 5***	***No answer***		
9.5 %	54.7 %	18.9 %	10.9 %	4.0 %	0.5 %	1.5 %		
Monthly income house (euros)								
No income	***0-1000***	***1000-2000***	***2000-3000***	***3000-4000***	***>4000***	***No answer***		
2.0 %	34.3 %	35.3 %	12.4 %	3.5 %	1.5 %	10.9 %		
Studies Level								
Equal or lower than secundary education			***Higher than secondary education***			***No answer***		
58.2 %			40.8 %			1 %		

Annex 4. Model for structured interviews with beneficiaries

Model for interviews conducted with 44 key informants between April and June 2013 in urban gardens in Barcelona, Spain.

INTERVIEW BARCELONA URBAN GARDENS

Good morning, my name is XXX and I am working in a European project about the relation between quality of life and urban gardens in collaboration with the Autonomous University of Madrid and the Autonomous University of Barcelona. The aim of the project is to study of how urban gardens contribute to human wellbeing. Specifically, we want to understand why the gardens are important to people, what kinds of things produce and what benefits or satisfactions provide to their users. For these reasons, we appreciate your help answering this interview. All the date is anonymous processed. Thank you.

Name of garden			
Address of garden			
Date:		**Interviewer:**	
Start time:	**:**	**Nº interview:**	
Final time:	**:**		
Sex respondent	0 woman 1 man	**Time worked in the garden:**	

SECTION 1- IDENTIFICATION AND CHARACTERIZATION OF ECOSYSTEM SERVICES PROVIDED BY URBAN GARDENS

The section of identification of services provided by urban gardens is divided in three levels: 1. Individual / personal level, 2. neighborhood level, 3. city level.

1.1- Identification and characterization of services-individual/personal level

a) Why is the garden important for you? (After this question, also test systematically: "b) How does the garden contribute to your personal well-being or quality of life?",c) Which	**For each of the services perceived by the respondent, ask for "why this service is generated and what generates these services", i.e., what structural element of the garden generates the service. (For example, if a service is food supply, "why" could be because**

more things does the garden provide you?).	**is a vegetable garden and "what" could be the place where they plant).**
Example of questions: **- Why do you make compost?** **- Why did you plant these flowers / plants / trees?** **- Is there anything that has a special function?** **- ...** **- ...** **- ...** **- ...**	

1.2- Identification and characterization of services – neighborhood's level

a) Why is the garden important for the neighborhood? (After this question, also test systematically: "b) How does the garden contribute to the neighborhood's well-being or quality of life of the neighborhood?" c) Which more things does the garden provide to the neighborhood?).	**Why this service is generated and what generate this service?**

1.3- Identification and characterization of services – city's level

a) Why is the garden important for the city? (After this question, also test systematically: "b) How does the garden contribute to the city's well-being or quality of life of the city?", c) Which more things the garden provide to the city?).	**Why this service is generated and what generates this service?**

SECTION 2- IDENTIFICATION AND CHARACTERIZATION OF DIS-SERVICES PROVIDED BY URBAN GARDENS

What are the problems generated by the garden? (After this question, also test systematically: “Anything bad or negative?;Annoyances?).	For each of the disservices perceived by the respondent, ask for "why this service is generated and what generates this service".

What do you do to solve these problems?

SECTION 3. BENEFICIARIES IDENTIFICATION

Finally we would like to ask if you could inform us of other people working in gardens and that they could help us in our project ('Snowball').

SECTION 4. RESPONDENT’S PERSONAL DATA

Name respondent:					
Contact:					
Birth year		**Origin**		**Time lived here**	
Could mark the rank of your monthly salary household in these following ranges?					
0 Non income	1 0- 500	2 500- 1000	3 1000-1500	4 1500-2500	5 >2500
How many people live in your household now?					
What is your study’s level? What degree / professional formation?					
What is/was your job?					

SECTION 5.OBSERVATIONS DURING THE INTERVIEW

Comments:

Annex 5. Model for survey with beneficiaries

Questionnaire used in a survey among 201 gardeners between July and October 2013 in urban gardens in Barcelona, Spain.

