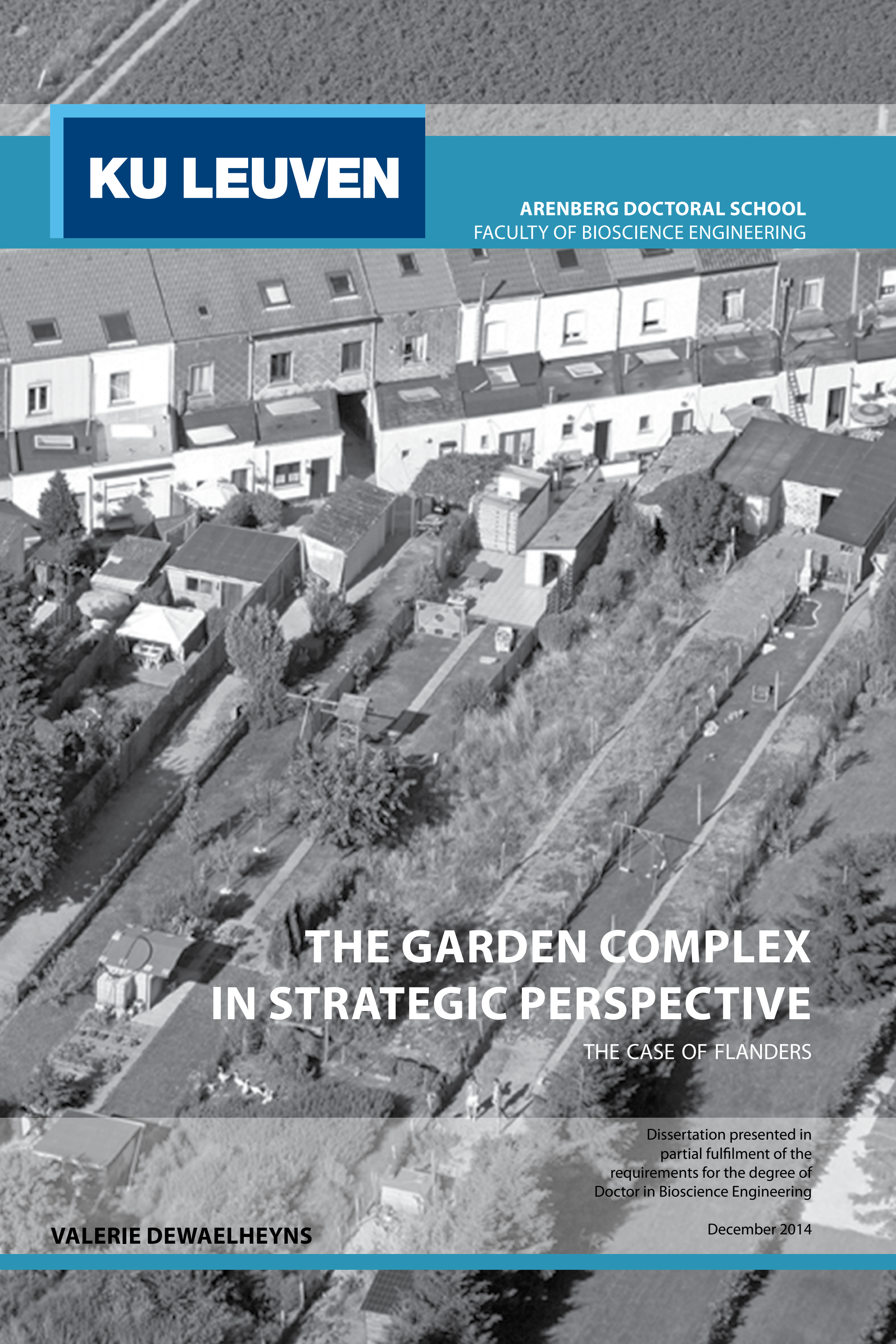

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ARENBERG DOCTORAL SCHOOL
FACULTY OF BIOSCIENCE ENGINEERING

THE GARDEN COMPLEX IN STRATEGIC PERSPECTIVE

THE CASE OF FLANDERS

Dissertation presented in partial fulfilment of the requirements for the degree of Doctor in Bioscience Engineering

December 2014

VALERIE DEWAELHEYNS

THE GARDEN COMPLEX IN STRATEGIC PERSPECTIVE

THE CASE OF FLANDERS

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For Gabriël & Sofie

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"Nothing happens unless first we dream."

Carl Sandburg

Geduld en passie zijn niet altijd even verenigbaar. Terwijl het ene noopt tot rust en kalmte, wakkert de andere vooral gedrevenheid en zin om vooruit te gaan aan. Ik ben blij dat ik uitgedaagd werd om soms even in te houden, maar toch niet los te laten. Elke omweg, elke toevallige of minder toevallige voorbijganger heeft me iets geleerd en bijgedragen aan het werk dat nu voor jullie ligt.

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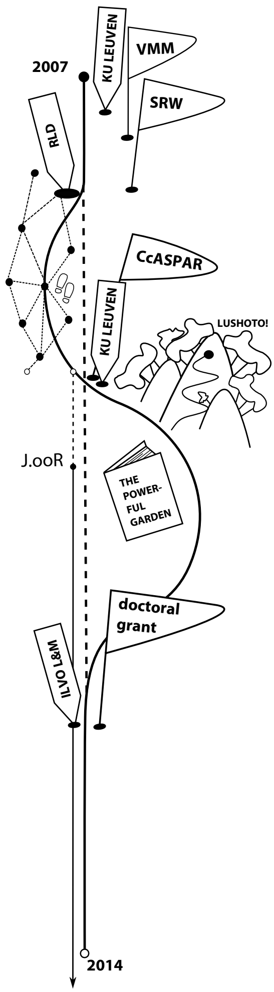

De eerste mogelijkheden om Vlaamse tuinen te onderzoeken werden geboden door de Vlaamse Milieumaatschappij en het toenmalig Steunpunt Ruimte en Wonen. Via twee kortlopende beleidsondersteunende onderzoeksprojecten kon ik mijn eerste stappen als onderzoeker zetten in het toen nog wazige en onbekende tuincomplex. Dankzij Ludwig Lauwers en Erik van Bockstaele kreeg ik de nodige ondersteuning van ILVO voor het afwerken van mijn doctoraatsonderzoek. Bedankt voor het vertrouwen dat jullie me daarmee gaven.

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Bedankt iedereen,

Valerie,

Leuven, 27 november 2014

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ABBREVIATIONS, SYMBOLS & UNITS

Abbreviations

ADSEI	Algemene Directie Statistiek en Economische Informatie
AFS	Area Frame Sampling
Agiv	Agentschap voor geografische informatie Vlaanderen
BELAC	Belgische Accreditatie-instelling *(Belgian Accreditation Institute)*
BEMEX	decision support system developed by SSB
BREEAM	Building Research Establishment Environmental Assessment Method
BUGS	Biodiversity in Urban Gardens Sheffield
CE	Cumulative Effects
CI	Cumulative Impacts
CICES	Common International Classification of Ecosystem Services
CAP	Common Agricultural Policy
CORINE	Coordination of information on the environment
DEFRA	Department for Environment, Food & Rural Affairs (UK government)
DM	dry matter
e.g.	exempli gratia
EEA	European Environmental Agency
ES	ecosystem services
EU	Europen Union
FAO	Food and Agriculture Organization of the United Nations
GIS	Geographic Information System
ISO	International Organization for Standardization
i.e.	id est
IT	Information technology
LPIS	Land Parcel Identification System
MEA	Millenium Ecosystem Assessment
N	sample size
NAEA	non-agricultural economic activities
NEA	National Ecosystem Assessment

NGI	Nationaal Geografisch Instituut (National Geographic Institute of Belgium)
NGO	non-governmental organization
OECD	Organisation for Economic Co-operation and Development
pH	measure of acidity
PSU	Primary Sampling Units
RWO	Beleidsdomein Ruimtelijk Ordening, Woonbeleid en Onroerend Erfgoed van Vlaamse Overheid
SSB	Soil Service of Belgium
SPU	Service Providing Unit
UK	United Kingdom
US	United States
VLM	Vlaamse Landmaatschappij *(Flemish Land Agency)*

Units

%	percentage
ha	hectare
K	Kelvin
kg	kilogram
l	litre
m^2	square meter

Model variables

C	consumed produce
c_1	bought food
c_2	home produce
γ	time constraints
L	area
L_h	garden area for food production
L_o	garden area for other activities than food production
L_{oo}	transformable garden area *(other open)*
L_{os}	non-transformable garden area *(other sealed)*
M	endowment
p	price
T	time
t_h	time spent on home food gardening
t_o	time spent on other activities than earning a wage or home food gardening
t_w	time spent on earning a wage
w	wage
z	input
λ	capital constraints
μ	area constraints

ABSTRACT

Gardens are part of the landscape worldwide and doubtless always will be. Despite their diversity and heterogeneity, domestic gardens have specific structural and functional characteristics and provide particular ecosystem services and benefits. Collectively they form a specific category of green spaces, but they have received far less attention than other green components of the territory like forests, nature reserves and urban parks.

This dissertation offers an assessment of the strategic value of the integral stock of domestic gardens in a regional context. The concept of the 'garden complex' is launched to represent this integral stock. By unlocking original information on the structures, services and strategies of the garden complex, the research breaks through the unavailability of information, the lack of attention in policy, and the scarcity of scientific research on gardens. The main objective, to assess the strategic value of the garden complex, is operationalized through the mapping and envisioning of the garden complex. The adopted research methodology comprises an original integration of both quantitative and qualitative research methods and techniques.

The research focuses on domestic gardens in Flanders, with an open mind to the universality of the theme. The history of the rise and disappearance of a former 'garden agenda' in Belgian territorial policies offers interesting references about the mobilization of households in the development of the territory and the persuasion of a common goal.

Both structures and services of the Flemish garden complex are mapped. The refinement of an existing land use map revealed that domestic gardens cover more than 8 % of the Flemish territory, which is comparable to the regional coverage of forest (11 %) and sealed surface (13 %, including housing, industrial sites, roads and railways). From a spatial perspective the garden theme is thus far from marginal. An investigation of the occupation of agricultural land by gardens within six municipalities indicated that domestic gardens cover about 6 % of the statutory farmland.

The study of services focused on the ecosystem function of nutrient cycling and the provisioning service of food production. The results on nutrient cycling indicated an excessive use of fertilizers. Also garden soil fertility states appeared to be well over the agronomical growth optimum for pH, carbon and phosphorus. The results equally well indicate that the garden complex has potential as a carbon sink, especially when lawn soils are taking into consideration.

Concerning the provisioning of food, the gardening decisions of households are further unraveled through the development of an economic model. Vegetable or kitchen gardens can be found in many Flemish gardens. Moreover, the home garden produce of vegetables covers about one third of the amount bought at the market for 25 gardens. These results illustrate the current productivity of domestic gardens and their potential contribution to the adaptive capacity of food systems.

To support the ecosystem services provided by the garden complex, governance strategies are needed. The garden is a key example of a complex social-ecological system: a place where the natural system is intimately linked with the social system. For example, gardeners (influenced by personal ideas, norms, salesmen in garden stores and friends) can adopt different management styles that include plant choices and usage of fertilizers, chemicals and water. Through their management, they influence ecosystem services like pollination.

Domestic gardens are private landscapes that are autonomously managed by a multitude of households. The cumulative outcomes of these individual garden management decisions occur post hoc and are often not optimal. This phenomenon has been referred to as the 'tyranny of small-decisions'. The hypothesis was that the 'tyranny of small gardening decisions' has potential to become a 'resource by small gardening actions'. The results showed that such a transformation is indeed feasible and that the cumulative actions of a manifold of gardeners can be considered an opportunity rather than a pitfall. However no 'silver bullet' came up: a multiplicity of actions will be needed to establish garden governance with enhanced strategic value at regional level.

Bringing these findings together allows to conclude that the garden complex indeed has strategic potential. This strategic potential is not only present in its spatial and functional characteristics, but also in terms of governance strategies. Matching this renewed assessment of domestic gardens with the historical strategic roles assigned to gardens gives inspiration for future pathways towards a garden complex that is a true resource by the cumulative effect of small gardening actions.

This dissertation contributes to the integrated knowledge of a land use system which hitherto has been ill-documented and largely neglected in a range of territorial policies. I hope that it helps to open up a novel way of looking at the role of modest gardens as a collective good that can actually contribute in building a resilient society.

SAMENVATTING

Tuinen maken wereldwijd deel uit van het alledaagse landschap. Ondanks hun verscheidenheid hebben ze enkele strategisch interessante eigenschappen gemeenschappelijk. De aanwezigheid van (groene) structuren en de vele ecosysteemdiensten die ze bieden, inspireren om tuinen vanuit een meer strategisch perspectief te benaderen. Toch krijgen ze veel minder aandacht dan andere groene ruimtes, zoals bossen, natuurgebieden en parken.

Dit doctoraat verheldert de strategische waarde van het geheel aan privétuinen in een regionale context. De specifieke onderzoeksobjectieven zijn het in kaart brengen van het geheel aan privétuinen en het onderzoeken van de strategische betekenis van dit geheel. Het concept 'tuincomplex' wordt gelanceerd om dit geheel aan tuinen voor te stellen. Door originele informatie over de structuren, diensten en strategieën van het tuincomplex te ontsluiten, doorbreekt dit onderzoek een vicieuze cirkel waarin tuinen gevangen zitten, tussen het niet beschikbaar zijn van gegevens, het gebrek aan beleidsaandacht en de schaarste aan wetenschappelijk onderzoek. Voor dit onderzoek werden bestaande methoden om gegevens te verzamelen op originele wijze gecombineerd, op maat van specifieke onderzoeksvragen. Zowel kwantitatieve als kwalitatieve onderzoeksmethoden en technieken kwamen hierbij aan bod.

Het onderzoek richt zich op Vlaanderen. Een overzicht van de opkomst en het verval van een 'tuinprogramma' doorheen het historische Belgische territoriale beleid biedt een interessant referentiekader voor het inschakelen van private huishoudens in ruimtelijke ontwikkelingen en het nastreven van een maatschappelijke doelstelling. Een zekere mate van zelfvoorziening in voedsel en sociale rust waren belangrijke motieven voor het Belgische beleid, aandachtspunten die na WOII zijn uitgedoofd. De focus op Vlaanderen wordt doorheen het doctoraat aangevuld met aandacht voor het universeel karakter van tuinen en hun diensten.

Zowel structuren als diensten van het tuincomplex worden in kaart gebracht. Het verfijnen van een bestaande landgebruikskaart maakt duidelijk dat privétuinen meer dan 8 % van de Vlaamse oppervlakte bedekken. Dit is vergelijkbaar met de inname door bos (11 %) en verzegelde oppervlakten (13 %, inclusief bebouwing, wegen, spoorwegen en industriële gebieden). Vanuit een ruimtelijke benadering zijn privétuinen dus niet verwaarloosbaar in vergelijking met andere landgebruiken.

Verder onderzoek naar de inbeslagname van landbouwland binnen zes gemeenten toont aan dat tuinen gemiddeld ongeveer 6 % innemen van de oppervlakte die officieel toegewezen is aan landbouwfuncties.

Het onderzoek naar diensten focust op de kringloop van nutriënten en de voorziening van voedselproductie. De resultaten van de analyse van de kringloop van nutriënten wijzen op een overmatig gebruik van meststoffen. De bodemvruchtbaarheid van tuinbodems blijkt ook boven het agronomische optimum te liggen wat betreft de zuurtegraad, koolstof en fosfor. De resultaten geven eveneens aan dat het tuincomplex, zeker de gazonbodems, kansen biedt voor de opslag van koolstof.

De keuzes van huishoudens over hun tuininrichting en - beheer worden verder bestudeerd aan de hand van een economisch model. De nadruk van dit model ligt op de tijd en tuinruimte die gezinnen reserveren voor voedselproductie. De resultaten illustreren dat de huidige productiviteit van privétuinen niet onbeduidend is. Groentetuinen zijn niet zeldzaam en de hoeveelheid aan geproduceerde groenten in 25 tuinen bleek overeen te komen met een derde van de hoeveelheid groenten die aangekocht worden. Daarnaast is het potentieel van tuinen om bij te dragen aan de adaptieve capaciteit van voedselsystemen niet gering.

Om de ecosysteemdiensten die (mogelijk) door tuinen geleverd worden te kunnen ondersteunen is er behoefte aan innovatieve strategieën voor 'governance'. De tuin is namelijk een voorbeeld van een complex sociaal-ecologisch systeem: een plaats waar het natuurlijke systeem innig verweven is met het maatschappelijk systeem. Via hun beheer hebben tuiniers een effect op de levering van ecosysteemdiensten.

Tuinen zijn echter strikt private landschappen die autonoom beheerd worden door een veelheid aan, op zich unieke, huishoudens. De cumulatieve gevolgen van al deze individuele beslissingen verschijnen *post hoc* en zijn vaak niet optimaal. In de wetenschappelijke literatuur wordt dit de 'tirannie van de kleine beslissingen' genoemd. Vanuit dit perspectief zou het tuincomplex als een onhandelbaar medium beschouwd kunnen worden op regionaal en strategisch gebied.

De cumulatie van acties van een veelheid aan tuiniers zou echter ook als een opportuniteit beschouwd kunnen worden. De hypothese is dat de 'tirannie van de kleine tuiniersbeslissingen' mogelijkheden biedt voor omvorming tot een 'hulpbron door kleine tuiniersacties'. De resultaten maken duidelijk dat zo een omvorming inderdaad haalbaar is.

Het werd wel duidelijk dat deze omvorming niet onmiddellijk en moeiteloos zal kunnen verlopen: er zal een veelheid aan maatregelen en acties nodig zijn om dit te kunnen verwezenlijken.

Op basis van deze bevindingen kunnen we besluiten dat het 'tuincomplex' inderdaad strategisch potentieel heeft. Dit potentieel zit niet alleen vervat in de ruimtelijke en functionele eigenschappen van het tuincomplex, maar ook in de mogelijkheden voor 'tuingovernance'. Deze hernieuwde waardering van privétuinen in samenspel met de historische inzichten in de rol van private huishoudens in de Belgische ruimtelijke ontwikkeling geeft inspiratie om het tuincomplex te beschouwen als een strategische hulpbron.

Dit doctoraat draagt bij aan de geïntegreerde kennis over een landgebruik dat tot nu toe slecht gedocumenteerd was en geen deel uitmaakt van ruimtelijk gerelateerde beleidsdomeinen. Ik hoop dat dit werk inspireert om op een nieuwe manier te kijken naar tuinen, van bescheiden zelfstandige entiteiten tot een regionaal en strategisch geheel, een gemeenschappelijk goed dat wezenlijk kan bijdragen aan het bouwen aan een veerkrachtige maatschappij.

INTRODUCING
THE GARDEN COMPLEX

"Almost any garden, if you see it at just the right moment, can be confused with paradise."

Henry Mitchell

1. GARDENS WITH A HOUSE

"I never had any other desire so strong, and so like to covetousness, as that one which I have had always, that I might be master at last of a small house and a large Garden."

Abraham Cowley, The Garden, 1666

Gardens are part of the common scenery worldwide. A garden is *"a piece of ground fenced off from cattle, and appropriated to the use and pleasure of man: it is, or ought to be, cultivated"* (Turner, 2005).

Gardens are ancient cultural elements that go back to the earliest history of urbanization and agriculture. Gardens and urbanization have a common origin since the first gardens appeared when early settlements and cities started to develop (Cleveland and Soleri, 1987; Niñez, 1987; Pregill and Volkman, 1999; Turner, 2005). To feed sedentary societies, plots were staked out to grow crops. These plots were necessarily fenced off for safeguarding the crops from theft and damage by animals. Etymology shows that the words for 'garden' in different languages (yard, hortus, jardin, hof, tuin) refer to this enclosure of outdoor space (van Koolwijk and Meijers, 1981; Aben and de Wit, 1998; Turner, 2005; Vroom, 2005). Since gardens can be seen as the first fields close to homesteads (Doolittle, 2004) and as a form of intensive agriculture (WinklerPrins, 2002), they also go back to the earliest history of agriculture (Cleveland and Soleri, 1987; Niñez, 1987).

In the course of time and across continents, the morphologies and functions of gardens have changed. Aesthetics became an aspect of garden design, next to utility. Some gardens were created as micro-farmsteads, by necessity or as a hobby, while others were deliberately designed as decorative places and showpieces.

For millions of people worldwide, the garden is a special part of their intimate living environment. It is a little private paradise and safe haven where happiness, creativity and contact with nature are searched (van Koolwijk and Meijers, 1981; Blomley, 2005; Gross and Lane, 2007; Phillips et al., 2008; Gulinck et al., 2011; Freeman et al., 2012; Phillips, 2014). This makes the garden an object that is rich in meaning, functions and values. It is a place just as it is an idea, an object of action and much more (Vroom, 2005). Gardens, in one form or another, have been a part of human existence for a very long time, and doubtless always will be (Doolittle, 2004).

The focus of this dissertation lies on domestic gardens. A domestic garden is defined here as a garden that is spatially associated with a dwelling (Cameron et al., 2012). The term 'domestic garden' is preferred rather than 'private garden', since the latter can be any privately owned garden that is not necessarily related to a dwelling.

1 Is there a need for new perspectives on domestic gardens?

In a world of growing urbanization, gardens are present worldwide. The area they occupy is expected to increase (Cooper et al., 2007; Kiesling and Manning, 2010; Kendal et al., 2012; Dewaelheyns et al., 2014a). Yet, they remain one of the least studied and understood land uses (Christie, 2004; Mathieu et al., 2007) whilst the phenomenon of gardening has not been given due consideration for its global relevance (Niinemets and Peñuelas, 2008). Domestic gardens have received far less attention compared to public green spaces, although they contribute to the overall sustainability and resilience of urbanized areas (Moulaert and Van Dyck, 2011; Goddard et al., 2013; Balooni et al., 2014).

In the following, several characteristics are discussed that support the quest for a revaluation of domestic gardens, as well as three characteristics that hinder such a revaluation. The two inviting characteristics are their presence as a 'green' category across the urban-rural gradient, and the provisioning of multiple benefits. The three characteristics that hinder a revaluation are their escape from attention, the fact that they are generally a less appreciated and acknowledged land use, and the complexity of their private management.

1.1 Garden characteristics supporting a quest for revaluation

1.1.1 A 'green' land use across urban-rural gradients

Domestic gardens bridge the urban-rural gradient: they are present in urban, peri-urban and rural areas. A substantial fraction of (peri-) urban and residential areas all over the globe is covered by domestic gardens. In Europe, gardens take up between 22 % and 27 % of the total area within the administrative city boundaries of Edinburgh, Belfast, Leicester, Oxford and Cardiff (UK) (Gaston et al., 2005b; Loram et al., 2007; Tratalos et al., 2007), and 16 % of the central part of Stockholm, Sweden (Colding et al., 2006). In Dunedin, New Zealand, the vegetated garden area occupies 46 % of the residential area, and 36 % of the total urban area (Mathieu et al., 2007).