SURVEY- VALUATION OF ECOSYSTEM SERVICES

Good morning, my name is XXX and I'm working in a European project about the relation between quality of life and urban gardens in collaboration with the Autonomous University of Madrid and the Autonomous University of Barcelona. The aim of the project is study how urban gardens contribute to human wellbeing. Specifically, we want to understand why the gardens are important to people, what kinds of things produce and what benefits or satisfactions provide to their users. For these reasons, we appreciate your help answering this survey. All the date is anonymous processed. Thank you.

Name of garden:			
Date:		**Researcher :**	
Start time:	**:**	**Nº survey:**	
Final time:	**:**		

1. Habits and uses of the garden

a.How often do you go to the garden?							
	Every day	Every second day	Twice a week	Once a week	Twice a month	Once a month	< Once a month
Summer							
Winter							
b.How long do you spend in the garden, on average?							
	< 30 min	30-60 min	1-2 hours	2-3 hours	3-4 hours	4-5 hours	> 5 hours
Summer							
Winter							

2. Valuations of ecosystem services using Likert-scales

In this section we want to know which benefits or good things provided by urban gardens are more important for the people, we want that say us your grade of agreement with the following affirmations in a scale range between 0 to 5, being 0 totally disagree with the affirmation and 5 totally agree. For example, in the affirmation: "According to you this garden is important because it supplies food", 0 means totally disagree with the affirmation, i.e. according to you it does not seem at all important, and 5 means totally agree and according to you it is very important.

Provisioning services		*0 = Totally disagree* *5 = Totally agree*					
Food supply	*Does this garden supply food?*	Yes			No		
	According to you, this garden is important because it supplies food.	0	1	2	3	4	5
Quality of food	*Does this garden supply quality food?*	Yes			No		
	According to you, this garden is important because it supplies quality food.	0	1	2	3	4	5
Medicinal resources/ aromatic plants	*Does this garden provide medicinal resources and/or aromatic plants?*	Yes			No		
	According to you, this garden is important because it provides medicinal resources and/or aromatic plants, e.g. spices?	0	1	2	3	4	5

Regulating and habitat services		*0 = Totally disagree* *5 = Totally agree*					
Air purification	*Does this garden produce air purification?*	Yes			No		
	According to you, this garden is important because it produces air purification.	0	1	2	3	4	5
Local climate regulation	*Does this garden refresh the air?*	Yes			No		
	According to you, this garden is important because refresh the air and it is a microclimate.	0	1	2	3	4	5
Global climate regulation	*Does this garden contribute to reduce the climate change, capturing carbon from the atmosphere?*	Yes			No		
	According to you, this garden is important because it contributes to reduce the climate change.	0	1	2	3	4	5
Maintenance of soil fertility	*Does this garden contribute to maintain or improve soil fertility and it closes the nutrient cycle (e.g. treating and processing organic waste).*	Yes			No		
	According to you, this garden is important because it maintains or improves soil fertility and it helps to close the nutrient cycle.	0	1	2	3	4	5
Pollination	*Does this gardenattractbees or other pollinators that improve the growing of the crops?*	Yes			No		
	According to you, this garden is important because it attracts bees or other pollinators that improve the growing of the crops.	0	1	2	3	4	5
Refuge for biodiversity	*Does this garden maintain or improve the biodiversity of seeds, species and habitats?*	Yes			No		
	According to you, this garden is important because it maintains or improves the biodiversity of seeds, species and habitats.	0	1	2	3	4	5

Cultural services		*0 = Totally disagree* *5 = Totally agree*					
Social cohesion and integration	*Is this garden a meeting point or a social relation point?*	Yes			No		
	According to you, this garden is important as a meeting point or a social relation point.	0	1	2	3	4	5
Placemaking (create and rehabilitate spaces)	*Does this garden let create and rehabilitate spaces?*	Yes			No		
	According to you, this garden lets create and rehabilitate/recover spaces.	0	1	2	3	4	5
Political task	*Does this garden contribute to the food sovereignty, the autonomy or others political ideas?*	Yes			No		
	According to you, this garden is important because it contributes to the food sovereignty, the autonomy or others political ideas.	0	1	2	3	4	5
Biophilia(satisfaction of plant-growing and creation)	*Does this garden create and you can see plants grow?*	Yes			No		
	According to you, this garden is important only for the satisfaction of plant-growing and creation.	0	1	2	3	4	5
Esthetical information	*Is this garden beautiful and/or has it gotlandscape value?*	Yes			No		
	According to you, this garden is important because it is beautiful, i.e. for their esthetical and landscape benefits.	0	1	2	3	4	5
Natural and spiritual experiences	*Does this garden let a reconnection with the nature in the city context?*	Yes			No		
	According to you, this garden is important because it lets a reconnection with the nature in the city context.	0	1	2	3	4	5
Relax & stress reduction	*Does this garden offer a place to disconnect, relax and stress reduction?*	Yes			No		
	According to you, this garden is important because it offers a place to disconnect, relax and stress reduction.	0	1	2	3	4	5
Entertainment & pleasure	*Does this garden give distraction, diversion and leisure?*	Yes			No		
	According to you, this garden is important because it gives distraction, diversion and leisure and/or it is a hobby.	0	1	2	3	4	5
Exercise & physical recreation	*Does this garden let make exercise and/or it helps to get fit?*	Yes			No		
	According to you, this garden is important to make exercise and to get fit.	0	1	2	3	4	5