Although most studies on garden coverage essentially deal with urban gardens in developed countries, domestic gardens are also an important land use component in rural (Meert, 2000; Phillips, 2005b; Marco et al., 2008; Phillips et al., 2008; Bomans et al., 2010; Foré et al., 2012) and peri-urban areas, in developed and developing countries. Home gardens cover for example about 19 % of the Kirua Vunjo Division territory in Tanzania (Soini, 2005).

Domestic gardens also represent an important share of urban green space. Between 35 % to 47 % of the urban green in the United Kingdom (Loram et al., 2007) and 42 % of the urban green in the Brussels Capital Region (Belgium) (Van de Voorde et al., 2008) is domestic garden. Lawn, a characteristic component of domestic gardens, is estimated to cover 10 to 16 million hectares in the continental United States (Robbins and Birkenholtz, 2003; Milesi et al., 2005). In Kigali (Rwanda), garden trees belong to the most dominant types of green spaces in terms of city area coverage (Seburanga et al., 2014). Antrop and Van Eetvelde (2008) state that domestic gardens must be considered as important spatial networks of green and open spaces within rural areas.

Gardens are considered an important component of the urban and rural green infrastructure (Antrop and Van Eetvelde, 2008; Goddard et al., 2010b; Hermy and Claessens, 2011; Cameron et al., 2012). Yet their role in landscape ecological networks and in conserving biodiversity is not fully understood (Hermy and Claessens, 2011). The call is raised to focus more on common gardens and gardening practices with respect to biodiversity conservation (Davies et al., 2009; Moloney et al., 2009; Bossu et al., 2014).

Several studies have already done so, with the Biodiversity in Urban Gardens Sheffield (BUGS) I and II projects in the UK (Thompson et al., 2003; Thompson et al., 2004; Gaston et al., 2005a; Gaston et al., 2005b; Smith et al., 2005; Thompson et al., 2005; Smith et al., 2006a; Smith et al., 2006b; Smith et al., 2006c; Loram et al., 2007). These were the first projects that explicitly illustrated the biodiversity role of urban gardens (Hermy and Claessens, 2011).

The BUGS and other studies revealed that urban gardens represent a high diversity of plant and animal species (Owen, 1991; Hermy and De Blust, 1997; Zipperer et al., 1997; Daniels and Kirkpatrick, 2006a; Baker and Harris, 2007; Kirkpatrick et al., 2007; Evans et al., 2009; Owen, 2010; Kurz and Baudains, 2012; Andersson and Colding, 2014; Paker et al., 2014; Zhang and Jim, 2014). A substantial fraction of the natural regional plant species diversity was found in gardens (Hermy and De Blust, 1997; Smith et al., 2006b; Loram et al., 2007). The presence of invasive alien species is a point of attention (Smith et al., 2006b; Marco et al., 2008; Niinemets and Peñuelas, 2008; Chrobock et al., 2013; Bossu et al., 2014). But there are also benefits of exotic garden plants with regards to climate change adaptation (Van der Veken et al., 2008), the enrichment of local biodiversity and to maintain ecosystem functioning (Walther et al., 2009). Therefore Hermy and Claessens (2011) call gardens a 'mixed blessing' in the context of plant diversity. Concerning the importance of gardens for birds, tree species composition (Thompson et al., 1993), garden area (Thompson et al., 1993; Chamberlain et al., 2004) and variation in garden characteristics (Daniels and Kirkpatrick, 2006b) appeared to influence bird species richness.

So, gardens are rich in plant and animal species, yet their smallness and isolation limits their potential from a landscape ecological point of view. Research by Vergnes et al. (2012) already clarified that the connection of domestic gardens with other urban green spaces as well as more natural resources within regional green frameworks is crucial to enhance their biodiversity. To assess better the role of gardens in biodiversity conservation, research should be scaled up from the level of the individual garden to the level of the cityscape. To realize their conservation potential, design and management of private gardens should be integrated in citywide biodiversity strategies (Goddard et al., 2010b).

1.2 At your service! Gardens as providers of ecosystem services

Domestic gardens are semi-natural ecosystems that provide important amenities for the environment and society (Cameron et al., 2012; Cook et al., 2012). These amenities can be considered 'ecosystem services'. Ecosystem services are defined by the Millennium Ecosystem Assessment (MEA) as 'the benefits people obtain from ecosystems' (Millenium Ecosystem Assessment, 2003). Fueled by an increasing number of studies (Potschin and Haines-Young, 2011), a variety of classifications and ongoing debates, the MA definition and classification have been refined by the European Environment Agency (EEA) through the development of a Common International Classification of Ecosystem Services (CICES) (Haines-Young and Potschin, 2013).

CICES defines ecosystem services as 'the contributions that ecosystems make to human well-being.' A fundamental characteristic is that they retain a connection to the underlying ecosystem functions, processes and structures that generate them. Gardens also provide benefits: things like products and experiences that people create or derive from ecosystem services. This meets reflections from the wider scientific literature (Boyd and Banzhaf, 2007; Fisher and Kerry Turner, 2008; de Groot et al., 2010; Haines-Young and Potschin, 2010; Potschin and Haines-Young, 2011). A more in-depth discussion on the 'ecosystem services' concept is given in Chapter 2.

Scientific literature provides convincing information on the delivery of a wide range of such services by gardens (Figure 1.1 and Appendix A):

Provisioning services, being all the nutritional, material and energetic outputs from living systems.

Regulating and maintenance services, including all the ways in which living organisms can mediate or moderate the ambient environment that affects human performance.

Cultural services, which constitute all the non-material, and normally non-consumptive, outputs of ecosystems that affect physical and mental states of people.

Functions, being the biological, chemical and physical interactions between components of ecosystems. They are intermediate services that support the provisioning of final services (Boyd and Banzhaf, 2007).

Domestic gardens are even considered to have the potential to contribute more to ecosystem services provisioning than they currently do (Davies et al., 2011). Yet, they are often not considered when ecosystem services of (urban) green and agricultural ecosystems are put on the agenda (Davies et al., 2011; Cook et al., 2012).

The overview of ecosystem services suggests that domestic gardens are in fact multifunctional spaces, where multiple services (and benefits) are able to coexist (Rodríguez et al., 2006). But not every garden contributes equally to each service and benefit.

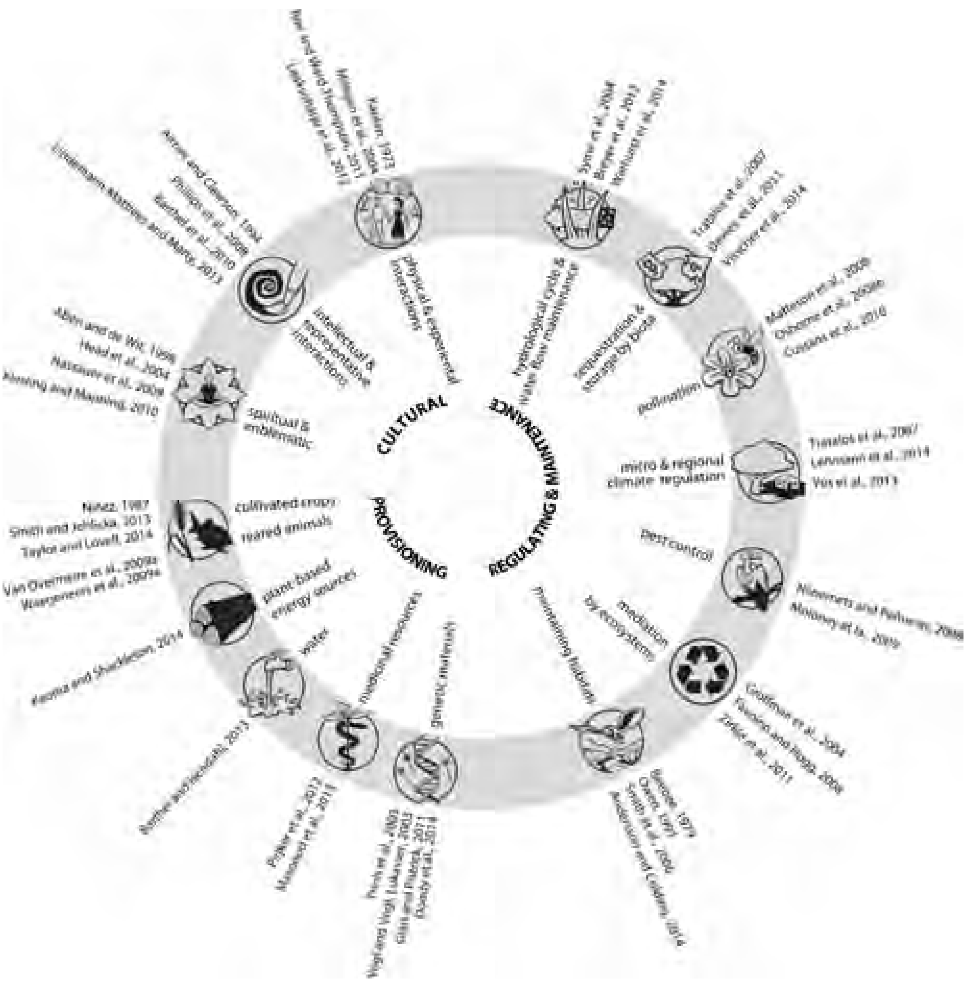


Figure 1.1 Ecosystem services supported by gardens

Many of the ecosystem services classified in CICES are supported by domestic gardens. An overview is given of these services, with an anthology of related papers. A more extensive literature overview is available in Appendix A.

Source Author, based on the CICES ecosystem services classification. The icons were designed by Jan Sasse for TEEB, except the icon for nutrient recycling.

1.3 Garden characteristics limiting a quest for revaluation

Besides their inviting characteristics, domestic gardens also have three characteristics that hamper their consideration as a land use type in its own right.

1.3.1 Hide and no seek: gardens hidden behind an urban façade

The garden is such a common part of people's everyday experience that it mostly escapes policy attention. It is like Haeg (2008) states about the front lawn in the US: they are so deeply embedded in our psyche that we don't see them anymore, at least for what they actually are. As such, gardens tend to be undifferentiated and second-ranked parts of urban and residential land uses.

According to Sayce et al. (2012), gardens have no special status in spatial planning law in the UK. For example, they are not mentioned as a specific use within the UK Town and Country Planning (Use Classes) Order (1987)[1]. This phenomenon that most built-up areas are labeled as 'urban' and perceived to be composed primarily out of buildings, roads and artificially covered areas (Gill et al., 2008) is not limited to the UK. Also in Flanders a parcel is categorized as 'built-up' or 'urbanized' once a dwelling is built on it, even if the dwelling covers a small fraction (NIS, 2011). In the Dutch land use map, gardens are only implicitly part of categories like 'housing in primary built area', 'grass in primary built area' and 'orchards' (Hazeu et al., 2014). In Europe the CORINE category 'discontinuous urban fabric' indicates the presence of green categories, but domestic green is not made explicit. Also, most of the urban, suburban and new town development models reduce domestic gardens to a mere appendage by focusing principally on the construction of housing and infrastructure (Pregill and Volkman, 1999) (see also Chapter 3).

But hidden behind urban built-up façades thousands of domestic gardens can be discovered (Loram et al., 2007; Van de Voorde et al., 2008; Van Delm and Gulinck, 2011). By making abstraction of the existing domestic and public green, the 'stony' interpretation of urban fabric puts its stamp on functional evaluations. For example, once land in the UK is considered to be urban, the biological carbon stock is assumed to be zero (Dyson et al., 2009). As Davies et al. (2011) state, this undervalues the actual ecosystem service of carbon storage in gardens and other urban green.

1 http://www.legislation.gov.uk/uksi/1987/764/made

Gardens exist abundantly in the countryside as well. In the UK, gardens are in fact an important aspect of rural nature (Phillips, 2005b; Phillips et al., 2008; Phillips, 2014). They can be considered as a form of middle class colonization of the countryside (Phillips et al., 2008), and domesticated flora may be important in developing desirable rural spaces (Phillips, 2005b). Also rural policies hardly pay attention to domestic gardens. Such policies, defined at the national or regional level, tend to focus on the planning and management of larger open spaces (Dewaelheyns et al., 2014b). Emphasis lies on farming and forestry, nature conservation, recreation and other functions (Brabec and Smith, 2002; Carsjens and van der Knaap, 2002; Jongman, 2002). Rural and ecological planning holds a dualistic vision of the countryside, whereby nature is to be found in the open countryside, so beyond and not within rural settlements (Phillips et al., 2008). Again, domestic gardens are excluded from the picture.

So, current policies are locked in clearly defined and standard sectoral land use categories (Larsson, 2006) like urban and agriculture. This fits in a strive for order, a distinctive feature of spatial planning for a long time (Qviström, 2007). Such clearly defined land use categories facilitated clear zonal demarcations and specialized policies, administrations, and rules (Gulinck et al., 2013). In fact, there has been an explosion of sectoral legislation, planning and instruments in Belgium (Laga et al., 2005; Van den Broeck et al., 2010). Domestic gardens do not fit well with any of these sectoral land use categories. As a consequence, they are not considered by any of the customary policy domains. Separate rural and urban planning legislations simply add to the arbitrary divide between the city and the countryside, between urban and rural, and between order and disorder (Qviström, 2007). This leads to a biased image of land use reality and to a bias in urban and rural policies (Maruani and Amit-Cohen, 2007).

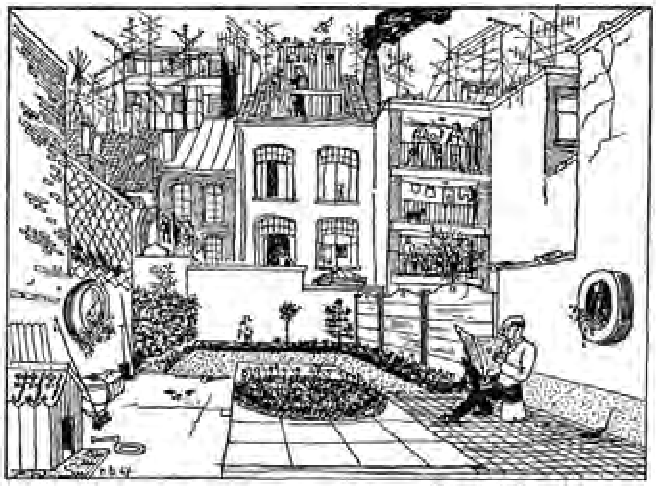
1.3.2 Gardens as luxurious consumers of space

Most domestic gardens belong to the generally less appreciated, fragmented and peri-urbanized parts of the territory. This makes that gardens, as far as they are part of urban expansion, may be interpreted as 'luxurious' consumers of space. Already in 1968 Renaat Braem (2010) (page 50) cynically critized the space consuming development of sprawled single family dwellings with a garden: "*The garden, no bigger than a pocket handkerchief of the De Taeye dwellings provide space nor nature, but pocket-sized ersatz nature*". While the domestic garden represents 'paradise' for individual households, Braem considered the individual garden as a delusion with respect to common interests.

Figure 1.2
'Reality does not match the dream'

While the domestic garden represents a 'private paradise' for individual households, Braem considered the individual garden as a delusion with respect to common interests. According to him, 'reality does not match the dream'

Source
Braem and Strauven (2010), page 49



According to him, 'the reality does not match the dream' (Braem and Strauven, 2010) (Figure 1.2).

This consumption of space by gardens can be interpreted in two ways. In a 'rural interpretation' gardens occupy a share of the rural land stock. This phenomenon is called 'garden sprawl' (Bomans et al., 2010) or 'hortification' (Antrop and Van Eetvelde, 2008). Especially in the countryside, the growth of garden area can be considered as a 'cumulative impact' or 'cumulative effect'. The difficulty of such cumulative effects lies in the demonstration that, while each single change or decision results in a rather negligible impact, the accumulation of all these individual changes over time and within a region may constitute a major impact (Theobald et al., 1997). Although cumulative effects pose significant but complex challenges for planning (Scott et al., 2014), there is currently only little consensus on their nature and meaning (Gunn and Noble, 2011).

In an 'urban interpretation', domestic gardens occupy land that could be used for a more dense development of residential areas, which at its turn would safeguard remaining open space from urbanization and sprawl (Berke, 2002; Filion, 2003; Downs, 2005; Millennium Ecosystem Assessment, 2005; Atkinson-Palombo, 2010). In many Australian cities, smaller block developments with decreased lot sizes are a modest way of increasing urban densities (Syme et al., 2001). The current policy tendency across Europe to densify existing urban areas can be operationalized by the intake of existing domestic gardens (Sayce et al., 2012), a phenomenon commonly referred to as 'in-fill developments', 'backland development' or 'garden grabbing' (Phillips, 2005a; Goode, 2006; Davies et al., 2011). Some retrofitting suburbia design proposals collected by Dunham-Jones and Williamson (2009) build upon garden space, like the construction of accessory apartments of maximum 92 m^2 per single family dwelling. The reconfiguration strategy of van de Weijer (2014) looks at the potential of such backland development in Flanders.

This densification paradigm needs further scientific exploration (Colding, 2011; Colding and Barthel, 2013). To date, no clear answers are given on how to achieve a more compact urban form (Dehaene, 2013). Above all, the support of ecosystem services by private and public green spaces within urbanized areas are often ill-known and may therefore be strongly underestimated (Davies et al., 2011; Cook et al., 2012) and unrecognized (Colding et al., 2006). Consequently, these spaces and their potential for ecosystem services support remain underutilized (Colding et al., 2006).

1.3.3 When nature and society meet in private: the tyranny of gardening decisions

Domestic gardens are individual and private spaces that are managed by a countless number of gardeners. For example; about 78 % of the USA households undertake some gardening activities in private green spaces (Kiesling and Manning, 2010). Their gardening decisions have direct implications for the environment (Goddard et al., 2010a; Cook et al., 2012). But many gardeners, if not most, make gardening decisions without a sound understanding of the environmental impact of their actions. According to Goddard et al. (2010b) and Hermy and Claessens (2011), gardeners often lack skills and experiences in biodiversity conservation.

While the use of fertilizers seems to be hardly questioned by individual gardeners, the work of Bijoor et al. (2008) and Livesley et al. (2010) indicated that lawn fertilizer usage leads to greenhouse gas emissions. Pimentel (1991) stated that homeowners are more likely to overuse pesticides compared to professionals. Moreover, awareness of the harmful effects of for example chemical products for lawn care seems insufficient to decrease usage (Robbins et al., 2001). Results of Hermy and Claessens (2011) suggest that gardeners mainly rely on aesthetic characteristics like the color of the flowers for selecting garden plants. Moreover, plant survival in gardens would mainly depend on maintenance rather than on a fine-tuning of species composition on site conditions. Doody et al. (2014) found that a lack of awareness was a main reason that people did not allow self-seeding native plants to mature in their garden.

A culmination of uncoordinated (e.g. autonomously and individually made) gardening decisions leads to major post-hoc effects on the environment (Odum, 1982; Thompson, 2004; Cooper et al., 2007; Goddard et al., 2010a; Goddard et al., 2010b). Such culminated effects are often neither optimal, desired, intended or preferred by society (Odum, 1982; Stern, 2000; Cooper et al., 2007).

This is the phenomenon of the 'tyranny of small-decisions' launched by Kahn (1966) in 1966. In essence, it is the 'cumulative effects problem' discussed above.

But there is more to it. Gardeners are also highly influenced by personal ideologies, household characteristics, rules and norms (Saugeres, 2000; Stern, 2000; Blomley, 2005; Kaye et al., 2006; Kiesling and Manning, 2010; Larson et al., 2010; Underdal, 2010; van den Berg and van Winsum-Westra, 2010; Cook et al., 2012; Freeman et al., 2012; Kendal et al., 2012; Kurz and Baudains, 2012; Politi Bertoncini et al., 2012; Giner et al., 2013; Zhang and Jim, 2014). As such, gardens have been as much subject of social studies as they have been of natural sciences studies (Doody et al., 2014).

This makes domestic gardens intriguing spaces where social systems (e.g. property rights, systems of knowledge, world views and ethics) are intimately linked to ecological systems (e.g. the natural environment). To emphasize such integrated 'humans-in-nature' characteristic, Berkes and Folke (1998; 2003) launched the term 'social-ecological systems'. Domestic gardens are considered to be social-ecological systems by several authors (Grove et al., 2006; Baker et al., 2007; Barthel et al., 2010; Cook et al., 2012).

Social-ecological systems are complex by definition (Cumming, 2011), so are domestic gardens. With the term 'a complex system', Cumming (2011) refers to a set of elements that interact with one another in a shared environment. In the garden case, these elements can be for example gardeners, plants, pollinators, water, and garden care chemicals. According to some, domestic gardens even stand model for studying social-ecological complexity in other systems (Bhatti and Church, 2001; Baker et al., 2007).

A link with the ecosystem services concept is present since complex systems research strives for understanding the connections between structures and functions (Cumming, 2011). As such, ecosystems services are at the interface between the biophysical and social components of social-ecological systems (Haines-Young et al., 2012).

The cumulative impacts of individual gardening decisions on the environment are already discussed above. It can be assumed that such negative environmental impacts lead to a degeneration of ecosystem services. Yet, several studies underpin the idea that cumulative gardening impacts could also support the delivery of ecosystem services (Colding et al., 2006; Cooper et al., 2007; Kiesling and Manning, 2010; Goddard et al., 2013). Daniels and Kirkpatrick (2006b) indicate that gardeners potentially have a substantial role in the conservation of (urban) native avifauna. In an attempt to document to which extent wildlife gardening activities (promoted by the UK government) are conducted, Davies et al. (2009) found a minimum of 4.7 million nest boxes within gardens across the UK. This results in at least at least one nest box for every six breeding pairs of cavity nesting birds. As ecosystem services are inherently linked to social systems and decisions, the range of processes leading to such decisions (called the decision context) is crucial for mobilizing the ecosystem services concept (Fisher et al., 2009).

Despite the rather negative positioning by using a concept like the 'tyranny of small decisions', these are major arguments for unveiling the importance of domestic gardens and private garden management in a wide range of strategic themes, including biodiversity loss and climate change. Most importantly domestic gardens are to be increasingly considered as a medium for self-responsibility of individuals and households in global sustainability challenges.

1.4 The vicious circle of non-attention

The garden theme is an interesting example of a vicious circle between non-availability of information, lack of attention in policy, and scarcity of scientific research on gardens (Figure 1.3).

Compared to other land uses, domestic gardens and gardening practices are poorly documented and systematic knowledge is largely lacking (González-García and Sal, 2008). Census systems that collect land use data match customary (and often sectoral) categorizations of space (Bomans, 2011), leaving aside non-orthodox land use categories like domestic gardens.