Learning & education in socio-ecological	*Does this garden contribute to learning and education in socio-ecological values?*	Yes			No			
	According to you, this garden is important because it contributes to learning and education in socio-ecological values	0	1	2	3	4	5	
Maintenance cultural heritage	*Does this garden maintain the knowledge and the traditional practices?*	Yes			No			
	According to you, this garden is important because maintains the knowledge and the traditional practices.	0	1	2	3	4	5	
Exercise & physical recreation	*Does this garden let make exercise and/or it helps to get fit?*	Yes			No			
	According to you, this garden is important to make exercise and to get fit.	0	1	2	3	4	5	

3. Personal data

Sex respondent	0 woman 1 man		**Time worked in the garden**		
Birth year		**Origin**		**Time lived here**	
How many people live in your household now?					
Could mark the rank of your monthly salary household in these following ranges?					
0 No income	1 0- 1000	2 1000-2000	3 2000-3000	4 3000-4000	5 >4000
Did you have the opportunity to study?				Yes	No
What is your study's level? What degree / professional formation?					

Are you retired?	Yes	No
What is/was your job?		

Are you a member of some environmental association? Which?	Environmental organization ☐
NO ☐	Excursion center /climbing / bike ☐
YES ☐	Cooperative or green consumer group ☐
	Others:

Do you buy products of organic farming?	Always	Frequently	Sometimes	Never
	Never because: - Economical limitation ☐ -Lack of interest ☐ -Difficult access ☐			

Annex 6. Ecosystem service values perceived by different actors.

Unpublished data derived through socio-cultural valuation of urban ES of Park Montjuïc, Barcelona. Valuation conducted as Likert-rankings (where 0=not important and 10=most important) with park users and experts (Expert surveys enquired 'local climate regulation' and 'air quality regulation' jointly and did not embed 'environmental education').

	Local Experts (n=10)		***Park Neighbours (n=49)***		***BarcelonaMetropol. Area (n=56)***		***National Tourist (n=28)***		***International Tourist (n=66)***	
Rank	***Mean***	*Std. Dev.*	***Mean***	*Std. Dev.*	***Mean***	*Std. Dev.*	***Mean***	*Std. Dev.*	***Mean***	*Std. Dev.*
1	Recreation & physical and mental health		Recreation & physical and mental health		Recreation & physical and mental health		Recreation & physical and mental health		Tourism	
	9.10	0.88	**9.27**	1.34	**9.23**	1.31	**8.96**	1.64	**9.06**	1.25
2	Tourism		Environmental education		Tourism		Tourism		Recreation & physical and mental health	
	8.80	1.14	**8.53**	2.15	**8.54**	2.12	**8.96**	1.84	**8.71**	1.52
3	Aesthetic appreciation and inspiration		Air quality regulation		Environmental education		Environmental education		Aesthetic appreciation and inspiration	
	8.60	1.51	**8.49**	1.89	**8.32**	1.98	**8.29**	2.17	**8.52**	1.93
4	Habitat for species		Tourism		Aesthetic appreciation and inspiration		Pollination		Environmental education	
	8.50	1.35	**8.39**	2.20	**8.05**	1.82	**8.00**	2.52	**8.36**	1.75
5	Maintenance of genetic diversity		Aesthetic appreciation and inspiration		Habitat for species		Aesthetic appreciation and inspiration		Maintenance of genetic diversity	
	8.20	1.48	**8.27**	1.94	**7.89**	2.28	**7.82**	2.25	**8.36**	1.87
6	Pollination		Habitat for species		Air quality regulation		Noise pollution reduction		Pollination	
	7.40	2.12	**8.04**	2.29	**7.68**	2.57	**7.82**	2.34	**8.33**	1.98
7	Erosion prevention		Local climate regulation		Pollination		Erosion prevention		Noise pollution reduction	
	7.30	1.89	**7.96**	2.51	**7.52**	2.64	**7.79**	2.35	**8.05**	2.08
8	Local climate regulation*		Pollination		Maintenance of genetic diversity		Habitat for species		Habitat for species	
	7.20	2.30	**7.82**	2.63	**7.39**	2.66	**7.54**	2.36	**8.05**	2.10
9	Air quality regulation*		Noise pollution reduction		Local climate regulation		Local climate regulation		Air quality regulation	
	7.20	2.30	**7.71**	2.58	**7.39**	2.74	**7.50**	2.30	**8.02**	2.43
10	Noise pollution reduction		Maintenance of genetic diversity		Erosion prevention		Air quality regulation		Erosion prevention	
	7.20	2.53	**7.37**	2.38	**7.23**	2.91	**7.21**	2.59	**7.98**	1.89

11	Spiritual experience and sense of place		Carbon sequestration and storage		Carbon sequestration and storage		Maintenance of genetic diversity		Local climate regulation	
	7.10	2.69	**7.31**	3.25	**7.04**	2.80	**7.18**	2.47	**7.68**	2.54
12	Biological (pest) control		Rain water retention		Noise pollution reduction		Carbon sequestration and storage		Biological (pest) control	
	7.10	2.02	**7.22**	2.30	**6.96**	2.92	**7.04**	2.38	**7.52**	2.54
13	Rain water retention		Erosion prevention		Biological (pest) control		Rain water retention		Carbon sequestration and storage	
	7.00	1.94	**7.02**	3.04	**6.36**	2.88	**6.86**	2.63	**7.48**	2.53
14	Carbon sequestration and storage		Spiritual experience and sense of place		Rain water retention		Biological (pest) control		Rain water retention	
	6.90	2.69	**6.65**	2.67	**6.20**	2.93	**6.46**	3.25	**7.15**	2.74
15	Regulation of extreme events		Biological (pest) control		Spiritual experience and sense of place		Provision of medicinal resources		Spiritual experience and sense of place	
	5.10	2.85	**6.65**	3.20	**6.13**	3.03	**5.96**	2.86	**6.58**	3.13
16	Waste water treatment		Provision of medicinal resources		Provision of medicinal resources		Spiritual experience and sense of place		Regulation of extreme events	
	4.90	3.03	**5.71**	3.14	**5.98**	2.96	**5.64**	3.19	**5.95**	3.34
17	Provision of fresh water		Regulation of extreme events		Regulation of extreme events		Regulation of extreme events		Provision of medicinal resources	
	4.6	3.17	**5.67**	3.28	**5.39**	2.88	**5.54**	3.00	**5.47**	2.92
18	Provision of medicinal resources		Provision of fresh water		Provision of food		Provision of food		Provision of fresh water	
	4.5	3.60	**4.96**	3.48	**3.82**	2.79	**4.32**	3.08	**5.39**	3.22
19	Provision of raw material		Provision of food		Provision of fresh water		Provision of fresh water		Waste water treatment	
	2.7	3.02	**4.73**	3.28	**3.73**	2.88	**4.29**	2.68	**4.67**	3.17
20	Provision of food		Waste water treatment		Waste water treatment		Waste water treatment		Provision of food	
	2.6	3.03	**4.45**	3.42	**3.55**	2.97	**3.93**	3.16	**4.64**	2.86
21	**		Provision of raw material		Provision of raw material		Provision of raw material		Provision of raw material	
			3.06	2.47	**2.61**	2.25	**3.68**	2.79	**2.95**	2.62

Annex 7. Supplementary online material Chapter 5. Survey excerpt (S1)

Excerpt from the survey-questionnaire used in the study underlying Chapter 5, for the economic and socio-cultural valuation of cultural ES at Park Montjuïc, Barcelona (Spain). Own elaboration.