Due to the lack of reliable, systematic and integrated data and knowledge (Zhang and Jim, 2014), no scientific insights can be gained in the strategic value of domestic gardens. This adds up to their trivial, private and small-scaled character, their extreme variation in size, appearance, management and use, and their relative inaccessibility for investigation (Niñez, 1987; Zmyslony and Gagnon, 1998; Loram

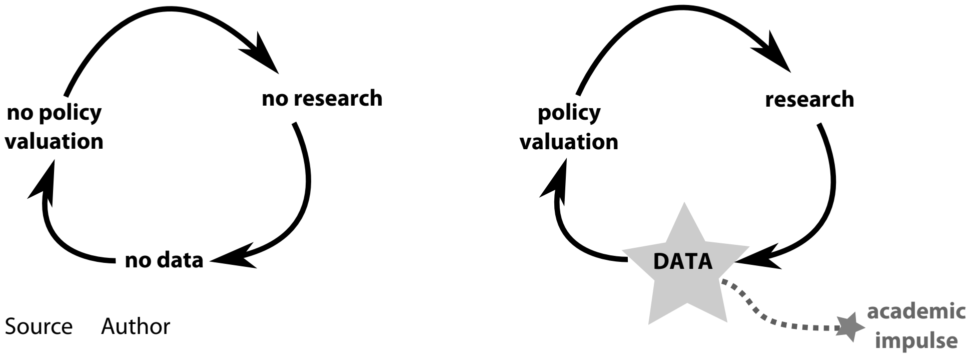


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Figure 1.3 The vicious circle of non-attention

The vicious circle between lack of data and lack of valuation traps domestic gardens within a 'knowledge gap'. (left). This dissertation aims at breaking through this vicious circle by giving an academic impulse to data collection (right).

et al., 2007; Phillips et al., 2008; Kortright and Wakefield, 2011; Van Delm and Gulinck, 2011; Cameron et al., 2012; Zhang and Jim, 2014). As a result, the general perception persists that everyday domestic gardens are only of marginal interest. This perception is a major hurdle to bring the domestic garden theme to the attention of policy and research.

Domestic gardens are beyond the scope of environmental and spatial policies (Thompson et al., 2003; Perry and Nawaz, 2008). As a consequence there is also a lack in research policies to take up the challenge of collecting data about domestic gardens. Such a phenomenon of circularity in data and information strategies is labeled the 'categorization bias' by Bomans et al. (Bomans et al., 2010; Bomans, 2011).

So, domestic gardens are trapped in a knowledge gap by the vicious circle between lack of data and lack of valuation. This dissertation aims at breaking through this vicious circle by collecting data to attract policy attention and give stimulus for further research.

1.5 Looking for the positive side of a paradox

Gardens create a paradox. Are they part of a systematic land grab with negative environmental effects, or do they contribute to a vast green infrastructure with social, economic and environmental potential?

Despite their diversity and heterogeneity, domestic gardens have characteristics that invite their consideration as strategic land use units. They are intimately linked to buildings and an important part of the living environment of thousands of people worldwide. Although the spectrum of garden types is extensive, the presence of 'green' is one of the main characteristics of a garden. This domestic green delivers multiple services and benefits comparable to those already demonstrated for public green and forests.

Seen this way, gardens can be considered as one of the positive faces of urbanization. They can be instruments of functional, ecological, cultural and spiritual compensation for the stress of our living and working conditions in non-natural built-up environments (Gulinck et al., 2011). As Moulaert and Van Dyck (2011) state, everyday gardens can become building blocks in new spatial forms such as common green spaces and ecological networks, but also factors of new forms of sharing, cooperating and producing.

Currently such a strategic interpretation of domestic gardens is largely lacking, leaving their potential largely unquestioned, undervalued and insufficiently capitalized. Keeping in mind global challenges like climate change, biodiversity loss and food security, it may be time to start looking for opportunities present within the current spatial reality of those thousands of domestic gardens present worldwide.

This plea for the revaluation of the domestic garden fits the calls of Dehaene (2013) and the temporary design collective named AWJGGRAUaDVVTAT (2012) to track down the qualities enclosed within the historical structures of a territory. Instead of condemning what is, like Braem (2010) did, we should start reading the development of the sprawled landscape as an opportunity (Dehaene, 2013). For those who look for it, the lack of readable order is a source of endless variation and diversity, and of possibilities of adaptation, that can be translated to a sense of possibilities (Dehaene, 2013).

2 Objectives

Based on the findings discussed above, the main goal of this doctoral thesis is to assess the strategic value of the integral stock of domestic gardens in a regional context. Stock includes here both the quantity (e.g. coverage) and quality (e.g. structure, diversity, environmental conditions, etc.) of the present area covered by domestic gardens. The main research question is: '*What is the surplus value of considering the integral stock of domestic gardens in a regional context?*'. In Chapter two, the concept of the 'garden complex' is launched to represent this integral stock of domestic gardens.

By unlocking original information on domestic gardens we want to break through the vicious relation between lack of data and lack of valuation. Since domestic gardens are complex social-ecological systems, a multiplicity of perspectives is needed (Berkes et al., 2003). Therefore a multi-perspective approach is used by focusing on three 'dimensions' of the integral garden stock: *structures, services* and *strategies*. The applied framework interlinking these three dimensions is discussed in detail in Chapter 2 (par. 3.2.). This makes the presented dissertation a cross-cutting work rather than a specialized in-depth study on one garden aspect.

To answer the main research goal two specific research objectives were defined: to map and to envision the integral stock of domestic gardens. Each research objective is operationalized through a series of more specific research questions.

Objective 1. Mapping the garden complex
generate baseline data on structures and services of domestic gardens.

Structures, or spatial characteristics and biophysical structures of the garden complex. Here, the focus lies on the collection of spatial baseline data about the coverage by domestic gardens. Future research focusing more in-depth on structures of the garden complex (e.g. area of sealed surfaces, vegetation structure types, ...) may build further on this. Land cover data is needed to monitor ecosystem service potential, being the capacity of land to deliver a range of ecosystem services (Haines-Young et al., 2012).

RQ1: What is the integrated area of the domestic gardens in Flanders? How are these gardens distributed?

RQ2: What is the cumulative impact of the occupation of agricultural land by domestic gardens?

Services, or ecosystem functions, services and benefits that are provided by domestic gardens. The generation of services depends on both social and ecological features (Andersson et al., 2007). So also the interactions between both should be understood (Berkes et al., 2003). The focus lies on the relation between garden management and functions, services and benefits. Since it is not possible to study all garden ecosystem functions and services due to the lack of baseline data, one ecosystem function and one ecosystem service were selected.

Nutrient cycling supports many of the services. It is studied here by focusing on fertilizer use and garden soil fertility states. The use of fertilizers seems to be hardly questioned in Flanders, although the environmental impact could be important. Insights in the state of this function will be linked to outlooks on the support of regulating services.

> **RQ3:** What is the soil fertility state of domestic gardens?
> What is the Flemish garden practice concerning fertilizer use?

The production of cultivated crops was selected as a provisioning service to study. The history of garden developments lies in food production and still today, many people all over the globe depend on their gardens for food provisioning (Marsh, 1998; Landon-Lane, 2004; Batello et al., 2010; FAO, 2012).

> **RQ4**: What are the degrees of freedom in the decision space of a household concerning food production in their garden? What is the spatial adaptive capacity of food production in domestic gardens at the household level?

Objective 2. Envisioning the garden complex
generate insights in the decision context concerning domestic gardens mobilization and explore pathways to garden governance.

Strategies, or whether or not it is possible to address the garden complex in spatial and environmental strategies. An understanding of how people use the land and ascribe purposes to it is fundamental in identifying how particular land covers might support ecosystem services and benefits (Haines-Young et al., 2012). Therefore, this part tries to get a wide-ranging insight in all opinions, ideas and meanings stakeholders have concerning the garden complex. This insight is seen as a starting point for the search of pathways to realize the strategic potential implicitly present within the garden complex.

RQ5: What are barriers to improve the service support by domestic gardens? Which levers can be used to overcome these barriers? Which pathways could be followed?

3 Research methodology

The lack of systematic and integrated data hampers scientific insights in the strategic value and potential of domestic gardens. The adopted research methodology comprises the development of quantitative and qualitative tailor-made methods, using a wide range of existing quantitative and qualitative research methods and techniques. To answer each of the above research questions, existing methods of data collection were selected and combined. Figure 1.4 gives an overview of the used combinations of methods and techniques.

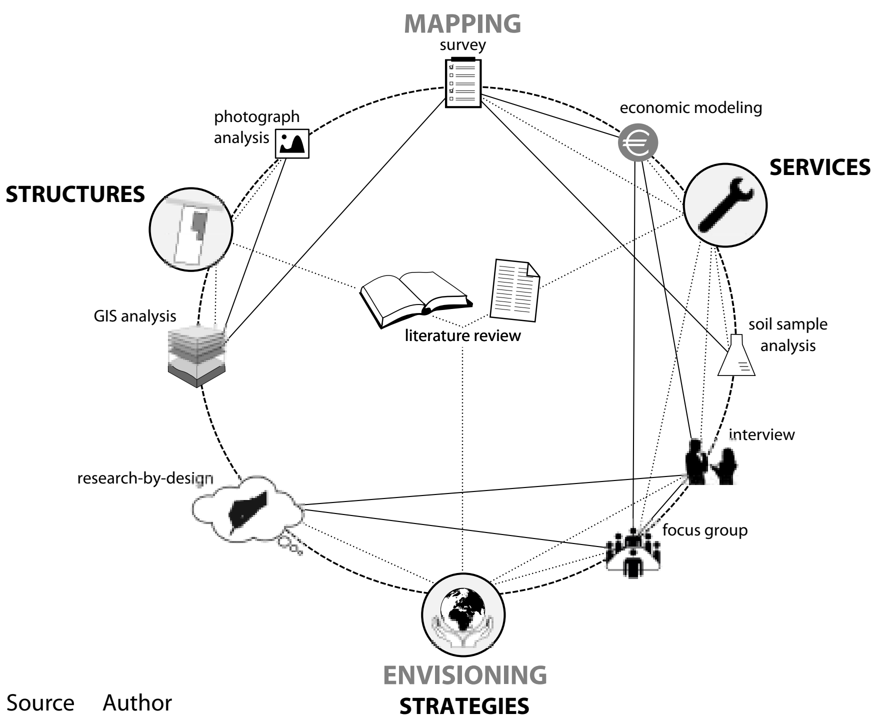

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Figure 1.4 Overview of the research methodology

Data are collected using a wide range of methods that are combined to form tailor-made methods. The dotted lines indicate which methods are used for collecting data on a specific dimension. The full black lines indicate which methods are combined.

For the analysis of structures, geographical analyses were combined with ortho- and streetview photographs. To study nutrient cycling, surveys were combined with soil sampling analysis. Quantitative surveys and qualitative focus groups and expert interviews were used to fuel the development of an economic utility model. For the exploration of strategies, qualitative data was collected by means of research-by-design, focus groups and interviews, and triangulated within a grounded theory approach. Each of these methods will be discussed in detail in the following chapters.

The research concentrates on the case study 'Flanders' (Chapter 3), but constantly keeps an open mind to the universality of the theme of domestic gardens.

4 Outline of the thesis

The dissertation is composed out of nine chapters, divided over four parts: Introducing, Mapping, Envisioning, and Revisiting the Garden Complex (Figure 1.5).

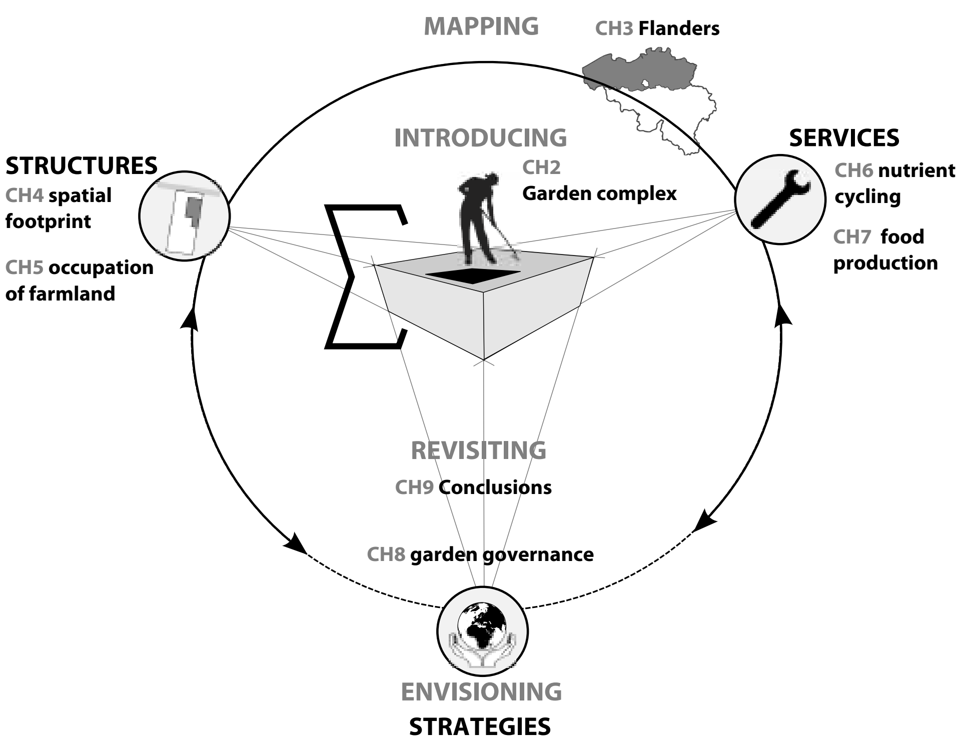


Figure 1.5 Outline of the thesis

The thesis is composed out of nine chapters, divided over the four sections Introducing, Mapping, Envisioning and Revisiting the garden complex.

Chapter 2 of the first part '**Introducing the garden complex'** launches the concept of the 'garden complex' and its associated framework to represent the integral stock of domestic gardens in their regional context.

The second part **'Mapping the garden complex'** presents the mapping of structures and services of the garden complex throughout four chapters. Chapter three introduces the case study Flanders and gives an overview of the historical development of gardens in Flanders. Chapters four and five focus on ***structures*** of the garden complex in Flanders by developing mixed methods to collect data on spatial coverage. In Chapter four, data is collected on the available stock of garden area and its spatial characteristics. The cumulative effect of the intake of farmland by domestic gardens is described in Chapter five. The chapters four and five are each based on a published article.

Chapters six and seven discuss the dimension of ***services*** of the garden complex. *Chapter six* focuses on the function of nutrient cycling by studying garden management and soil fertility in Flemish domestic gardens. Insights are gained in the impact of fertilizer usage on the soil fertility states. As such, reflections are made towards the support of regulating and maintenance services. Chapter six is based on a published article. Food production is at stake in Chapter seven, in which the impact of household preferences on the allocation of garden space and time to home food production is studied. The development of an economic model allows to gain insight in the food production potential of domestic gardens.

In the third part '**Envisioning the garden complex'**, Chapter eight explores if and how the garden complex can be included in spatial and environmental strategies. For that goal, it defines barriers as well as levers. This way, a toolbox for garden governance is assembled. Such a toolbox can serve as a starting point to develop pathways towards the aimed integration of the garden complex in spatial and environmental strategies.

In the fourth and final part '**Revisiting the garden complex'** I go back to the preliminary description of the garden complex and confront this with the main insights gained throughout the doctoral research in Chapter nine. Based on these reflections, I look ahead by formulating five key messages to go forward with the garden complex.

Source: Hubert Gulinck

2. Leaping the fence to see the 'garden complex'

"Landscapes are as small as a garden, as large as a planet."

Whiston Spirn, 1998

1 Introduction

My observation based on the discussion in Chapter 1 is that domestic gardens belong to the singular and generally less appreciated parts of the territory. A vicious circle of non-attention maintains a general perception of triviality: domestic gardens seem to be considered as private objects, with little or no societal and environmental surplus value. The countless number of gardeners seems to be experienced as a hurdle for reconsidering garden management practices in land use and environmental policies.

I believe that there is room for a new strategic assessment of domestic gardens. To be able to pursue sustainable and resilient landscapes that may respond to complex future challenges, it is necessary to consider and manage the landscape as a whole (Fry, 2001; Saunders and Briggs, 2002; Haines-Young et al., 2003; Selman, 2006). The multiplicity of individual gardens is part of this landscape matrix, and should be considered as such.

In this dissertation, the concept 'garden complex' is launched as a way to leap the garden fence. Hereby we refer to a famous quote of Horace Walpole (1750, in 'The history of modern taste in gardening'). With this quote Walpole described how William Kent, a famous English landscape architect, widened his outlook across the garden fences (Van Damme, 2013).

"He leaped the fence, and saw that all nature was a garden."

Horace Walpole, 1750

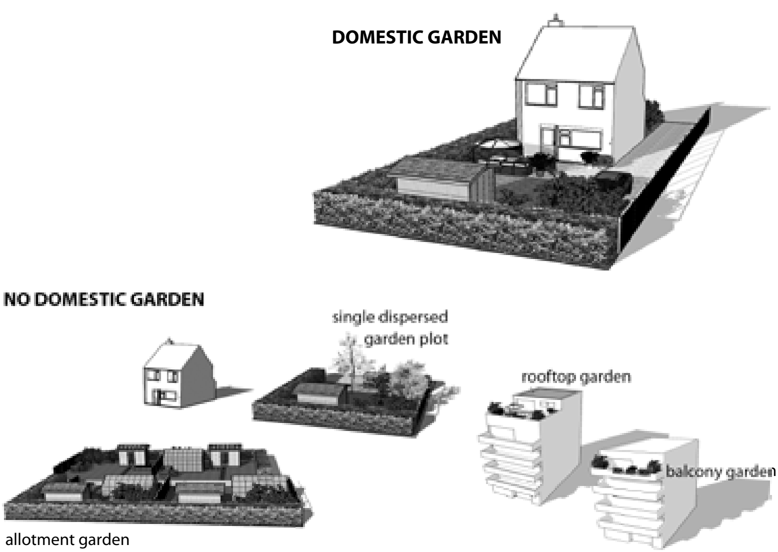
2 FROM INDIVIDUAL DOMESTIC GARDENS TO THE 'GARDEN COMPLEX'

After further explaining the definition of a 'domestic garden' used in this dissertation, a preliminary definition of the garden complex is given.

2.1 THE DEFINITION OF A 'DOMESTIC GARDEN'

A domestic garden is defined as the residential parcel, owned or rented, with exclusion of the associated house. So in the following I will concentrate on the residential parcel *without* the built module of the dwelling (Figure 2.1). It is a precondition that residents (both owners and tenants) have autonomy over the garden management, although responsibility can be delegated to professional gardeners (Cameron et al., 2012).

Small buildings in the garden like carports, garden houses and wood sheds are considered part of the garden. Domestic gardens associated with the dwellings of farmers are included, as well as small greenhouses not used for the commercial production of food or ornamental plants. Excluded are pasture for recreational farming; the area used for professional agriculture; storage space for building materials or refuse; greenhouses used for commercial production and extensive woodlots.



Source Frederik Lerouge

Figure 2.1 Definition of a domestic garden

Only soil-bound residential parcels without the house are considered as domestic gardens.

Given the above definition, only soil-bound gardens directly related to a house are considered as domestic gardens. Gardens not linked to housing like allotment gardens and dispersed single-plot gardens in agricultural land are not considered as domestic gardens. Also, roof and balcony gardens are excluded.

2.2 A PRELIMINARY DEFINITION OF THE 'GARDEN COMPLEX'

The private and small-scale character of domestic gardens (Phillips et al., 2008; Van Delm and Gulinck, 2011) seems to lead to the routinely consideration of gardens as unique objects (see e.g. Goddard et al. (2013)). Instead, we could consider them as an integral set of individual objects. By 'leaping the garden fence' we can consider domestic gardens from a bird's-eye perspective.

Therefore the concept of the 'garden complex' is launched (Figure 2.2). The garden complex is preliminary defined as the aggregation of individual domestic gardens within a certain region. This region can be a neighborhood, a city, a rural area, a country, etc. In fact, the concept can be applied at any scale level. This meets the call of Goddard et al. (2010b) to consider gardens as networks of green space acting at multiple spatial scales across the urban landscape.

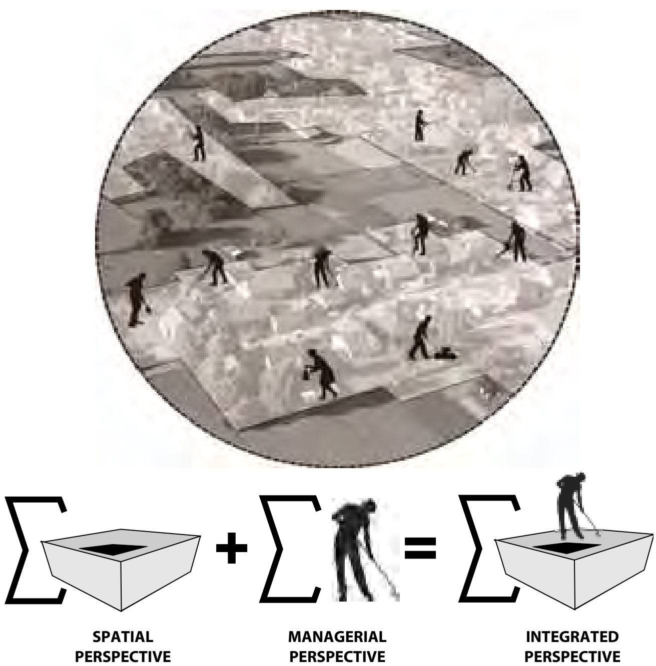


Figure 2.2
Definition of the garden complex

The aggregation of the whole of domestic gardens within a certain region is called the 'garden complex'. This aggregation integrates both the spatial and the managerial perspectives.

Source Author; photo www.lrqh.be

More specifically, the garden complex is the summation of a broad range of aspects and characteristics (*X*) of gardens within a certain region. This is symbolized as $\sum X$. From a spatial viewpoint, the garden complex represents the total area covered by the whole of individual garden areas. Similarly, the total area of lawn, kitchen garden or sealed surface can be calculated as parts of this complex. From a managerial perspective the food produced or the time spent on gardening by all gardeners, the total amount of a certain product used during garden management, etc. can be summed. Such aggregation is straightforward, since the amount at the higher scale is simply the sum of the amounts at fine scale (Scholes et al., 2013). The garden complex concept integrates both social and ecological perspectives of the complex social-ecological system that gardens are.

The 'garden complex' has a double interpretation. In a tangible way, it is a spatial structure that can be clearly demarcated on aerial photographs, land use maps, etc. A garden complex can exists out of gardens that are spatially connected, but this is not a precondition. Also domestic gardens dispersed in the countryside and physically not connected to other gardens are part of the garden complex. So, the garden complex is spatially interpreted as a region-wide landscape structure.

At the same time, the garden complex is also an abstract concept that represents a way of thinking about the multitude of individual gardens (Laurence and Margolis, 1999; Dewaelheyns et al., 2011). Gardens can be considered as 'forgotten spaces' in some way. In this sense, the garden complex is a mental representation of the whole of domestic gardens and their gardeners that is currently hardly noticed by policy and science. As such the concept allows to draw appropriate inferences about the domestic gardens we encounter in our everyday lives (Murphy, 2002). In this more abstract interpretation, the garden complex is a starting point for the consideration of domestic gardens as an environmental and social resource.

The garden complex allows for a straightforward upscaling of the garden theme, clarifying its importance. The cumulative impact of the whole of domestic gardens and gardening actions will be clearer when looking at domestic gardens from this bird's eye perspective. As such the concept should be able to initiate a more comprehensive and integral understanding on domestic gardens that challenges to think outside the box.

3 Framing the garden complex

Domestic gardens are in essence cultural landscapes in which both human and natural elements are merged into a physical and social entity loaded with individual and collective associations (Selman, 2006). Hence, as an aggregation of domestic gardens, also the garden complex can be considered a cultural landscape.

Stewardship of cultural landscapes requires an understanding of the three interlocking aspects form, function and meaning (Terkenli, 2001; Selman, 2006). These three aspects match the spatial, functional and societal interfaces of domestic gardens. Starting from the description of these interfaces, a framework is proposed to describe and analyze the garden complex from an interdisciplinary perspective (Berkes et al., 2003) and in the light of strategic opportunities (Blaschke, 2006). Inspiration is found in existing frameworks and integral approaches on open space, landscape and ecosystem services (Fry, 2001; Piorr, 2003; Musacchio et al., 2005; Tress et al., 2005; Blaschke, 2006; Termorshuizen and Opdam, 2009; de Groot et al., 2010; Bomans, 2011; Potschin and Haines-Young, 2011; Haines-Young and Potschin, 2013). This framework was also used to structure the dissertation.

3.1 The domestic garden as a spatial, functional and societal interface

A domestic garden can be considered as a triple interface (Figure 2.3). An interface is broadly defined here as a common ground where spatial and functional characteristics blend. Francis and Hester (Francis and Hester, 1990) already described the present-day meaning of gardens as the simultaneous existence of the garden as a place, an action and an idea. Elaborating further on this, a garden is described as a spatial, a functional and a societal interface, which are mutually linked through the garden space.

From a spatial perspective, domestic gardens are both a land use interface and a tenure interface. Within a peri-urban or rural land use environment, a domestic garden is often situated between strict urban and strict rural land uses, and so part of the rural-urban interface. In such a spatial configuration a garden can be considered as a transition zone between buildings and associated infrastructure on the one hand, and agricultural land, natural areas or forests on the other. Interfaces are implicitly and explicitly recognized as forms of spatial and functional interaction in landscape ecology (Forman, 1995). When looking from an urban perspective the term 'peri-urban interface' can be used, while the term 'agro-urban interface' starts from a more explicit rural perspective (Pérez Campaña and Valenzuela Montes, 2013). Domestic gardens can be considered part of both.

A garden is also a spatial interface in terms of tenure and encounter, between the public and strictly private sphere, or between different strictly private spheres: a public-private interface. Gehl (1987) described front gardens as a semi-public or semi-private space, making the transition between the public space and the private sphere. For neighboring households, backyards can be intervening zones between the most private sphere of the dwellings.

From a functional perspective domestic gardens can be considered as an interface par excellence between urbanity and rurality (Gulinck et al., 2013). They historically developed a blend of rural functions like food production and horticulture, and more urban functions like amenity and aesthetic pleasure (Clayton, 2007; Gross and Lane, 2007; Crouch et al., 2009; Moloney et al., 2009; Kortright and Wakefield,

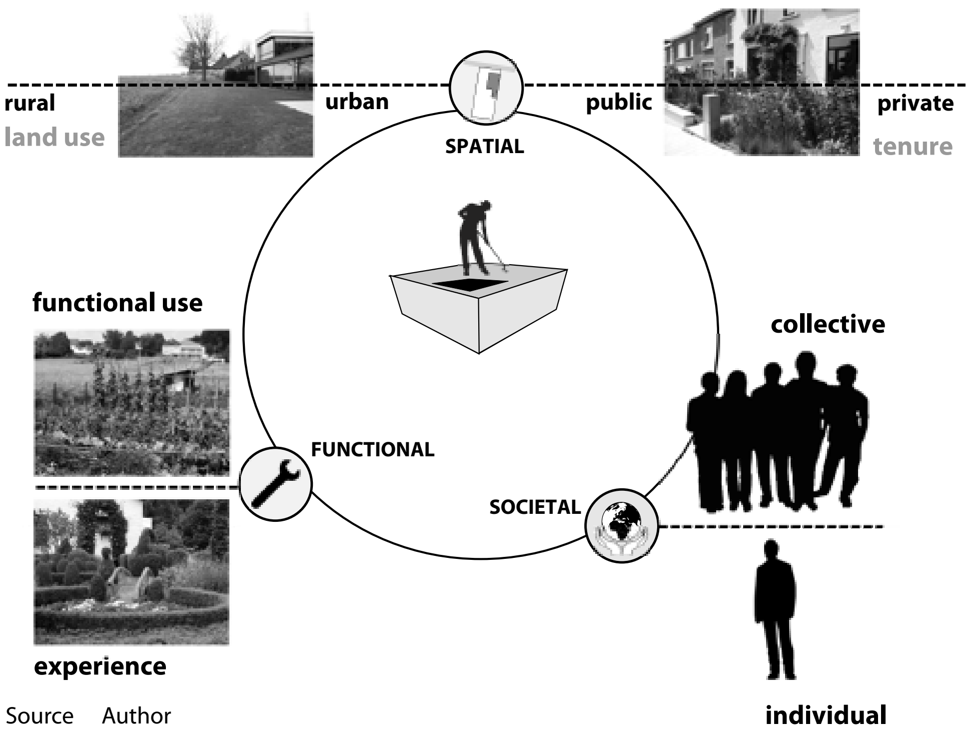


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Figure 2.3 The domestic garden as a triple interface

A garden is spatially often situated between rural and urban land uses and between private and public spaces. Functionally it combines experiences and functional uses. Societal it bridges between the individual and a collective through environmental care and stewardship.

2011; Gulinck et al., 2013). So, they are an interface between functional use and experience. This interface aspect of gardens also applies on the linkage between different disciplines and cultures (Bhatti and Church, 2001; Palang and Fry, 2003; Mazumdar and Mazumdar, 2009; Galluzzi et al., 2010; Mazumdar and Mazumdar, 2012). For rural people moving to urban areas, gardening keeps bonds to a rural past (Airriess and Clawson, 1994; Domene and Saurí, 2007) and cultural identities, religion and traditions (Head et al., 2004; Graham and Connell, 2006; Mazumdar and Mazumdar, 2009; Gladis and Pistrick, 2011; Mazumdar and Mazumdar, 2012; Pirker et al., 2012). Urban people moving to the countryside in counterurbanization movements search for connection with a rural nature idyll, represented for example in country or cottage style gardens (Phillips et al., 2008; Phillips, 2014).

From a societal perspective, a garden is an interface between people mutually, but also between people, nature and society, more than any other geographical or ecological system. This interface represents the linkage between the individual and a collective (Angélil and Hehl, 2013): an individual-collective interface. Here, a collective is understood as a set of individuals (and their actions, interests, etc.) contributing to a certain agenda, like a sustainable environment. Such contributions can be made through care and stewardship for the environment (Lehtonen, 2004; Nassauer, 2011).

3.2 A FRAMEWORK FOR THE GARDEN COMPLEX

The three interlocking key elements of the garden complex framework are *'structures'*, *'services'* and *'strategies'* (Figure 2.4). Each of these three elements is discussed further in detail.

3.2.1 STRUCTURES OF THE GARDEN COMPLEX

The 'Structures' dimension comprises the spatial characteristics of the garden complex. This key element includes (bio-) physical structures (both man-made and natural, like vegetation cover and area of sealed surfaces), the area and the morphology of the garden complex and its spatial configurations with other land uses. This dimension provides the basis for the 'Services' dimension: land cover data is needed to monitor the capacity of land to deliver a range of ecosystem services (Haines-Young et al., 2012).

Gardens typically contain several biophysical structures and a number of habitats (Hermy and Claessens, 2011). The diversity of plant and animal species is already briefly discussed in Chapter 1 (par. 1.1.1.). Additional studies indicate that there are about 28.7 million trees present in the UK gardens, with at least one tree in 54 % of all gardens (Davies et al., 2009). Moreover, in five major UK cities, lawns are present in 78 % of the gardens, borders in 87 %, patios (paved surfaces) in 93 %, ponds in 21 % and deckings (terraces made of wood) in 10 % (Loram et al., 2007). In Australia, trees are present in 86 % of the gardens as well as lawn, and borders are present in 72 % of the gardens. Only 2 % of the Australian gardens contain no plants (NGIA, 2009).

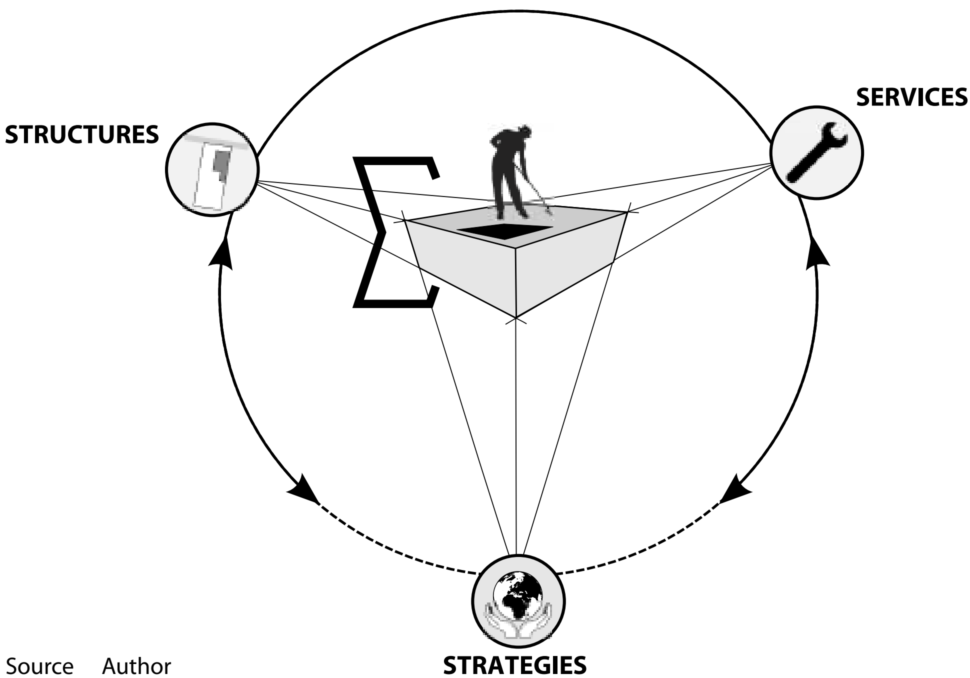

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Figure 2.4 The garden complex framework

An interdisciplinary look at the garden complex needs three dimensions: the structures, services and strategies of the garden complex. Structures refer to the biophysical structures and spatial characteristics, services to the ecosystem functions, services and benefits, and strategies to the search for pathways to realize the strategic value implicitly present within the garden complex. Strategies preferably aim at a positive feedback on the structures and the provisioning of ecosystem services and benefits.

Besides the biophysical structures and habitats present in the garden, also the morphology of the garden complex is of interest. Since domestic gardens are per definition associated with houses, this morphology is briefly discussed analogous to urban morphologies (Laskari et al., 2008; Hermosilla et al., 2014). There are three morphological configurations (Figure 2.5): garden lots at the lowest scale level of the individual household, garden units at the level of the neighborhood, and the garden complex at the highest scale level. These morphological configurations are discussed more into detail, providing insight in their structural characteristics and origins, like urban morphology studies do (Ariza-Villaverde et al., 2013).

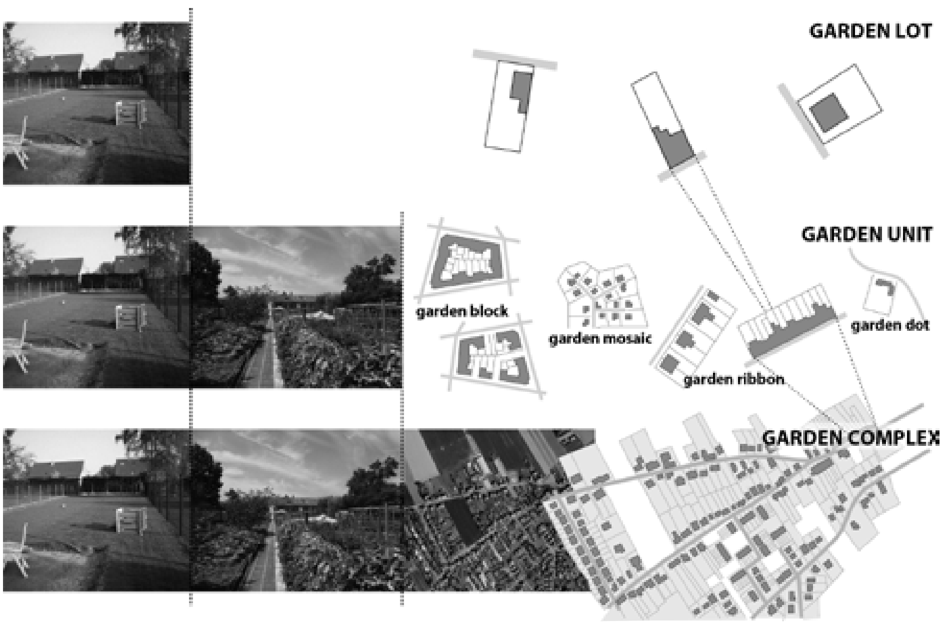


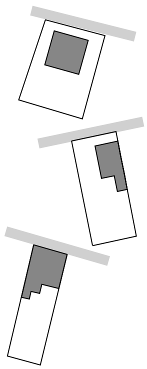
Figure 2.5 Morphology and scale of the garden complex

Specific morphological types are related to each of the three scales intrinsically part of the garden complex: the garden lot at the smallest scale, the garden unit at the meso-scale and the garden complex at the largest scale. These garden typologies are related to urban typologies: the garden lots are related to housing typology and the garden unit to urban units. The garden block relates to the building block, the garden ribbon to ribbon development and the garden mosaic to residential allotments.

Source Author, including imagery by Frederik Lerouge and AGIV

Garden lot

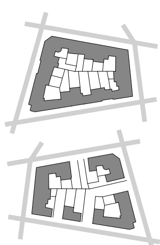
There are three morphological types of the garden lot at the individual scale, closely related to the housing typologies of detached, semi-detached and terraced houses.



The housing stock in Flanders consisted in 2005 for about 80 % of single family houses, of which 42 % are detached houses, 26 % semi-detached houses and 32 % terraced houses. The vast majority (75 %) of the single family dwellings in 2001 had a garden (De Decker et al., 2010). In general, the individual garden area is closely associated with the housing type: semi-detached houses have larger gardens than terraced houses, and smaller gardens than detached houses (Smith et al., 2005; Loram et al., 2007).

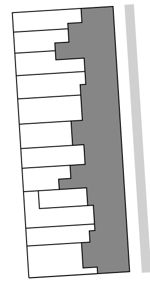
Garden unit

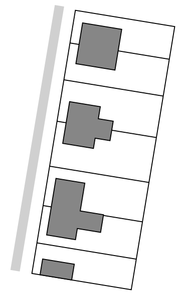
Also at the local scale a clear analogy is present with urban typologies, in this case the *urban units*: building block, ribbon development, residential allotment and building dot (Knox, 2005; Laskari et al., 2008; Verbeek et al., 2011; Gil et al., 2012; Meeus et al., 2013; Sanaieian et al., 2014; Verbeek et al., 2014). The four basic types of a *garden unit* are defined: garden block, garden ribbon, garden mosaic and garden dot. The garden block and garden ribbon can have an open or closed configuration.



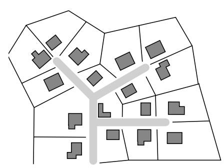
Within urban centers, garden blocks are the most prominent garden unit type. Garden blocks constitute the inner space of urban building blocks, which at their turn are defined as a group of private or public buildings and open spaces composing an island surrounded by public roads or streets (Gil et al., 2012).

Outside the urban centers, garden ribbons and garden mosaics are the most prominent garden unit types.





About 40 % of all buildings outside residential cores are part of ribbon development, making this the most important spatial configuration of buildings in the Flemish open space (Antrop, 2000; Xaveer De Geyter Architecten, 2002; Verbeek et al., 2011; Tempels et al., 2012). The average building density in Flemish ribbon developments is low, about 1 to 2 dwellings per hectare (van de Weijer, 2014). This can be explained by the ratio of garden area over built-up area which is significant higher for ribbon developments compared to residential cores and scattered developments (Verbeek et al., 2011). This has its implications for the related *garden ribbons*, especially in terms of garden area and connectivity. Gardens that are part of a garden ribbon are better interconnected than garden dots dispersed in the countryside.



A second urban morphology that is abundantly present in Flanders is the residential allotment. Assembled into a *garden mosaic,* domestic gardens are an integral part of residential allotments. Typical allotments have a rather low building density with on average about 4 dwellings per hectare (van de Weijer, 2014). These low density residential allotments are similar to the American suburbia (Knox, 2005; Bruegmann, 2006).

Both ribbon development and residential allotments are subtypes of urban sprawl, e.g. a physical pattern of low-density expansion of urban areas into the surrounding agricultural areas (European Environment Agency, 2006)(page 6). This phenomenon of sprawl is not restricted to Flanders as it can be found elsewhere (Ewing et al., 2003; Bruegmann, 2006; Kasanko et al., 2006).

Garden complex

The garden complex is situated at the highest scale level, and is assembled from the garden lots and garden units.

3.2.2 Services of the garden complex

The 'Services' dimension groups the functions, services and benefits related to the garden complex. The ecosystem services (ES) concept is used as the backbone. This concept underpins the wise use of natural resources (Wallace, 2007) by highlighting explicitly which direct and indirect benefits people obtain from natural capital, domestic gardens in this case. As such, the ecosystem service concept presents a more complete, holistic and integrated consideration of the socio-ecological system (Baker et al., 2013).

The first mentioning of the services of ecological systems and natural capital were made by Constanza et al. (1997). Picking up the ecosystem services concept, the Millenium Ecosystem Assessment (MEA) (2005) has stimulated much of the current interest in ecosystem services (Potschin and Haines-Young, 2011). It has evoked an increasing number of studies and up until now, the ecosystem services approach is still the topic of many debates (see e.g. de Groot et al. (2002); Boyd and Banzhaf (2007); Wallace (2007); Fisher and Kerry Turner (2008); Wallace (2008); Fisher et al. (2009); de Groot et al. (2010); Potschin and Haines-Young (2011); Haines-Young et al. (2012)). Consequently, the constellation of concepts related to the idea of ES is not universally agreed (Potschin and Haines-Young, 2011).

To help negotiating the different perspectives that have evolved around the ecosystem service concept, the European Environment Agency (EEA) initiated the development of a Common International Classification of Ecosystem Services (CICES) (Haines-Young and Potschin, 2013). CICES is a refinement of the MEA typology of ecosystem services (Millenium Ecosystem Assessment, 2005), obtained throughout an extensive consultation process. Fisher et al. (2009) already remark that there is not one classification scheme of ES that will be adequate for the many contexts in which ES research may be utilized. Given the aim of CICES to be a common framework, it was chosen here since it fits the purpose of giving a common framing of the services dimension of domestic gardens.

The supporting services defined by MEA as "*necessary services for the production of all other ecosystem services*" (Millenium Ecosystem Assessment, 2003) are treated in CICES as part of the underlying biophysical structures or processes and functions that characterize ecosystems. Also, CICES is a classification of services but not benefits. Ecosystem benefits are things that people create or derive from final ecosystem services like products and experiences. These choices meet reflections from the wider scientific literature (see e.g. Boyd and Banzhaf (2007); Fisher and

Kerry Turner (2008); de Groot et al. (2010); Haines-Young and Potschin (2010); Potschin and Haines-Young (2011)).

The ecosystem services concept helps to describe how humans and natural capital are related (Haines-Young and Potschin, 2013) and as such, it is at the interface between the biophysical and social components of social-ecological systems (Haines-Young et al., 2012). This linkage between humans and natural capital is especially interesting in the context of the garden theme given its characteristics as a complex social-ecological system, and the tyranny of small decisions. Domestic gardens, hence the garden complex, can be considered to be 'Service providing units', described by Luck et al. (2009) as 'the collection of individuals from a given species and their characteristics necessary to deliver an ecosystem service at the desired level'.

The concept of the Ecosystem Service Cascade summarizes the logic beneath the linkages between the ecological and the social system (Figure 2.6). The cascade concept, adopted by CICES, was launched by Haines-Young and Potschin (2010), and refined by de Groot et al. (2010) and Potschin and Haines-Young (2011). It is discussed more into detail.

Biophysical structure or process

'Biophysical structure or process' corresponds to the ecosystem components (Boyd and Banzhaf, 2007). 'Function' indicates some capacity or capability of the ecosystem to do something that is potentially useful to people (Potschin and Haines-Young, 2011) and corresponds to the supporting services (Millennium Ecosystem Assessment, 2005). Fisher et al. (2009) label both 'Biophysical structure or process' and 'Function' as 'intermediate services'.

Service

'Service' comprises 'the contributions that ecosystems make to human well-being' and are the outputs of ecosystems (whether natural, semi-natural or highly modified) (Haines-Young and Potschin, 2013). This corresponds to the definition of 'final services' by Boyd et al. (2007) and Fisher et al. (2009), who refer to final services as "*Ecological components directly consumed or enjoyed to produce human well-being*"' CICES only classifies services, and uses the three classes provisioning services, regulating & maintenance services and cultural services. These include the provisioning, regulating and cultural services defined by MEA (Millennium Ecosystem Assessment, 2005).

The linkage between biophysical structure or process, function and service is illustrated by two examples on domestic gardens. The *garden block* offers interesting perspectives concerning the regulation of the biotic environment. Lehman et al. (2014) demonstrated a temperature lowering capacity of built-up land with richly structured park-like gardens. The morphology of a *garden mosaic* offers interesting ecological perspectives on habitats of birds. In Stockholm, areas with detached housing appeared to be sufficiently attractive for at least some neotropical migratory birds that typically breed in temperate regions and then travel long distances to spend the majority of the annual cycle in tropical wintering areas (Andersson and Colding, 2014).