Monetary valuation – Individual travel cost method (ITCM)

c. *How often did you visit Park Montjuïc over the last 12 months?*	
d. *How much time do you spend to get to Park Montjuïc?*	
e. *How much money did you spend to get to Park Montjuïc?*	
f. *What is your household income (€/month)*	

Monetary valuation – Pebble Distribution Method (PDM)

g. *Pebble Distribution Method (PDM)* *Please, consider your overall motivation to visit Park Montjuïc as 10, and distribute your motivation across the following activities. (Carried out with 10 pieces put on different field on a sheet of paper)*			
Recreation and physical and mental health		*Spiritual experience and sense of place*	
Tourism		*Environmental education*	
Aesthetic appreciation and inspiration		*Cultural activities (expositions etc.)*	

Non-monetary valuation (Likert scales)

a. Cultural Services	*Park Montjuïc is important because ...*	*1 = I totally disagree* *10 = I fully agree*				
Recreation and physical and mental health	*... it serves as an area for recreation such as sports activities, walking, picnics, etc.*	1	2	3	4	5
		6	7	8	9	10
Tourism	*... its green areas and gardens attract international and local tourists.*	1	2	3	4	5
		6	7	8	9	10
Aesthetic appreciation and inspiration	*... its nature with its colours, sounds, and smells enriches the human mind.*	1	2	3	4	5
		6	7	8	9	10
Spiritual experience and sense of place	*... its landscape and specific sites create a sense of place and stimulate spiritual experiences.*	1	2	3	4	5
		6	7	8	9	10
Environmental education	*... its natural environment forms a place for education of the population.*	1	2	3	4	5
		6	7	8	9	10

Annex 8. Supplementary Material A, Chapter 6

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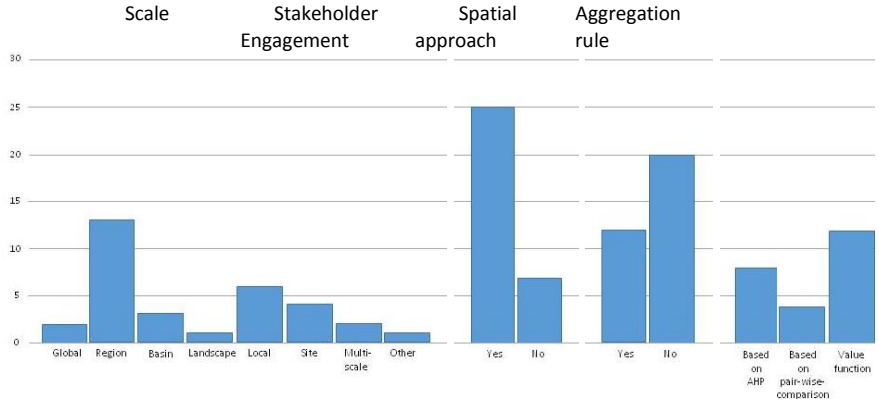
Annex 9. Supplementary Material B, Chapter 6

Review of 32 studies that applied ecosystem services within MCDA – Overview.



Annex 10. Additional scientific achievements 2012-2015

Peer-reviewed publications

Published / Accepted:

Elmqvist T., Gómez-Baggethun E., Langemeyer J. (2016) Ecosystem Services provided by Urban Green Infrastructure. In Potschin (ed.) Ecosystem Service Handbook. In press.

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Voigt A, Leitão T, Béchet B, Christ Y, Heller A, Hursthouse A, Jokinen A, Kylvik M, Brito da Luz P, Langemeyer J, Latkowska M (2015). Lessons learned: Indicators and best practices for an environemental friendly garden. In Bell, S. (ed.) Urban Allotment Gardens in Europe. Routledge, London. In press.

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In Review:

Langemeyer, J., Gómez-Baggethun E., Haase, D., Scheuer S., Elmqvist T (forthcoming) Bridging the gap between ecosystem services and land-use policy and planning: An exploration of multi-criteria decision analysis. Environmental Science and Policy. Accepted with minor revisions.

Camps-Calvet, M., Langemeyer, J., Calvet-Mir, L., Gómez-Baggethun, E. (forthcoming). Assessment and valuation of ecosystem services provided by urban gardens: Insights for policy and planning. Environmental Science and Policy. Accepted with minor revisions.

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