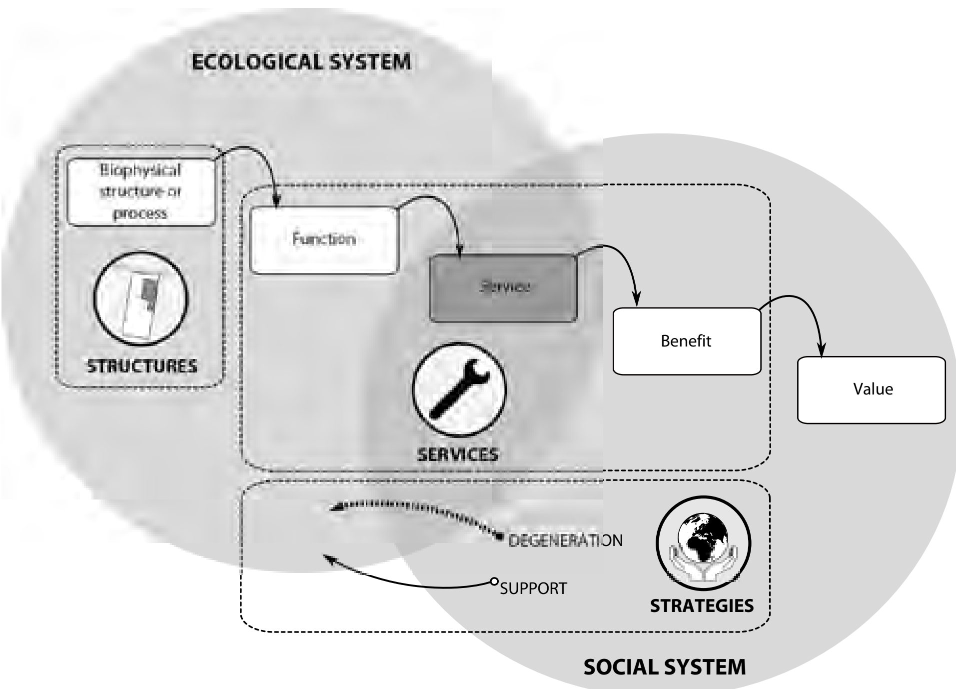


Figure 2.6 The ecosystem services cascade

The ecosystem services concept is situated in the interface between the ecological and the social system. The ecosystem services cascade summarizes how biophysical structures and processes are fundamental for functions. These functions support services, which on their turn can contribute to benefits. Services and benefits eventually become valued by society. This valuation fuels the way society supports or degenerates the provisioning of services through impact at the ecosystem. The dimensions of the garden complex framework (functions, services and strategies) are positioned in this cascade.

Source The cascade model presented here is adapted by the author from Potschin and Haines-Young (2011) and Braat et al. (In press)

Benefits

'Benefits' (and goods) are things that people create or derive from final ecosystem services, like products of experiences. There is no functional connection between benefits and the ecosystems they were derived from (Haines-Young and Potschin, 2013). A benefit can result from multiple inputs, combining natural capital with human, social and built capital (Boyd and Banzhaf, 2007).

Value

'Value' refers to the value or importance assigned to services or goods by people (de Groot et al., 2010). This value can be expressed in different ways, with in general three broad distinctive types of value: ecological, socio-cultural and economic (Millenium Ecosystem Assessment, 2003). De Groot et al. (de Groot et al., 2002; de Groot et al., 2010) describe the ecological value as the health state of and ecosystem, the socio-cultural value as the importance people give for example cultural identity and economic value as use values (e.g. direct consumptive use values) and non-use values (the value attributed to the existence of the "object").

Besides the (non-) use values, ecosystem services can also have an exchange value, being the money potential of goods through market exchange (Kallis et al., 2013). Reviews on monetary valuation approaches are given by, amongst others, de Groot et al. (2002), Bateman et al. (2011), Potschin and Haines-Young (2011) and Kallis et al. (2013). Iniesta-Arandia et al. (2014) provide work on the socio-cultural valuation of ecosystem services.

Economic valuation, dominating the debates on ESS valuation, allows a comparison (between services, ecosystems, future options) in monetary terms: it allows to make the multiple aspects of ecosystems economically explicit. For example, the UK National Ecosystem Assessment (UK NEA) estimated the value of UK Biodiversity pollination services at £430 million per year, the benefits for water quality from inland wetlands as high as £1,500 million per year and a climate change induced loss of water between £350 million to £490 million per year (Bateman et al., 2011). The ecosystem service approach uses value assessments as an economic tool for market based regulation and governance (Bateman et al., 2013).

Kallis et al. (2013) quote how this economic valuation has lead to a schism between those who accept that the valuation of nature in monetary terms is a pragmatic choice, and those who reject it on methodological and ethical reasons. The pragmatic choice is inspired by the aim to improve environmental protection

(Spash, 2008). But Kallis et al. (2013) also quote the phenomenon of "the tragedy of well-intentioned valuation", described by Gómez-Baggethun and Ruiz-Perez (2011). To assess whether or not monetary valuation is desirable, Kallis et al. (2013) provide a normative guiding framework.

Several authors underline the importance of value in formulating planning perspectives and priorities (Leinfelder, 2007; Broussard et al., 2008; Kroll et al., 2012; Dewaelheyns et al., 2014b) as the way we value land is at the heart of land use decisions (Foresight Land Use Futures Project, 2011). Especially relevant in the case of the garden complex, Potschin and Haines-Young (2011) state that understanding of the values people assign to particular services and their opinions about trade-offs between these services requires the acknowledgement of the multifunctional character of the places in which decisions are made. As Pröpper and Haupts state (2014), the concise market-based valuation of ecosystem services remains challenging.

The term 'Services' was chosen to label this dimension, since it groups all elements of the ecosystem cascade that are directly related to services: the ecosystem functions providing ecosystem services, these services themselves, and the benefits derived from ecosystem services. Potschin and Haines-Young (2011) already suggested a pragmatic approach by considering terms as final and intermediate services, goods and benefits as thematic labels, since there is no final agreements on terminology yet.

3.2.3 Strategies for the garden complex

The 'Strategies' dimension comprises the search for pathways to realise the strategic value implicitly present within the garden complex. A vital question in adaptive and sustainable planning remains how different planning options, with their related uncertainties and impacts of ecosystem services, can be addressed to enhance the sustainability of our living environments (Niemelä et al., 2010; Niemelä, 2014). According to Egoh et al. (2008), assessments of ecosystem services and their biophysical, economic and social context should be combined with considerations about possibilities and constraints for implementation. Such combination should lead to the development of strategies, implementation and management with the involvement of stakeholders.

Combining the Structures and Services dimension of the garden complex with current and upcoming challenges (like climate change, food security and biodiversity loss) invites to explore the (potential) strategic value of the garden complex. The goal of the 'Strategies' is to positively influence the provisioning of ecosystem services by gardens. This can be done by supporting the biophysical structures and processes and the ecosystem functions, as well as by preventing their degeneration (Figure 2.6).

A domestic garden, hence the garden complex, is a social-ecological system (Barthel et al., 2010; Cook et al., 2012) with an intimate interaction between humans on the one hand and structures and services of gardens. This highlights the importance of social assessments as these provide insights in the perspectives of the owners and beneficiaries of ecological systems that give rise to a service (Cowling et al., 2008). An understanding of how people use the land and ascribe purposes to it is fundamental in identifying how particular land covers might support ecosystem services and benefits (Haines-Young et al., 2012).

As Scott et al. (2014a) remark, an interdisciplinary thinking is necessary, involving a wide variety of actors (e.g. specialists, stakeholders), knowledge systems and cross-sectoral approaches. Private actors can also play their role, as demonstrated by Glass et al. (2013) in Scotland. By co-producing a sustainability assessment toolkit for the management of private upland estates, they clarified the need for behavioral change to be able to embrace the aspects of 'proactive' practice. At the same time, more collaborative attitudes are needed as these would enhance accountability and connectivity across landscapes (Glass et al., 2013). This fits the idea of Steiner (2014) on 'regenerative design', defined as "a collaborative process that enhances life in complex, co-evolving social and ecological systems through intentional action" (Steiner, 2014; page 310).

The search for strategies is mainly embedded in (environmental, multilevel) governance (Lemos and Agrawal, 2006; Paavola, 2007; Underdal, 2010; Folke et al., 2011), social learning (Garmendia and Stagl, 2010; Reed et al., 2010) and social memory (Barthel et al., 2010), adaptive co-management (Olsson et al., 2004; Folke et al., 2011), collaborative and fuzzy planning (Healey, 1997; Healey, 1998; De Roo and Porter, 2007), strategic planning and co-production (Healey, 2004, 2007; Albrechts, 2013), and storytelling and narratives (Throgmorton, 2003; Satterfield et al., 2013).

The disciplines of spatial, environmental and landscape planning and design cover a playing field where the above approaches and disciplines can be integrated. The ecosystem services concept is a rising principle in guiding this spatial and urban planning and management (see e.g. Ahern (2005); Egoh et al. (2008); de Groot et al. (2010); Niemelä et al. (2010); Kroll et al. (2012); Jansson (2013); Lehmann et al. (2014); Niemelä (2014); Steiner (2014)), but it still has to become embedded within everyday landscape planning, management and decision making (de Groot et al., 2010; von Haaren and Albert, 2011; Prager et al., 2012). This remains challenging, among other things because of a potential gap between expertise (being knowledge and understanding of ecosystem services) and implementation in planning procedures (being opportunities to apply this expertise) (Cowling et al., 2008; Daily et al., 2009; de Groot et al., 2010; von Haaren and Albert, 2011; Lehmann et al., 2014). Five challenges are discussed more into detail below, with a reflection to the domestic garden theme. The issue of scale is discussed in paragraph 3.3.

A first challenge is the difficulty of a systematic consideration of ecosystem services. An answer to this challenge is the assessment of the potential of a landscape to provide ecosystem services (Burkhard et al., 2009; Bolliger and Kienast, 2010; Lautenbach et al., 2011; Müller et al., 2011; Kroll et al., 2012). Koschke et al. (2012) developed a framework to generate qualitative estimations of the regional potential to provide ecosystem services. These estimations could serve as a prerequisite to support regional development planning. Lehman et al. (2014) have developed the 'urban vegetation structure type' approach to provide a solid basis for the investigation of diverse ecosystem services. Currently, the limitations of data however largely prevent such assessments for domestic gardens.

A second challenge is the possible interaction between multiple services that are spatially linked. The overview of ecosystem services related to gardens (Figure 1.1, Appendix A) suggests that domestic gardens are multifunctional spaces, where multiple ecosystem services coexist. Interactions between services can be positive (synergies) or negative (trade-offs). Such spatial interdependences between multiple ecosystems form so called 'bundles' of ecosystem services (Bennett et al., 2009; Raudsepp-Hearne et al., 2010; Turner et al., 2014). The study by Haines-Young et al. (2012) estimated trade-offs within such a bundle of ecosystem services for a supportive as well as a degenerative land use trajectory. The work by Vidal-Legaz et al. (2013) focused on trade-offs between the maintenance of two ecosystem services (landscape aesthetics and water supply for human use), and socio-economic development associated with different land use changes. They argue that simulation models, like used by them, may contribute to policy making.

Since the management of multiple ecosystem services across landscapes is considered a key challenge of ecosystem management (Raudsepp-Hearne et al., 2010) and land planning, the ecosystem service bundle approach can be a useful tool for identifying ecosystem service trade-offs and synergies (Bennett et al., 2009; Raudsepp-Hearne et al., 2010). It would allow the improvement of the management of multifunctional landscapes (Kareiva et al., 2007) and to promote multi-functionality by reducing trade-offs and creating synergy (Bennett et al., 2009; Turner et al., 2014). The garden complex allows such an identification of trade-offs and synergies in ecosystem services at the landscape scale.

The third challenge lies in the socio-cultural valuation of ecosystem services. By analyzing ecosystem bundles according to the experiences of individual stakeholders, Klain et al. (2014) found that it is not possible to find spatial or biophysical ES bundles that equally represent the interests of all people. Any bundle of ES is person-specific and shaped by social and environmental contexts. Iniesta-Arandia et al. (2014) made similar conclusions. They found that socio-cultural valuation of ecosystem services is case sensitive as it detects differences in perceptions in different areas, and stakeholder sensitive as it detects differences in perceptions among stakeholder groups. Gardens are places par excellence where cultural valuations of ecosystem services matter.

A fourth challenge in the implementation of ecosystem services in planning is the participation of stakeholders (Koschke et al., 2014). Given the goal of the ecosystem services concept to reconnect the ecological and social systems, participation is integral part of ecosystem research (Menzel and Teng, 2010; Müller et al., 2011; Koschke et al., 2014). Based on their results, Kosche et al. (2014) advocate a stronger focus on stakeholder processes as a key element for implementing ES into planning and management practice, together with efforts to develop standardized methods for ES assessment. In the case of domestic gardens, stakeholders to be involved include individual households as well as national policy makers.

A fifth and final challenge discussed here is the integration of science, professional practice, and stakeholder participation (Ahern et al., 2014). With a focus on adaptive urban planning and design, Ahern (2014) presents a transdisciplinary working method. This method includes experimental design guidelines, monitoring and assessment protocols, and strategies for including urban ecosystem services into urban development. He adopted his 'safe to fail' framework on green infrastructure. Green infrastructure is an emerging theme in the search for ecosystem services provisioning in landscapes dominated by humans (Colding, 2011; Niemelä, 2014).

According to Andersson et al. (2014), green infrastructure in cities can offer opportunities for people to actually become stewards of ecosystem services. This is an interesting insight, since many people fail to link their individual actions to global issues of sustainability and environmental quality (Steiner, 2014). Domestic gardens are explicitly part of green infrastructure (Goddard et al., 2010b; Cameron et al., 2012), and guiding gardeners towards stewardship of garden services is a valuable objective. It could meet the call raised by Folke et al. (2011) to strive for the reconnection of people with the capacity of the biosphere and essential ecosystem services to be sustained.

3.3 The issue of scale

'Scale' refers to the spatial and temporal dimension of phenomena or observations (O'Neill and King, 1998; Millennium Ecosystem Assessment, 2003) and is an important issue in both ecological and social studies (Scholes et al., 2013). Gardens, hence their upscaling to the garden complex, can be considered as 'service providing units' (SPU): the collection of individuals from a given species and their characteristics necessary to deliver an ecosystem service at the desired level (Luck et al., 2009). As stated by Hein et al. (2006), this provisioning of ecosystem services spans a range of ecological and institutional spatial scales. The garden complex is seen as way to bring this range of spatial and institutional scales together. As such, it is considered exemplary for the wide variety of spatial and temporal scales spanned by ecological and social systems and processes (Turner et al., 2000).

The garden complex spans different *spatial scales*, ranging from the garden lot over garden units to the garden complex (Figure 2.5). A linkage can be found with institutional scales or levels of decision making (North, 1990). The lowest institutional scale level includes individuals and households, while the higher institutional scales include the communal or municipal, state or provincial, national, and international level (Hein et al., 2006). This makes the garden complex a layered concept that explicitly brings a multi-scalar perspective into environmental and spatial planning. Kosche et al. (2014) found that the benefits of applying ecosystem services in planning cannot be realized consistently across the different spatial scales and decision-making levels.

The small scales of the 'garden lot' (lowest spatial scale, level of individuals and households) and 'garden unit' (intermediate spatial scale, level of neighborhood and municipality) maintain a connection with the local planning scale (Figure 2.5). This fits the growing attention for 'local identity', 'landscape identity', 'sense of place', and 'area specific development' (Selman, 2006; Bomans, 2011; Allaert et al., 2012; Dewaelheyns and Foré, 2012), in reaction to the loss of associations with places and people by processes of globalization and modernization (Selman, 2006).

According to Niëmela et al. (2014), there is indeed a need for specific and place-based research concerning green infrastructure, but there are equally well broader issues at stake, like the support of biodiversity and adaptation to climate change. The highest spatial scale level of the garden complex introduces the domestic garden in such issues at the global scale. The level of the garden complex corresponds mainly with the provincial, national, and international institutional level. The management for certain ecosystems needs to be coordinated at the landscape scale to optimize their provisioning (Goldman et al., 2007; Samways et al., 2010). For example, the consideration of garden management at multiple spatial scales is necessary to maximize the gardens' potential for biodiversity conservation (Goddard et al., 2010b).

Spatial and environmental planning at the highest scale needs knowledge and cooperation from the lower scales. Decisions at the smallest scale level in the garden lot influence environmental and spatial outcomes at the highest scale level of the garden complex. This phenomenon is generally referred to as the 'tyranny of small decisions' (Odum, 1982; Thompson, 2004) or as 'cumulative effects'. Such local scale changes and decisions, made by individuals, interweave with larger forces of globalization (Terkenli, 2005) and often accumulate to a major impact (Theobald et al., 1997).

Spatial planning more and more seeks to activate local stakeholders for increasing the resilience and adaptive capacity of neighborhoods and simultaneously indicates the need for common collective strategies (Tress and Tress, 2003; Bracke and Van den Broeck, 2012; Dewaelheyns et al., 2014b). At the same time, the cumulative effect phenomena challenge spatial and environmental planning, they remain an insufficiently acknowledged issue (Scott et al., 2014b).

So, an understanding of processes at a particular scale level is insufficient because interactions exist with the larger and smaller scale levels. Cross-scale interactions exert a crucial influence on outcomes at a given scale. These outcomes cannot be predicted with the information solely from the scale under consideration (Scholes et al., 2013): focusing on a single scale level would allow missing these interactions (Millennium Ecosystem Assessment, 2003). The multitude of cross-scale interactions is intrinsic to the garden complex.

Due to the cross-scale interactions knowledge transfers are required between different scale levels (Blaschke, 2006). A garden lot can contribute to values merely relevant at a higher level of scale, while reversely this value can also depend on processes that operate at a higher scale level (Bomans, 2011). Yet, an increase in value at one scale level does not necessarily mean an overall increase in value (Blaschke, 2006). For example, introducing an aesthetic but invasive garden plant may increase the aesthetic value for an individual garden owner, but it does not increase the gardens' value for local biodiversity (Bardsley and Edwards-Jones, 2007). This highlights the importance of fine-scale urban planning policies (Bossu et al., 2014).

The garden complex also spans a range of *temporal scales*, from very short to long term perspectives. Three phenomena are related to the temporal scales of the garden complex.

First, the temporal scales are largely associated with the spatial scales. While goals set for the garden complex have to be considered at the long term, some initiatives at the garden lot pursuing these goals could be taken immediately.

Second, garden management effects could persist in time. For example, it is possible that chemical products used decades ago can still be traced back from soil or water samples.

Third, dynamics related to the housing pathways (Clapham, 2005; Meeus et al., 2013) and lifestyle preferences (Pisman et al., 2011; Pisman, 2012) of individual households changes the design and management of individual gardens over time. Older gardens show the result of sequential regimes of (re)design, use and management. Insights in this temporal change and dynamism are fundamental to an understanding of present patterns and processes (Selman, 2006). In his work on frontiers in urban ecological design and planning research, Steiner (2014) poses that it is essential that designs and plans are no longer considered as fixed and permanent solutions. Instead, they should be perceived as a work that is constantly in process, making change and time key variables of any design and planning initiative.

So, the garden complex spans three spatial scale levels and stimulates a multi- and cross scale spatial and temporal perspective (Hay et al., 2001; Millennium Ecosystem Assessment, 2003). Moreover, also the supply of ecosystem services takes place at various spatial and temporal scales, influencing the value different assign to these services (Hein et al., 2006). This way, the garden complex is situated in the centre of the scale issue in sustainable planning (Botequilha Leitão and Ahern, 2002; Selman, 2006).

4 Garden complex v2.0: the extended version

In the strict sense and within the scope of this dissertation, the garden complex solely encompasses domestic gardens. From domestic gardens it is just a small step to other 'green themes' such as community gardens, urban parks, village greens and rooftop gardens.

So, the strict domestic interpretation of the garden complex used within this dissertation could be broadened to an 'extended' garden complex including other urban green and open land uses like urban parks, allotment gardens, temporary open spaces waiting for construction and pasture for hobby farming (Figure 2.7).

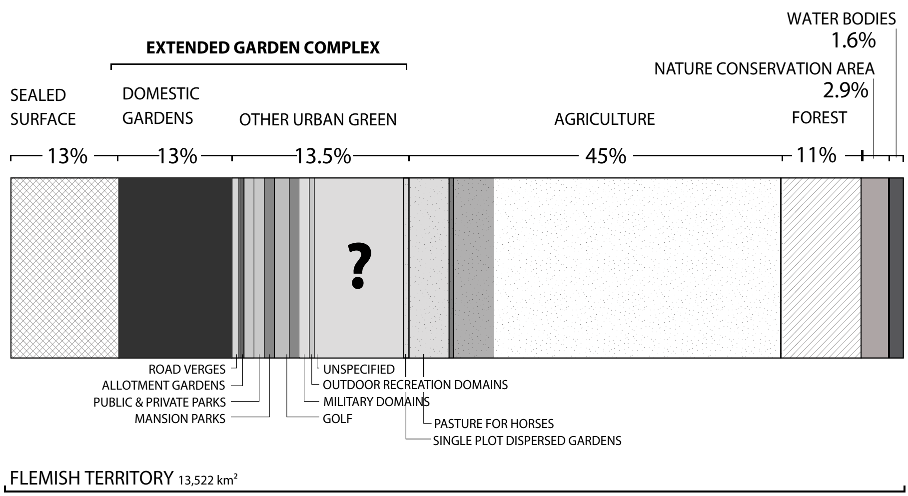


Figure 2.7 The extended garden complex

Domestic gardens are just one element of the wide range of green elements related to urban features. The aggregation of all these green elements covers an important share of the Flemish territory.

Source Author, based on the following data sources: category 'garden' in the topographical land use map (NGI, 2004); 'public and private parks' and 'mansion parks' in the Biological valuation map 2010 (De Saeger et al., 2010); 'military domain' from the Spatial Allocation Plan 2011 (RWO, 2011); 'wateroppervlakken 2006' from Mercator database 2006; sealed surfaces 2011 (De Meyer et al., 2011); golf (WES, 2004); outdoor recreation domain (WES, 2007); forest 2007 (Van der Aa, 2007); conservation area 2007 (http://www.natuurindicatoren.be); road verges through personal communication with Koenraad Van Meerbeek

Based on a wide range of data sources, land use categories were inventoried that can be part of this extended garden complex (Figure 2.7). For comparison, also the traditional land use categories are included: agriculture, nature, forest, water bodies and the aggregated category 'sealed surfaces' (including housing, industrial terrains, (rail)roads).

There are two intriguing findings. First, domestic gardens appear to cover an important part of the Flemish territory (13 %) compared to other traditional land use categories (nature 2.9 %, forest 11 %, sealed surfaces 13 %). Allotment gardens cover solely 0.01 % and the totality of public and private parks cover a mere 1 %. Yet, much of the attention of policy and research concerning 'green' focuses mainly on these allotment gardens and parks, although they cover a minimal fraction of the spatial coverage by domestic gardens.

Second, an important share of the green categories remains unspecified. This means that we are left with an important information gap. Although this dissertation focuses on domestic gardens, this remains an interesting finding.

MAPPING
THE GARDEN COMPLEX

"Search and you will find it – what is unsought will go undetected"

Sophocles


KANKER
UITGEZONDERD

3. FLANDERS, A REGION SPRINKLED WITH GARDENS

"De voorschoot grote tuintjes der Taeye-huisjes geven noch ruimte, noch natuur, maar ersatznatuur in mini-formaat"

Renaat Braem, 1968

This chapter introduces the case study area Flanders and gives an overview of the rise and disappearance of a 'garden program' throughout Belgian housing and spatial policies. The insights from this overview are relevant in a broader geographical perspective.

1 Introduction

This dissertation focuses on the case study Flanders, the northern region of the federal state of Belgium, located in north-western Europe.

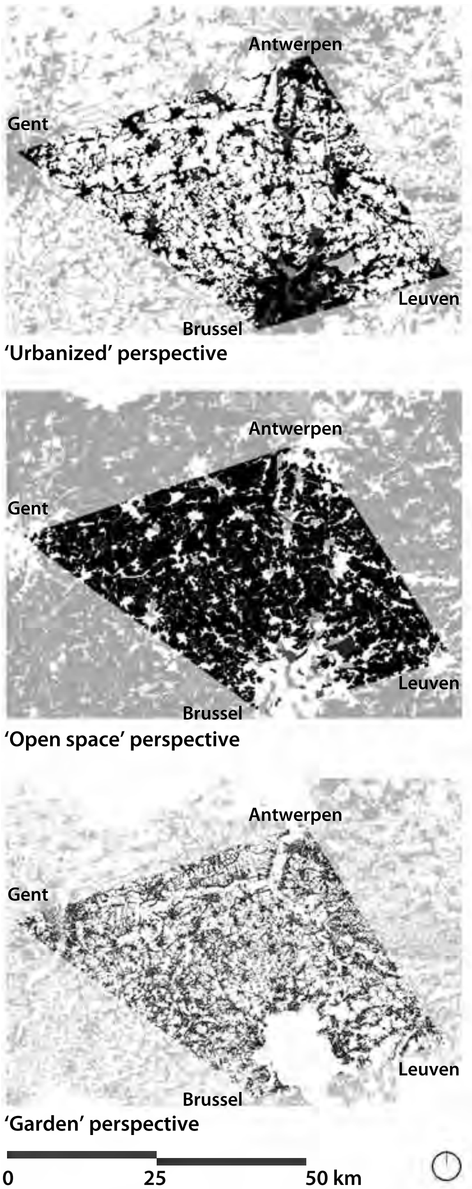
Continuous processes of (peri-)urbanization transformed Flanders into a '*citta diffusa*' (Indovina, 1990; Ryckewaert, 2002): a dispersed and varied landscape with a mixture of urban and rural structures and functions. Flanders is known as a strongly urbanized and highly built-up region, characterized by urban sprawl and fragmentation (European Commission, 2003; Antrop, 2004; Bengs et al., 2006; Kasanko et al., 2006; Verbeek et al., 2014) (Figure 3.1 above). With a population density of 447 inhabitants per km^2 in 2007, it is one of the most densely populated regions in Europe. According to the OECD criterion (more than 150 inhabitants per km^2 (OECD, 2011)) and Eurostat (more than 300 inhabitants per km^2 (Eurostat, 2010)), Flanders is labeled as one metropolitan area. Homeownership is 75 %, a figure that lies far above the European average (De Decker et al., 2010).

According to national statistics, over 25 % of the Flemish area is officially registered as urban, or more specifically as 'built-up', meaning consisting of individual cadastral parcels with a built-up element (NIS, 2011). Looking in finer detail, only 13 % of the Flemish soil is actually physically sealed by buildings and hard infrastructures (De Meyer et al., 2011).

The other fraction of 87 % is considered to be not sealed-off and can therefore be called 'open space' (Dewaelheyns et al., 2014) (Figure 3.1 middle). Open is used here in a vertical perspective as 'not sealed', but these spaces can eventually be fenced or enclosed by built elements.

As a result, Flanders is rich in domestic green. A significant part of the Flemish territory exists out of domestic gardens. According to the topographical land use map (NGI, 2004), about 13 % of the Flemish territory is 'garden-like', including not only domestic gardens but also public gardens and other categories of greenery in the vicinity of built-up elements. (Figure 3.1, below). We will 'distill' the fraction of domestic gardens from this 'gross cover' of garden-like land cover in Chapter 4.

In 2001, a vast majority of the Flemish households (78 %) lives in a single family house with a garden (De Decker et al., 2010). The genesis of much of this garden landscape across the region lies in the Belgian urbanization policies in the 19th and 20th century.



Source Author, based on CORINE land cover data and the topographical land use map, category 'garden' (NGI, 2004)

Figure 3.1
Three perspectives on the 'Flemish diamond'

The 'Flemish diamond' is not as much dominated by urban infrastructure as one tends to think. The perspectives on 'open space' (middle) and 'gardens' (under) place the urbanized diamond (above) in a different light. The urbanized view represents the artificial, sealed surfaces in black and agricultural areas, forest and semi-natural areas, wetlands and water bodies in white. The open space perspective inverts this symbolic.

In what follows I briefly discuss the genesis of Flemish gardens. Domestic gardens are an indivisible part of the housing ideal of a 'single family house with garden'. They can be traced back to the 19th century when policies instigated private housing development in an already dense settlement pattern (Dewaelheyns et al., 2014; van de Weijer, 2014).

To understand the genesis of domestic gardens in Flanders, a literature review is conducted. Studies on housing and spatial policies in Belgium (and Flanders) were reinterpreted from the perspective of the domestic garden. This reinterpretation leads to a better understanding of the position of the garden in past policies and in the current spatial structures of Flanders. For this purpose, a selection of works has been consulted. Five core works form the backbone of this review, while 14 supporting works allowed more insights in the general planning context (Figure 3.2).

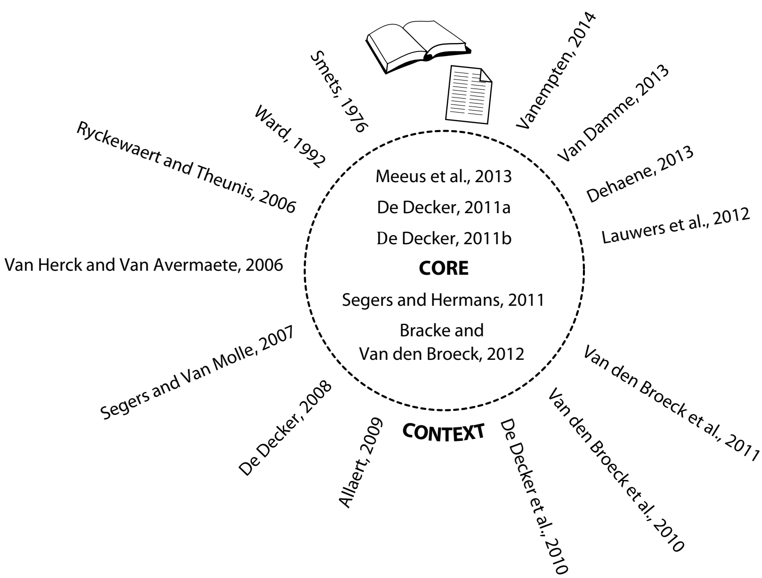


Figure 3.2 Source used for the literature review

Five core works (including a paper and book chapters) and 14 supporting works (including papers, book chapters, books and dissertations) formed the basis of a literature review on the position of the garden in past planning policies and in the current spatial structures of Flanders.

2 The rise and disappearance of a 'garden agenda' in Flemish policies

Five phases can be distinguished in the development of the 'house + garden' model in Flanders (Figure 3.3).

2.1 Phase 1: 'A house with a garden' as an all-round solution at the end of the 19th century

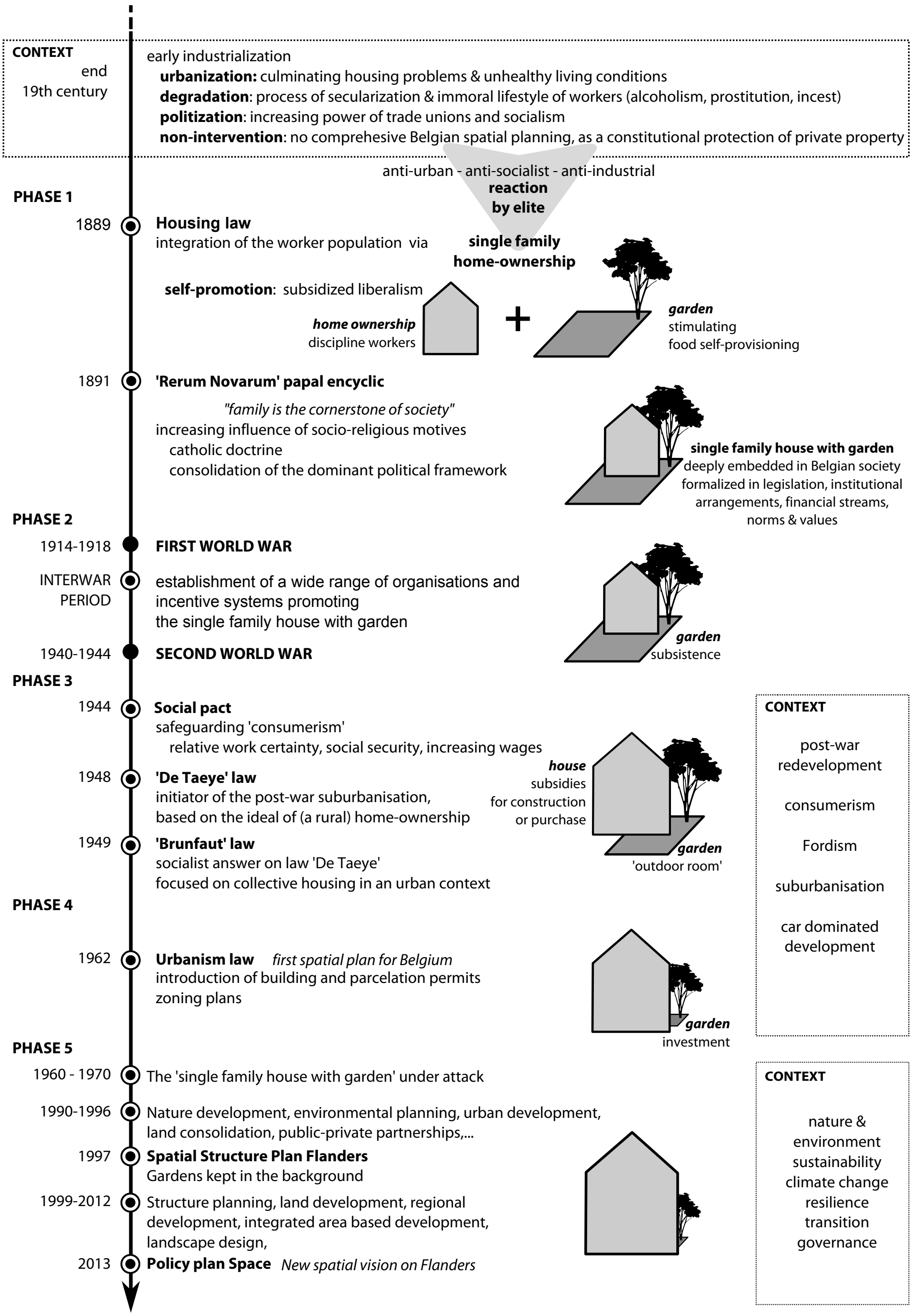
The rise of the 'house with a garden' ideal was embedded in broader political and policy goals. At the end of the 19th century Belgium experienced an early and fast industrialization. This resulted in culminating housing problems, unhealthy living conditions and secularization of the workers class. Especially the dominant catholic elite, traditionally empowered in rural areas, was concerned with unhealthy living conditions, the loss of moral control and the rise of socialist unions (De Decker, 2008, 2011a; De Decker, 2011b).

In reaction against these evolutions, the catholic elite adopted an anti-urban, anti-industrial and anti-socialist political culture. Since repressions did not work, another solution was sought and found in the housing model of a single family house with garden. This housing ideal proved to be an all-round solution. The promotion of home ownership of a 'single family dwelling with garden' amongst the working and lower-middle classes was seen as a way out of the culminating housing problems and unhealthy living conditions (De Decker, 2011a). The garden was meant as a safety net to counteract periods of industrial unemployment: it allowed the production of fruit and vegetables at home (Meert, 2000; De Decker, 2011a).

Before the blessings of post-war prosperity, having or renting a garden was vital for households to provide in their food (De Decker, 2011a). However, figures on the historical food productive value of domestic gardens seem to be unavailable despite intensive search. At the same time, policy took the liberty to educate the workers and lower-middle class. The house with a garden model was used as an instrument for stabilizing and disciplining the workforce. Workers that needed to pay off a loan had to keep their job (Smets, 1976; De Decker, 2011a).

Figure 3.3 Historical overview of the rise and disappearance of the garden in Flemish policies

Five phases can be distinguished in the development of the 'house + garden' model in Flemish territorial policies. From a rise at the end of the 19th century, the garden nowadays almost disappeared behind the house.



Source Author, based on the literature review

The program behind the allotment gardens, mainly social initiatives established for the poorest amongst the workers, was rooted in the same context. Also here, food subsistence was a priority for the influential Catholic Church, one of the necessities to stop the migration of people from the countryside to the cities (and even evoke a return to the countryside) (Segers and Van Molle, 2007; Segers and Hermans, 2011).

The 'house + garden' model was formalized by the first Housing Law of Belgium in 1889. This law strived for the integration of the worker population via (private) housing. Single family home-ownership continued to be stimulated as a means to discipline workers while at the same time allowing food self-provisioning. The policy option of private housing development moreover fitted the prevailing spatial policy of 'non-intervention' (De Decker, 2011b; De Decker, 2011a) as a constitutional protection of private property (De Decker, 2011a).

The organization of housing centered around the family was a pro-catholic and anti-socialist measure, that was reinforced by the papal encyclical letter 'Rerum Novarum' in 1891. This letter idealized the family as the cornerstone of society (Meeus et al., 2013). This statement fitted well the doctrine of the catholic party and stimulated the Christian workers' movement to promote the house with a garden model. Gardens expressed the ideal of the family as the cornerstone of society and contributed strongly to the consolidation of the dominant catholic political framework (De Decker, 2011b; De Decker, 2011a).

Meanwhile in the UK, Ebenezer Howard launched the concept of the 'garden city' in 1989 with his book '*To-morrow: a Peaceful Path to Real Reform*'. His initial idea of the garden city offered a comprehensive vision of social and political reform, by transforming the existing highly concentrated and unhealthy cities into a decentralized but closely interrelated network of garden cities. These were collectively called 'the social city' (Ward, 1992): the garden city idea was rooted in Howard's interest in social change rather than in physical forms (Aalen, 1992). Howard's book was republished in 1902 in a revised version entitled 'Garden cities of To-morrow' (Howard, 1970).

In 1903, his theory was put into practice by the development of the first garden city, Letchworth (Ward, 1992). However, some key principles like communal land ownership were eroded due to the need for compromises (Ward, 1992). As such, the social ideals behind the garden city idea became liberalized in the reality of Letchworth (Korthals Altes, 2004).

The 'garden city' idea arrived in Belgium only after the First World War (Smets, 1976). According to Smets (1976) the garden city idea had no direct influence on the development of the 'single family house with garden' housing model. Already before the First World War, this 'house + garden' ideal became deeply embedded in society. It was formalized in legislation, institutional arrangements, financial streams, norms & values (De Decker, 2011a; De Decker, 2011b; Meeus et al., 2013).

2.2 Phase 2: paving further the way for private homeownership during the interwar period

During the interwar period, the 'house + garden' model became a self-fulfilling ideology with food production as a major function (De Decker, 2011a). Gardening was a useful supplement to the household income, also for households living in the countryside (Meert, 2000; Meert et al., 2005). Especially the economic crisis at the end of 1920ies gave a boost. A papal encyclical letter 'Quadragesimo Anno' (1931) reconfirmed the importance of owning a house with a garden and reinforced the catholic dominance.

The significance of the imaging of the garden should not be underestimated. Both socialists and catholics considered a 'return to the field' as the solution to raise the population morally, economically and physically (Meeus et al., 2013). This 'house + garden' ideal, inspired by a rural idyll and a reactionary attitude toward growing cities, was deliberately exploited by policy (Meeus et al., 2013). A number of civil society organizations and incentive systems were established to promote and facilitate ownership of a house + garden (preferably in the countryside) amongst the working and lower-middle class (Table 3.1). The 'Nationale Maatschappij van Kleine Landeigendommen' (National Agency for Small Rural Properties) founded in 1935 was such an organization devoted to the realization of the Belgian housing model (Meeus et al., 2013). This agency aimed at bringing people back to the countryside while the garden would provide an extra income through kitchen gardening or keeping small live stock.

Belgian gardeners were guided and supported by a wide range of educational initiatives, including the mobilization of status and identity (Meeus et al., 2013); cultural training (De Decker, 2011a; Segers and Hermans, 2011; Meeus et al., 2013) and imaging in television series (Emmery, 2009). Also the allotment associations and the Ministry of Agriculture launched several educational initiatives (Segers and Hermans, 2011). These were a reaction to the unwillingness of allotment users to embrace diversification and modernization in horticulture.

In 1916 Victor Stappaerts published the book ‘Hoe eenieder kan hovenier worden’ (How anyone can become a gardener) (Stappaerts, 1916). The booklet ‘Het hofje der planters’ (The planters’ Garden) by P. E Backer, firstly published in 1917, was the most widespread and best-known gardening guide in Belgium during the first half of the 20th century (Paris, 1922). From 1930 onwards, the members’ magazine ‘De Volkstuin’ (‘The allotment garden’) played an important role in the dissemination of knowledge and information amongst allotment gardeners.

Also the Ministry of Agriculture took initiatives. Between 1921 and 1922, they organized more than 1,000 classes for amateur horticulturists in the provinces of Liège and Hainaut alone. Together with the allotment boards, the ministry also developed model gardens from the 1920s. Inspectors from the Allotment Association visited the allotments to give both additional recommendations and warnings (Segers and Hermans, 2011).

The ‘Nationale Maatschappij voor Goedkope Woningen en Woonvertrekken’ (National Agency for Cheap Housing and Living rooms), founded in 1919, was an agency for social housing (Smets, 1976). Already after the First World War, social housing was preferable realized according to the ‘Garden Neighborhood’ idea.

Table 3.1 Historical initiatives to promote home-ownership and the ideal of a house with garden

During the interwar period and after the Second World War, several organizations and incentive systems were established to facilitate and promote ownership of a single family dwelling with garden.

Source De Decker (2011a); De Decker (2011b); Meeus et al. (2013)

Year	Promotion and facilitation initiatives to promote home-ownership
1891	Papal encyclic ‘Rerum Novarum’
1919	Foundation of the ‘Nationale Maatschappij voor Goedkope Woningen en Woonvertrekken’ (National Agency for Cheap Housing and Living rooms)
1922	Incentive system Moyersoen
1928	Official recognition of ‘Woningfonds van de Bond der Kroostrijke Gezinnen van België’ (Housing fund of the association of large families in Belgium) as a credit company for financing housing for large families.
1931	Papal encyclic ‘Quadragesimo Anno’
1935	Foundation of the ‘Nationale Maatschappij van Kleine Landeigendommen’ (National Agency for Small Rural Properties)
1944	Social Pact
1948	Law ‘De Taeye’
1949	Law ‘Brunfaut’

This garden neighborhood ideal was adopted by the 'Nationale Maatschappij voor Goedkope Woningen en Woonvertrekken' since it matched well the suburban housing style of the higher classes. An example is the neighborhood Le Logis-Floréal in suburban Brussels, initiated in 1921-1922 and designed by Van der Swaelmen. But a garden city fully developed according to the English model was never realized in Belgium (Smets, 1976).

Meanwhile in the UK, Welwyn Garden City was launched, but although it became a complete garden city, it got lost in-between the major New Town developments around London (Ward, 1992). By then, the garden city idea had been overtaken by social reality (Korthals Altes, 2004). Around the world, the garden city idea became transformed to designs of 'garden neighborhoods': a light version of the original garden city idea (Smets, 1976; Hardy, 1992). Still, Hardy (1992) believes that the many hybrid versions reinforced the vitality of the original garden city concept.

2.3 Phase 3: continuing on the same path after World War II but losing sight of the garden

After the Second World War the socio-democratic vision on Belgian society shifted towards a more neo-liberal vision (Van den Broeck et al., 2010). Due to an increase in prosperity, improved social security and government subsidies for private house construction the housing ideal became reality for the majority of the people (De Decker, 2011a).

Multiple laws and coupled incentive systems were established that took advantage of the enchantment of owning a house with a garden (Table 3.1). The main motivation was the stimulation of the consumerism way of life as a way to boost economy after the Second World War (Meeus et al., 2013). The private initiative in housing became favored above government interventions (Smets, 1976). Suburbanization and car dominated development became dominant planning discourses in territorial organization.

The Social Pact, established directly after the Second World War in 1944, aimed at safeguarding consumerism by ensuring a relative work certainty and social security, and by increasing wages (Meeus et al., 2013). This should allow the workers and middle class to contract a loan. The catholic inspired law 'De Taeye' of 1948 provided subsidies for the construction or purchase of an own house, preferably at the countryside.

The modus operandi of this law proved to be extremely successful: between 1950 and 1970 about 36 % of the new housing development was built by individual households using the De Taeye subsidies (Ryckewaert and Theunis, 2006).

Its socialistic equivalent was established in 1949 with the law 'Brunfaut', inspired by the socialist political party. The law Brunfaut focused on collective housing and allotments in an urban context. Small neighborhoods inspired by the garden city model of Howard (1970) were developed here and there thanks to a financial division of tasks between the public and private sector (Smets, 1976; Ryckewaert and Theunis, 2006; Allaert, 2009).

Both laws resulted in a well-oiled investment machine, initiated by the government but functioning fully on private capital and initiatives (Ryckewaert and Theunis, 2006). As such, the facilitation of private homeownership amongst the workers and middle class became strongly embedded within the broader institutional, political and macro-economic structures. Meanwhile, the number of allotments and gardeners fell sharply from the 1940s onwards. From 400,000 members in 1943 membership dropped to 95,000 members in 1950 (Segers and Hermans, 2011).

Until now, two strategies remained. First, since the end of the 19th century Belgian policy mainly mobilized the private household as the elementary developer of the territory. Second, a wide range of organizations was established to steer these private initiatives by promoting the rural idyll and enchantment of owning a house with a garden amongst the workers and middle class. These organizations were pivotal between social and territorial policies and private households.

2.4 Phase 4: disappearance of the garden theme

In the early 1950s, development became more and more rooted in Fordism, an economic expansion model based on mass production and consumption and with a strong intervention of the government (Bracke and Van den Broeck, 2012).

In 1962, the first national law on urbanism was approved and laid the basis for the first spatial plan for Belgium: the 'Stedenbouwwet' (Urban Planning Act). One of the main goals was to safeguard the natural assets of the nation: "*'s lands natuurschoon ongeschonden bewaren*" ("*to preserve the country's natural wealth unharmed*") (Albrechts and Meuris, 2000; Lauwers et al., 2012). Policy took a technocratic option by applying a zoning approach. This approach divided the territory in different functional zones or land use categories. This planning approach is nowadays called blueprint or object-oriented planning (Allaert, 2009).

The Urban Planning Act was at many levels a compromise between the goals of pre-war trained planners and urbanists, owners associations and building sector and the economic sector (Van den Broeck et al., 2010). The urbanism law also introduced a restrictive system with building and subdivision permits to prevent undesired developments. This restrictive system was rooted in the right of ownership according to the Belgian civil law and the constitution (Van den Broeck et al., 2010). Importantly, gardens lost their identity in the urban zoning category. They were only very implicitly acknowledged within the category 'housing area with rural character' (woonzone met landelijk karakter).

Although the prevention of suburbanization and the protection of open space were explicit goals, in reality open spaces were placed in a passive and inferior position (Vanempten, 2014). The definition of the zoning plan indirectly assigned a market value to each square meter of the Belgium territory, determined by the allocated use. Allocated agricultural land had a much lower market value than land allocated for housing development.

Many private owners started to aim for profits from transactions of real estate and land division, fueling the exposure of the territory to land speculation (Ryckewaert and Theunis, 2006; Van den Broeck et al., 2010; Meeus et al., 2013). For individual households, the garden became a form of land speculation. Individuals bought a neighboring building lot as extra garden space or a housing parcel large enough to be subdivided later, according to the existing local zoning regulations. It was speculated that this extra land might be built upon by children or grandchildren, or it could be capitalized when selling the house (van de Weijer, 2014).

So, in practice the Urban Planning Act of 1962 was mobilized to receive allotment permits by owners, project developers and architects. The financial and economic functioning of Belgium was grafted upon the issuing of mortgages and private housing construction in an historically embedded 'ownership society' (Dehaene, 2013). This fitted the policy support of consumerism. In the US, the suburban dwelling became one of the best selling 'products' ever (Meeus et al., 2013). The focus on construction and land speculation may help to explain the disappearance of the garden to the background of territorial policies. The garden became merely an appendage of the economic valorization of land through the construction of housing and infrastructure (Pregill and Volkman, 1999).

In the second half of the 20th century residential development was triggered even more by increased affordability and mobility. The cultural interpretation of the domestic garden evolved from a strict utility perspective that was part of a common food security goal, to a functioning for recreation and display in a strict privatized context. The Flemish 'house-with-garden' unit became an object of consumption rather than an instrument of subsistence (De Decker, 2011a). It can be assumed that at this moment in time, gardens ceased to be of strategic interest.

2.5 Phase 5: new incentives for a strategic position of the garden complex?

From the 1960s onwards, several critiques arose on the Belgian spatial policy and the model of a single family house with a garden. From a spatial perspective, the concern was raised that there were limits to the Belgian way of urban development. From the perspective of an emancipator ideal, reactions arose against the effects of unrestrained building by private initiatives (Meeus et al., 2013). The protest by Renaat Braem with his essay 'Het lelijkste land ter wereld' (The ugliest land of the world) in 1968 (Braem and Strauven, 2010) and by Karel van Isacker (1971) with his essay 'Het land van de dwazen' (The land of fools) in 1976 are just two examples.

Nature and environment became more prominent themes again in the 1970s (Bracke and Van den Broeck, 2012). The oil crises of 1973 and 1979 initiated the end of Fordism in Flanders. This gave room for environmental organizations. There were experiments with a process oriented and emancipatory way of spatial policy with much attention for the natural environment. Yet, the sectors of housing, industry and infrastructure managed to create an overstock of building land at the final approval of the zoning plans (1976-1980). This refueled the consumption of space for development (Bracke and Van den Broeck, 2012).

During the 1980s, an economical crisis set the stage for a neoliberal planning approach (Allaert, 2009; Bracke and Van den Broeck, 2012). The aim was to develop Flanders as a high-tech region. Public-private partnerships were launched and spatial policy evolved towards a tolerant permit system, focusing on individual interests. Environmental policy became formalized and the sectoral policy on nature became integrated. As such, Fordism became replaced by selective deregulation, privatization, and spatial decentralization, based on a trust in the free market (Bracke and Van den Broeck, 2012).

Sustainability came in the picture in the 1990s spurred by the conference in Rio in 1992 (Allaert, 2009; Bracke and Van den Broeck, 2012). Mid 1990s the interest for regional development was reflected in 'process planning', mainly aiming at a social and economic development of the territory, but with a growing attention for the environment (Bracke and Van den Broeck, 2012). New insights in landscape ecology fueled a new spatial strategy for nature development crystallized in the concept of ecological networks.

These new concepts of sustainability and ecological networks were picked up by spatial planners. During the 1990s the Spatial Structure Plan Flanders (Ruimtelijk Structuurplan Vlaanderen, RSV) was drawn up (Ministerie van de Vlaamse Gemeenschap, 1998). Using the 'structure planning' approach, compromises were made between economy and open space, and between agriculture and nature.

The Spatial Structure Plan Flanders briefly mentioned gardens as a part of the regional ecological network that has to be maintained and developed (Ministerie van de Vlaamse Gemeenschap, 1998), but how this was to happen was not made explicit. To preserve the remaining open space, the permit system became more restricted. The impact of these restrictions on a multitude of private properties provoked much protest (Bracke and Van den Broeck, 2012).

During the last decade, the translation of the Spatial Structure Plan Flanders from policy to practice increased the attention for integrated area-based development (Bracke and Van den Broeck, 2012) with an action-oriented approach, called 'integrated strategic planning' (Allaert, 2009). Examples are river basin plans, environmental policy plans, and rural development plans. Also the concept of ecosystem services is gaining attention. The participatory development of an area-based vision for De Wijers was a first pilot project in Flanders exploring the possibilities of the ecosystem services concept for planning (Ulenaers et al., 2014).

In the last two years, a new debate was launched about reshaping once more the Flemish planning system. The Policy Plan Space presented in the 'Groenboek Ruimte' ('Greenbook Space') focuses on key issues of sustainability and resilience within the frame of the metropolitan region (RWO, 2012). Several forums were launched to discuss on this Policy Plan.

In one of these forums, Coppens et al. (2014) (page 61) propose 'strategic alliances' as "*innovative coalitions at the system level, aiming at innovative uses of space that could lead to a more sustainable and resilient regime*". Such alliances could operate under the guideline of 'territorial pacts' linked to places and localized issues (Coppens et al., 2014) (page 63).

These strategic alliances and territorial pacts fit the concept of self-organization, launched by Boonstra and Boelens (2011) in the context of urban development. Self-organization is based on the idea that an active and involved society should not only bear shared responsibility, but can also contribute through shared initiatives.

Direct attention for gardens is still absent in these recent planning theories and discourses, or at the most present in a rather negative way by considering gardens as part of land consumption. Despite the opportunities offered by the sustainability concept and the idea of self-organization to recruit gardens again in territorial development, the positive sides of the domestic garden stock are mainly ignored. Calls are still raised to revise the Flemish housing culture, giving ample space and freedom to individual households. Transformations towards more collective housing models are found within the pilot projects 'collective housing' of the Vlaamse Bouwmeester (2014). The study of van de Weijer (2014) explores the potential of Flemish low-density, dispersed residential neighborhoods for densification and transformation in line with contemporary housing standards and demands.

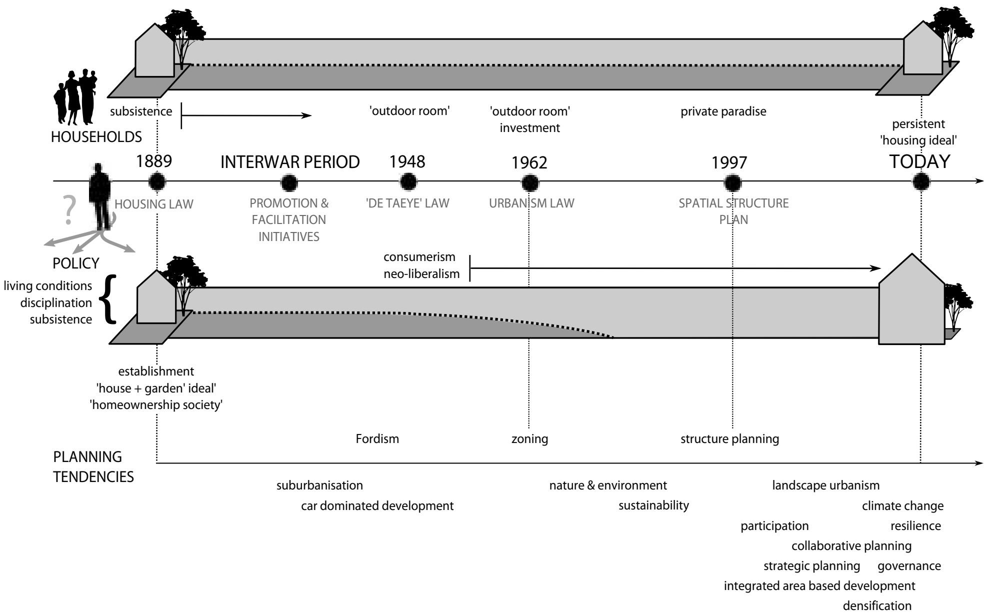
In the international context, similar planning tendencies can be noticed like collaborative planning (Healey, 1997) and landscape urbanism (Waldheim, 2006). In all such planning models, a central role could be given to domestic gardens and the garden complex.

3 A well-established private but forgotten policy garden ideal

Policy attention for the domestic garden disappeared almost unnoticed. At the launch of the 'house + garden' model in 1889, both the garden and the house were equal parts of a unity. Throughout history, the macro- economic and institutional formalizations and embodiments increasingly placed the constructed element, the house, on the fore (Figure 3.4).

Until today the deliberate policy promotion of the single family house with a garden leaves its marks in the landscape and in the institutional and macro-economic organization of Flemish society (Figure 3.5). The ideal of owning a house with a garden stays strongly embedded within the 'dreamscape' of Flemish families (Pickery, 2004; De Decker, 2011a).

Time after time, studies on Flemish housing preferences demonstrate the persistence of this ideal of a house with a garden (Verhetsel et al., 2004; Elchardus and Roggemans, 2010; Bomans et al., 2011). Being or becoming a homeowner of a house with a garden is integral part of the way of life for a Belgian household (De Decker, 2011a) and part of a lifestyle (Pisman et al., 2011). While the garden shifted to the background in the perspectives of policy, it still is the ultimate place of freedom for private households.



Source Author, based on the literature review

Figure 3.4 Synthesis of the garden agenda of policy and households

While the garden remains part of a persistent housing ideal of households, originally launched by the government, it disappeared from sight of territorial policies from the urbanism law onwards. Today, the garden complex could fit within several of the contemporary planning tendencies.

Figure 3.5 The cumulative effect of the garden agenda in policy

The gardens are not the first point of attention: the houses pop-out first. Spatial and urban policies gave opportunities to households to realize the dream of owning a little paradise. However, the collective result of these individual actions is at odds with the policy motto of 'preserving the country's natural assets', what was the basic objective of the same policy.

Source @hannes_BHC from uglybelgianhouses.tumblr.com/

4 From gardens in Flanders to gardens worldwide?

Whilst Belgium and its regions may be rather unique because of (i) historical political choices in favor of a garden and (ii) a housing policy with liberal rights of ownership, four analogies are found with suburban evolutions in other regions as presented by Meeus et al. (2013). These include i) the influence of the macro-economic logics of suburbia, e.g. stimulating consumerism way to boost economy; ii) the foundation in a kind of 'rural idyll', e.g. the garden as a place to produce the own food and to relax with the household; iii) the cracks in this idyll due to the degradation of spatial quality by private housing; and iv) issues of governing an area with an unclear orientation towards city or countryside.

Domestic gardens are a global theme exceeding the borders of the Flemish case studied in this dissertation. They exist all over the globe, in all continents and several cultural contexts. Looking from a perspective of the developed world, the functioning of domestic gardens has shifted from food production to multi-functionality. Yet, many gardens in developing countries worldwide still function in the context of food security and subsistence (Marsh, 1998; Landon-Lane, 2004; Batello et al., 2010; FAO, 2012). It is this subsistence logic that historically paved the way for the current Flemish garden complex. As such, Flanders can be inspiring for other regions in the world.

Chapter 4 is based on

Dewaelheyns, V., Rogge, E. , Gulinck H., (2014). Putting domestic gardens on the agenda using emprirical spatial data. The case of Flanders.
Applied Geography 50, pp. 132-143

The presented research was conducted in 2008.

Source: digital orthophotos, mid-scale, colour, province Vlaams-Brabant, flight season 2007 (AGIV)

4. THE SPATIAL FOOTPRINT OF THE GARDEN COMPLEX

"Not everything that can be counted counts,
and not everything that counts can be counted"

Einstein

This chapter focuses on the first objective to map the structures of the integral stock of domestic gardens. The goal is the collection of spatial baseline data about the coverage by domestic gardens.

1 INTRODUCTION

Urban and residential fabric is usually perceived as a mosaic of buildings, roads and artificially covered areas (Gill et al., 2008). Yet a closer look behind this urban façade confirms the existence of thousands of domestic gardens (Gaston et al., 2005a; Gaston et al., 2005b; Smith et al., 2005; Loram et al., 2007) differing in size, composition, use and management. Domestic gardens are beyond the scope of land use statistics, spatial and green structure planning and environmental policies (Thompson et al., 2003; Perry and Nawaz, 2008). Main reasons are their private and small-scale character (Phillips et al., 2008; Van Delm and Gulinck, 2011) and lack of data. As a consequence, the value of domestic gardens as a strategic land use remains largely unquestioned.

Detailed information on the stock of domestic gardens is needed to develop policies that include domestic gardens. We consider spatial data as an entry point for bringing the theme of domestic gardens on the agendas of research and policy. Such data will allow the demonstration of the spatial and strategic significance of domestic gardens in relation to the more traditional and better acknowledged land use categories. It will also allow a better assessment of the environmental impacts and the support of ecosystem services by domestic gardens at a regional scale.

Since regional spatial data on domestic gardens is scarce, a mixed methodology was developed that elaborates further on the limited data available. This research aims to collect data on the available stock of garden area and its spatial characteristics for Flanders, the northern region of Belgium. By placing the results in the broader context of densification, we want to start a debate on the strategic significance of domestic gardens.

1.1 In need for new perspectives on domestic gardens?

The unsealed and green characteristics of domestic gardens invite to consider them as strategic land use units. Although scientific literature on gardens is scarce in comparison to literature on forests, nature conservation areas and public parks, it provides substantial information on the ecological, social and economic characteristics, functions and services of domestic gardens (Appendix A).

Positive effects of gardens on well-being and physical health are described (Dunnett and Qasim, 2000; Milligan et al., 2004; Clayton, 2007; Gross and Lane, 2007) as well as their role for biodiversity (Daniels and Kirkpatrick, 2006; Tratalos et al., 2007; Goddard et al., 2010). Also economic relevance (Dunnett and Qasim, 2000), organic waste processing (Barr et al., 2013; Dewaelheyns et al., 2013) and home food production (Niñez, 1987; Pandey et al., 2007; Alayon-Gamboa and Gurri-Garcia, 2008; Siviero et al., 2011; Calvet-Mir et al., 2012; Reyes-García et al., 2012; Taylor and Lovell, 2012) are of general interest. Concerning cultural services, gardens are a resource of well-being, physical health and exercise (Ousset et al., 1998; Milligan et al., 2004; Gross and Lane, 2007; van den Berg et al., 2010) and spiritual places (Martin et al., 2004; van den Berg and van Winsum-Westra, 2010; Mazumdar and Mazumdar, 2012).

Gardens also have a role in global challenges like climate change. Water use (Syme et al., 2004; Breyer et al., 2012) and infiltration (Verbeeck et al., 2013), greenhouse gas emissions from lawn fertilizer usage (Howarth et al., 2002; Kaye et al., 2006; Bijoor et al., 2008; Lorenz and Lal, 2009; Livesley et al., 2010; Trudgill et al., 2010), and the storage of carbon by garden soils (Groffman et al., 2004) are a few climate related aspects. For a review on the contribution of the domestic garden to urban green infrastructure, we refer to Cameron et al. (2012).

1.2 Domestic gardens in urban development and spatial planning

The origin of domestic gardens relates strongly to the history of urbanization. In many languages the words for 'garden' refer to the act of enclosing outdoor space (Turner, 2005). The first gardens appeared when early settlements and cities started to develop (Niñez, 1987; Pregill and Volkman, 1999; Turner, 2005) and gardens and urbanization evolved in relation to each other. In fact, Tuner (2005) states that many of the world's best-designed cities have been inspired by garden concepts. In the 19th and early 20th century, several housing and city models were developed based on the social and ecological benefits of both public and private green, for example the 'Garden City' of Ebenezer Howard (1970) and the 'Lobe City' model of Tjallingii (1995). Improving the urban living quality was thereby a main argument. The promotion of gardens has even been explicit in the development of the garden cities Letchworth and Welwyn in Britain (Pregill and Volkman, 1999) and by the promotion of the housing model of a single-family house with a garden in Belgium (Van Herck and Van Avermaete, 2006; De Decker, 2011) (Chapter 3).

The total area of domestic garden increases by both planned and unplanned urbanization processes. Residential development is often accompanied by increase of the garden area (private or collective). Also unplanned and small-scale non-agricultural processes lead to an increase of garden area in peri-urban and rural areas. For example the re-use of former agricultural buildings as bed & breakfast or wellness centre (Verhoeve et al., 2012) is often accompanied with an increase of garden area. But the increase of garden area is not only a consequence of housing. Gardens themselves may be an object of investment and restructuring (Paquette and Domon, 2003; Phillips et al., 2008). For example, gardens in the countryside or peri-urban areas are expanded by annexing (a part of) an adjacent agricultural parcel to a garden. Such autonomous processes (Antrop, 1998) are often deviant from land use policies and hard to grasp without empirical data.

In reaction to some undesirable effects of the continuing urbanization of open space like increased fragmentation and high mobility costs, a 'sustainability-turn' appeared in planning theory (Berke, 2002; Atkinson-Palombo, 2010). Concepts like 'smart growth', 'new suburbanism' and 'retrofitting' proclaim the increase of residential densities in both new-growth areas and existing neighborhoods as a solution for the space consuming effects of sprawl (Filion, 2003; Downs, 2005; Dunham-Jones and Williamson, 2009; Atkinson-Palombo, 2010). Horizontal densification models aim essentially at the infill of remaining open space in between housing. As such, the area occupied by domestic gardens is considered as land stock for housing development (Sayce et al., 2012; Dewaelheyns et al., 2014), a phenomenon commonly referred to as 'backland development' or 'garden grabbing' (Goode, 2006; Davies et al., 2011).

The long-term effects of densification initiatives are not known yet (Preuss and Vemuri, 2004; Colding, 2011), neither are the full range of related aspects. For example from the perspective of biodiversity, Olive and Minichiello (2013) state that smart growth programs have not yet taken seriously into account the recovery of endangered species. As densification programs are likely to be realized at the expense of the domestic garden area and their associated value (for example for biodiversity, food production and climate adaptation and mitigation), it should be clear what the effects of densification on these functions would be.

1.3 Spatial data on domestic gardens

Gardens are often not represented by traditional mapping approaches (Gill et al., 2008). As such, there are only a handful of studies that focus on the spatial footprint of domestic gardens. Perry and Nawaz (2008) and Mathieu et al. (2007) point out that little information is available about the extent of individual gardens. Nevertheless, several studies discussed in Chapter 1 (par. 1.1.1) confirm the spatial importance of gardens (Gaston et al., 2005b; Soini, 2005; Loram et al., 2007; Mathieu et al., 2007; Tratalos et al., 2007; Van de Voorde et al., 2008; Seburanga et al., 2014). These studies essentially deal with urban domestic gardens, although gardens are also an important land use component in peri-urban and rural areas (Marco et al., 2008). Because of their focus on urban areas, none of the above studies sufficiently informs about the regional spatial coverage and distributions of gardens. This limits a full appreciation of strategic values of the total garden area at a regional or national level.

1.4 Research objectives

From a spatial perspective, domestic gardens can be considered as consumers of open space as well as land stocks for housing development. Surprisingly little information is available on the spatial footprint and characteristics of domestic gardens. The overall goal of this research is to make the domestic garden theme analyzable by collecting baseline data about the spatial coverage by domestic gardens. The focus lies on the available stock of garden area and its spatial characteristics.

The research questions are:

> What is the integrated area of the domestic gardens in Flanders, i.e. what is its spatial footprint?
>
> How are these gardens distributed?

Future research focusing more in-depth on structures of the garden complex (e.g. area of sealed surfaces, vegetation structure types, etc.) can build further on this.

We developed a mixed methodology to measure the spatial footprint of domestic gardens. This methodology involves the improvement and update of an existing land use map by using empirical data. The empirical data is collected by digitizing domestic gardens and houses from orthophotographs. The analysis of the obtained spatial data focuses on three aspects: coverage, distribution and growth of domestic garden area. Coverage includes both the size of individual gardens and associations with building types as well as the total garden area in Flanders. Distribution gives a more detailed image of different concentration areas of gardens in Flanders, while growth focuses on the evolution of garden area over a period of 15 years.

2 Data and methodology

The topographic land use map, published in 2004 by the National Geographical Institute in Belgium (Nationaal Geografisch Instituut (NGI), 2004), provides the basis for this research. This land use map was produced by an on-field interpretation and completion of black and white aerial photographs (scale 1:50.000, production dates ranging between 1995 and 2003) using a field protocol from 1991. The NGI land use category 'Garden' not only includes domestic gardens, but also parts of public green areas. Also, the map can be considered as relatively outdated.

Therefore, we want to determine and update the fraction of domestic gardens within the general NGI land use category 'garden'. In addition, we want to collect currently unavailable data on individual garden sizes and related building types. The improvement and update of the topographic land use map from the National Geographical Institute (NGI, 2004) was done by means of linear regression. This regression was based on empirical spatial data of individual gardens. These data were collected by an orthophotograph analysis of 60 square segments of 25 ha. So, an existing land use map is refined through linear regression, using detailed orthophotograph analysis in a GIS environment (Figure 4.1).

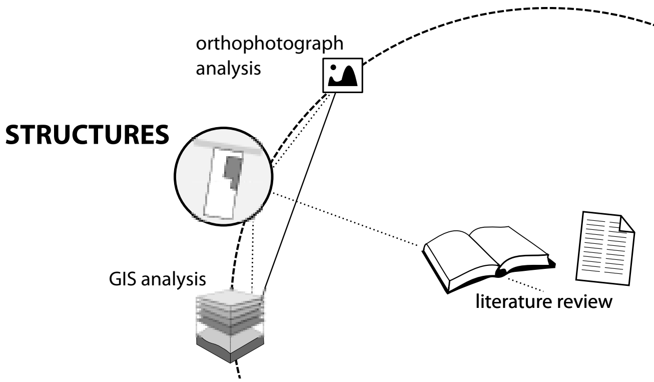


Figure 4.1
Overview of methods used in Chapter4
Data was collected in a GIS-environment by combining an existing land use map with data from detailed orthophotograph analysis.

2.1 Sampling design

Detailed spatial data on individual gardens was collected by orthophotograph analysis in a GIS-environment. The orthophotographs were sampled using the Area Frame Sampling technique (AFS). AFS is a statistical sampling technique that is widely used (FAO, 1995; Gallego, 1999; Bettio et al., 2002) to make spatial estimations about a material or object of interest within an 'area frame' or study area, being Flanders in this research. The area frame is divided into Primary Sampling Units (PSU's), out of which a random selection is made (Cotter and Nealon, 1987). Within the selected PSU's, spatial data on the object of interest is collected, in this case the land use 'domestic garden'.

To ensure accurate estimations within the sample, the area frame was divided into four homogeneous strata or groups (Mandana, 2002) by a K-means clustering of 280 of the 308 Flemish municipalities. At the time of clustering analysis, area covering data from the topographical land use map was not available for 28 municipalities. Such clustering allows to reduce variation within the strata, while the variation between the strata is increased (EPA, 2002; Lauridsen, 2004). These clusters are solely used for data sampling, not for data analysis.

The clustering was based on the area-percentages of the following land use categories, calculated from the existing topographical land use map (NGI, 2004): (i) garden, (ii) agriculture, (iii) impervious area and (iv) the ratio of garden area over impervious area. Agriculture and impervious surfaces are aggregates of several distinct land use classes. Agriculture encompasses arable land, pasture and meadowland, orchard and tree nursery, while impervious areas include buildings, industrial areas, roads and the railway network. The ratio of garden area over impervious area was included since it appeared to be significant higher for ribbon developments compared to residential cores and scattered developments (Verbeek et al., 2011).

The K-means clustering resulted in four municipality clusters (Table 4.1). Each cluster is characterized by a specific land use configuration. The balanced cluster has a proportion of the three land use classes' equivalent to the land use proportion in the overall topographical map (NGI, 2004). The other three clusters are each dominated by a specific land use category.

Next, the PSU's were defined as segment samples for reasons of higher accuracy compared to point samples (Gallego, 1999). The segments were defined by a raster built up out of 25 ha squares. For complex and diverse landscapes, 25 ha is a commonly used study unit (Cooper and McCann, 2002; Bunce et al., 2008). Bettio et al. (2002) state that an optimal number of segments ensures a representative sampling without being inefficient due to a too large number of segments.

Table 4.1 Characterization of the four clusters or strata used for sampling

To ensure accurate estimations of the garden area, Flanders was divided into four clusters using K-means clustering based on the area-percentages of garden, agriculture, impervious area and the ratio of garden area over impervious area as indicated by the topographical land use map (NGI, 2004). At the time of clustering analysis, area covering data from the topographical land use map was not available for 28 of the 308 Flemish municipalities.

Source Topographical land use map (NGI, 2004); De Meyer et al. (2011)

	Area percentage			Garden area/ impervious area	Cluster area	Number of segments
	Garden	Agriculture	Impervious			
FLANDERS	13.4 %	56,45 %	13 %	1.03	13,599 km²	60
Balanced cluster	15 %	55 %	11 %	1.30	3,837 km²	20
Agricultural cluster	9 %	73 %	10 %	0.94	4,751 km²	25
Garden cluster	24 %	38 %	13 %	1.89	766 km²	5
Impervious cluster	17 %	38 %	27 %	0.69	2,130 km²	10

Based on a One-Way ANOVA statistical test, a total of 60 segments was considered sufficient to be representative for Flanders (p-value = 0.878, α=0.05). The null-hypothesis stated that there are no significant differences between the mean area of gardens (calculated from the NGI land use map) in sampling sets with different sample sizes (60, 80,100 and 140 segments). The random selection of the segments was conducted proportionally, taken into account the total area of the stratum: bigger strata are assigned more segments.

2.2 IDENTIFICATION AND DIGITIZATION OF DOMESTIC GARDENS

Within each segment, individual garden areas and their related houses were identified on digital orthophotographs[1], taken in the period 2002 to 2005, and digitized in a GIS-environment. These orthophotographs were in general more recent than those used by NGI to support the production of the topographic land use map.

The garden parcel (including garden paths, driveways and sheds) was demarcated as the parcel on which a house is located. The house itself was not included in the garden area and was digitized as a separate polygon, including an attribute on building type (terraced, semi-detached or detached).

1 Digital orthophotographs, mid-scale 1/12.000, colour, 2002 provinces Flemish-Brabant and East-Flanders, 2003 provinces Limburg and Antwerp and 2005 provinceWest-Flanders, AGIV. Production dates: between 1995 and 2003

Figure 4.2
Identification and digitization of domestic gardens
The topographical land use map (NGI, 2004) overestimates the area of domestic garden. The orthophotograph analysis is illustrated for segment 21, with a comparison between the topographical land use map (above), the orthophotograph (middle) and the digitized gardens and houses (under).

Source Topographical land use map (NGI, 2004); digital orthophotograph, mid-scale 1/12.000, color, 2002, Oost-Vlaanderen (AGIV); author.

Also extensive woodlots on the garden parcels are not categorized as garden. This matches the garden criteria of the NGI field protocol. According to this protocol, parts of garden parcels where the crowns of groups of trees touch each other were categorized as forested.

2.3 Garden size and relationship with building types

Since so far spatial data on domestic gardens are lacking, we looked for possible indicators for garden size. The results of the orthophotograph interpretation were used to determine area statistics of individual gardens. Only gardens that fell completely within the segments were retained for further analysis.

Domestic gardens are per definition associated with houses. Houses are physical and functional units that are much better inventoried through enquiries, systematic censuses, aerial photographs, etc. So, it is interesting to deduce accessible house-bound indicators of garden characteristics. More particularly, we analyzed correlations between garden area on the one hand and building type and house area on the other hand using two hypotheses.

The first hypothesis is that smaller gardens are mainly associated with terraced buildings, while larger gardens will be more likely to occur in relation to detached houses. The median garden area was compared between the three building types. The nonparametric Kruskall-Wallis One-way Analysis of Variance was used since the variable garden size was not normally distributed.

The second hypothesis states that smaller houses are associated with smaller gardens, while larger houses will be related to larger gardens. At first sight this is obvious, but evolutions in housing size in Flanders indicate a strong growth of the number of smaller houses, apparently without a comparable decrease in parcel size (Vanneste et al., 2007). Since both variables (garden area and house area) and their transformations (LN, Log, SQRT) were not normally distributed (Kolgomorov-Smirnov: $p < 0.05$), the correlation was tested by means of the non-parametric Spearman's Rho correlation coefficient. The significance was tested by means of a t-test. All statistical tests were conducted in SPSS 15.00 and 20.00.

2.4 Coverage percentage and regional distribution

The coverage percentage of Flanders by domestic gardens was extrapolated from the digitized individual garden areas using a linear regression formula. For all 60 segments, data from the orthophotograph analysis were compared to the topographic land use map and differences in garden area percentages were calculated. Segments with a difference in garden area of more than 5 % were analyzed based on orthophotographs to identify the differences.

Next, a linear regression was used to systematically compare the garden area percentages according to the topographic map (the independent variable) with the garden area percentages according to the orthophotograph analysis (the dependent variable). Both variables were log-normalized. With the regression model, the total area of the Flemish garden complex was estimated for different spatial units, leading to a more accurate baseline map and an improved image of the total domestic garden area in Flanders.

To clarify the spatial distribution of the garden area, the garden area percentage was calculated for the two spatial units 'statistical sectors' and 'residential cores'. A statistical sector (NIS, 2005) is a small administrative subunit of a municipality for which the Directorate-General Statistics Belgium (ADSEI) collects different types of statistical data. They are characterized by social, economic, urban and morphological criteria. The unit of a statistical sector gives better insight into (i) the distribution of garden area in the urban -rural gradient because of its fine scaled character and (ii) linkages with building patterns. The residential cores are a subset of the statistical sectors, only including cities, village centers and hamlets.

For the whole of Flanders, the initial garden area according to the topographical land use map (NGI, 2004) (resampled to a cell size of 100 m^2) was calculated per statistical sector by means of zonal statistics (statistics type 'sum'). This initial garden area was then converted into garden area percentages. Next, the linear regression formula defined in paragraph 2.2 was applied on this initial garden area percentage per statistical sector. This leads to an improved garden area percentage per statistical sector. The same procedure was repeated to calculate the garden area percentage of the residential cores.

2.5 Measuring growth of the garden area

We introduce two types of garden growth: passive and active. Passive growth is a consequence of new housing development. In this perspective, the garden is the residual part of the developed parcel. Active growth is the result of an active search for land, specifically for its intended use as garden. The garden itself is an object of investment by the expansion of existing domestic gardens.

In order to collect data on the growth of garden area, a temporal analysis was conducted starting from the same sample of segments. Orthophotographs[2] from the period 1988-1990 were compared with the digitized garden polygons based on the orthophotographs from the period 2002-2005. Since such orthophotographs were not available for the period 1988-1990 for 16 of the 60 segments, the temporal analysis was limited to 44 of the 60 segments. The digitized garden polygons were assigned two extra attributes: 'completely or partially new' and 'located in agricultural land'. The first one helped to detect a difference between active and passive growth. The latter allowed the estimation of the share of agricultural land converted to domestic garden.

3 Results and discussion

3.1 Garden size and relationship with building types

The average area of an individual private garden in Flanders is 571 m². About 30 % of the identified gardens has an area between 250 and 500 m² (Figure 4.3). Most of the gardens related to terraced houses are smaller than 100 m². Gardens between 100 and 250 m² are almost equally distributed amongst the terraced and semidetached building types. Larger gardens, between 500 and 750 m², are typically associated with detached houses. The semidetached houses fall in between the two other groups, with most of the gardens having an area between 250 and 500 m². The median areas of the gardens with detached, semi-detached and terrace houses are respectively 703 m², 324 m² and 141 m².

Our results coincide with the study of Loram et al. (2007) in the United Kingdom (UK), who found that the median garden area of detached houses was twice the median of the garden area of semidetached houses, which in turn was also twice the median of the garden area of terraced housing.

2 Digital orthophotographs, color, Eurosense, 1/10.000, 1988-1990, published in 1990, OC-GIS Flanders

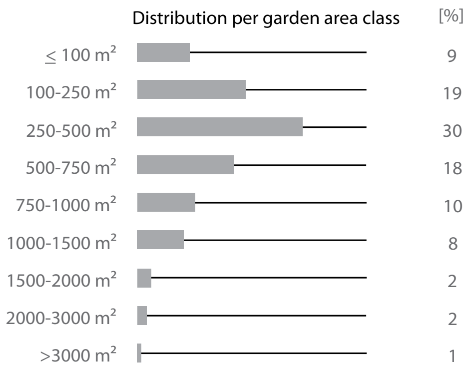


Figure 4.3 Distribution of garden size classes

The most frequent garden size lies between 250 and 500 m². The graph gives the distribution of garden size classes for the digitized gardens (N=2,391).

In our sample, detached houses constitute the largest share with 47 %, while semi-detached houses account for 34 % of the sample and terraced houses for 19 %. These observations on building type occurrence are somewhat opposite to Loram et al. (2007), who found mainly terraced houses in their sample and detached housing making up the smallest portion of the sample. This may be due to a difference in the demarcation of the municipal boundaries or in the sampling methodology, as their sample was being set up as a point sample selecting randomly 1000 building polygons and associated gardens within the city boundary. Also differences in building morphology between the United Kingdom and Belgium should be taken into consideration. Flanders, with its typical ribbon development (Antrop, 2000; Verbeek et al., 2011), is characterized by more semi-detached and detached housing.

The graphs in Figure 4.4 confirm the hypothesis that smaller gardens are mainly associated with terraced houses, while larger gardens rather occur with detached houses. The Kruskall-Wallis One-way Analysis of Variance rejects the null hypothesis that each building type has the same distribution of garden sizes (p-value < 0.001, $\alpha = 0.05$). The mean ranked garden area differs significantly between the three building types. So the housing type is a useful indicator for estimating associated garden areas.

This corresponds to the findings for the UK, where Loram et al. (2007) found that the individual garden area is closely associated with housing type: semi-detached houses have larger gardens than terraced houses and smaller gardens than detached houses. Smith et al. (2005) found similar results for back gardens. Also the second hypothesis, that smaller houses are associated with smaller gardens and larger

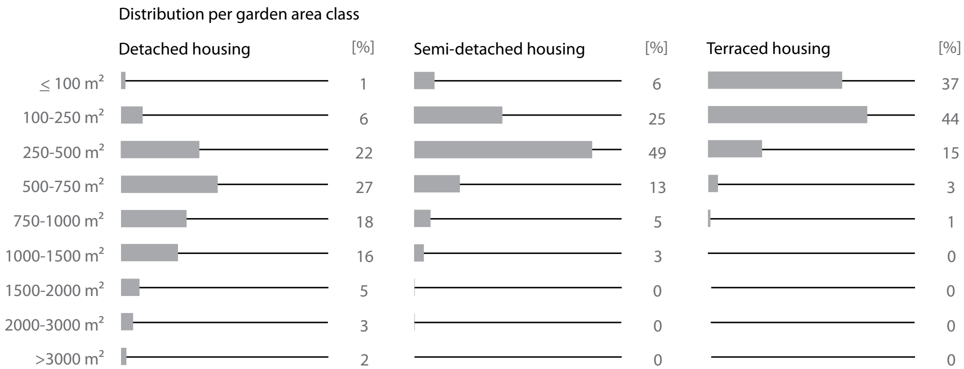


Figure 4.4 Distribution of garden size classes per housing type

Smaller gardens are mainly associated with terraced houses, while larger gardens rather occur with detached houses. The graphs give the distribution of garden area per building type (N=2,391).

houses with larger gardens, is confirmed by the high Spearman Rho correlation coefficient of 0.672 (p-value < 0.00, α =0.05 and α=0.01). So also the housing area is an indicator for the associated garden size.

Housing type and housing area are potential indicators for garden size. This puts forward the possibility of using existing census data on housing characteristics to obtain more detailed insights. For now, the regional dispersal is only incorporated in the area percentage of domestic gardens per spatial unit (the statistical sector). Based on housing characteristics, future research can better evaluate the regional distribution of garden sizes.

As scenarios and land use models indicate an increase in the number of houses, it is interesting to assess whether the relation between house and garden size stays stable or evolves, in space (distribution) and time. Sander and Zhao (2015) found for example that lot size influences the premium attached to tree cover. Neighborhood tree cover may matter more to homeowners of smaller lots. Future research on the relation between house characteristics and garden size could for example take into account the date of construction of the houses to estimate the evolution of garden sizes. It is possible that the correlations between garden and housing area may evolve or even become less clear due to changes in policies, as is the case in Australia for example (Syme et al., 2001), or changes in market prices. Also cultural changes might have an effect. The ratio of garden over house size may become smaller, or there may be a trend towards more public or collective gardens instead of private gardens. The results presented here can be considered a baseline for future research on the garden-house relationships in Flanders.

3.2 Regional coverage by domestic gardens

The orthophotograph analysis shows a smaller overall size of the area occupied by gardens in comparison to the reference cartographic data (Figure 4.5). In 19 of the 60 segments, the difference in garden area between the land use map and the orthophotograph analysis was more than 5 %. Several categories of land use, such as sand or clay-pits, farms and agricultural land, forest and forested parts of parcels, fallow (parts of) parcels and parcels for recreational farming, were classified as 'garden' by the NGI cartographers. The core of the scatter plot suggests a linear correlation between the garden area percentages according to the topographic map and our orthophotograph analysis. The bivariate Pearson correlation coefficient (0.866) and the determination coefficient R^2 (0.745) indicate that 75 % of the variance of the digitized garden area percentage is explained by the garden area percentage according to the topographical land use map (NGI, 2004). The null hypothesis of the variance analysis, stating that the regression coefficient equals zero, is rejected ($p < 0.001$).

With the linear regression formula

$$V = -0.472 + 1.002\ U$$

in which U = ln (cartographic garden area percentage) and V = ln (digitized garden area percentage), the total area of domestic gardens in Flanders is calculated to be 8.2 % (or 1,100 km^2) of the Flemish territory. This is less than the 13.4 % (or 1,726 km^2) according to the reference topographical map (NGI, 2004). In comparison with other land uses the Flemish garden complex still takes up an important green area: forest area and nature conservation areas cover respectively 11 % and 2.9 % of the Flemish area (Table 4.2). For these land uses, a wide range of policy goals exists as well as specific research institutions and policy domains. Although they cover a comparable or even larger area, domestic gardens are not part of any policy sector in Flanders.

3.3 The regional distribution of garden area

The garden area percentage per statistical sector is shown in Figure 4.6. The average garden area percentage is 16.4 %, and the maximum garden share is 63 %. In the Brussels Capital Region (the white enclave in the map), green areas are unequally distributed according to Van de Voorde et al. (2008). They encountered the highest proportion of green areas in the neighborhoods near the capital.

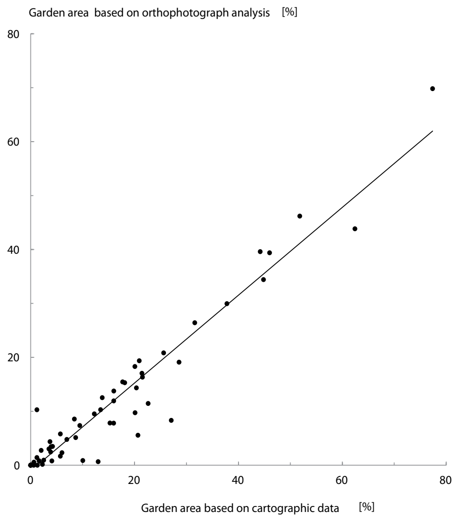


Figure 4.5
Correlation of garden area between cartographic data and orthophotographs analysis
The orthophotograph analysis shows a smaller overall size of the area occupied by gardens in comparison to the reference cartographic data. The scatter plot presents the linear correlation between the garden percentages by the cartographic data and by the digitized data results in a Bivariate Pearson correlation coefficient = 0.866; determination coefficient R^2 = 0.745 (N=60).

Table 4.2 Coverage by gardens and other land uses
In comparison with other land uses the Flemish garden complex takes up an important area. Area coverage is expressed in percentage of the Flemish territory.

Sealed surfaces (2007)	Forest (2007)	Garden	Conservation area (2007)	Park (2005)
12.9 %	11 %	8.2 %	2.9 %	1.6 %
Gulinck et al. (2007)	Van der Aa (2007)		Institute for Nature and Forest Research[a]	VVOG (2005)

[a] http://www.natuurindicatoren.be, Indicator: Area with 'effective nature management' (MINA-plan 3/3+-)

In the 19th and 20th century belts domestic garden cover up to 70 % of the green area. Our garden distribution map shows similar patterns for Flanders, with a concentration of gardens especially around city and town centers.

In Figure 4.7 a lower concentration of gardens is visible inside the city centre compared to a higher concentration of gardens in the areas surrounding the centre and in semi-urban areas (e.g. Ghent, Bruges, Antwerp and Leuven). Only the agricultural areas in the west and southeast and the larger forest areas in the east of the region have a smaller fraction of gardens. Here, the garden pattern corresponds to the dispersed pattern of urbanization typical for these areas (Verbeek et al., 2011). The garden concentration along the coastline is in sharp contrast with the nearby rural areas. The second urbanization pattern is ribbon development, also reflected in the garden distribution map. The map in Figure 4.7 also shows a higher concentration of garden area around built-up road segments.

Overlay with delineations of residential areas show that 67 % of the Flemish garden area lies within the residential cores and 33 % in non-residential area. The 67 % lying in residential cores coincides with 21.3 % of the total area of residential cores. The maximum garden share within the residential cores is 45 %, the average 23.7 %. These figures illustrate the importance of gardens in urban areas, but also that gardens cover a non negligible part of the countryside.

3.4 Growth of the garden area

Based on the temporal analysis of 44 of the 60 segments, 8.4 % of the garden area observed in the period of 2002-2005 was new compared to the period 1988-1990. By extrapolating the percentage of new garden area for the 44 segments to Flanders, it is estimated that 91 km^2 of the 1,100 km^2 garden area in 2005 was new compared to 1988-1990, meaning that about 8 % of the domestic garden area in Flanders was created over the analyzed time period. The majority of the new garden area is the consequence of new housing development, hence of passive growth (147 gardens accounting for a total of 9.8 ha), while a minority concerns garden expansions (10 expansions or a total area of 0.7 ha).

The majority of new garden area in the 44 segments (90 %) lies in former arable land. Extrapolated to Flanders this means that 82 km^2 new garden area lies in formerly agricultural land, or a conversion of 1 % of agricultural land registered in 1990 to gardens by 2005 (NIS, 2011). According to Kerselaers et al. (2011), 2.3 % of farmland was lost to other land uses in the period 2000-2011. Based on our results we can assume that a substantial part was subjected to 'green urbanization': as urbanization encroaches upon rural areas (Antrop, 2004; Kerselaers et al., 2011), agricultural land is not only converted to sealed surfaces, but also to domestic gardens.

4 General discussion

The domestic garden area for Flanders has been estimated by combining empirical data with an existing land use map. The mixed methodology applied here has demonstrated its strength in collecting regional wide data on the spatial footprint of domestic gardens. The empirical data gives information on the exact locations and sizes of individual domestic gardens for the digitized segments. Gill et al., (2008) also collected empirical data by digitizing detailed urban morphology types on aerial photographs. The surplus value of using such empirical data is the higher accuracy at a smaller (time-place) scale. This makes it possible to better apprehend

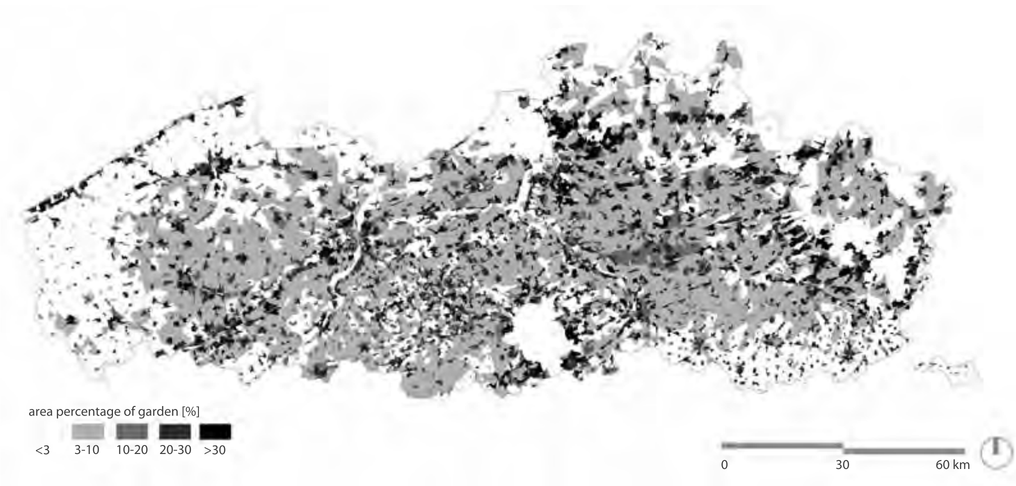


Figure 4.6 Regional coverage of garden area

Gardens are present all over Flanders. The map presents the percentage of garden area in Flanders per statistical sector, based on the NGI cartographic data (2004) and the orthophotograph analysis.

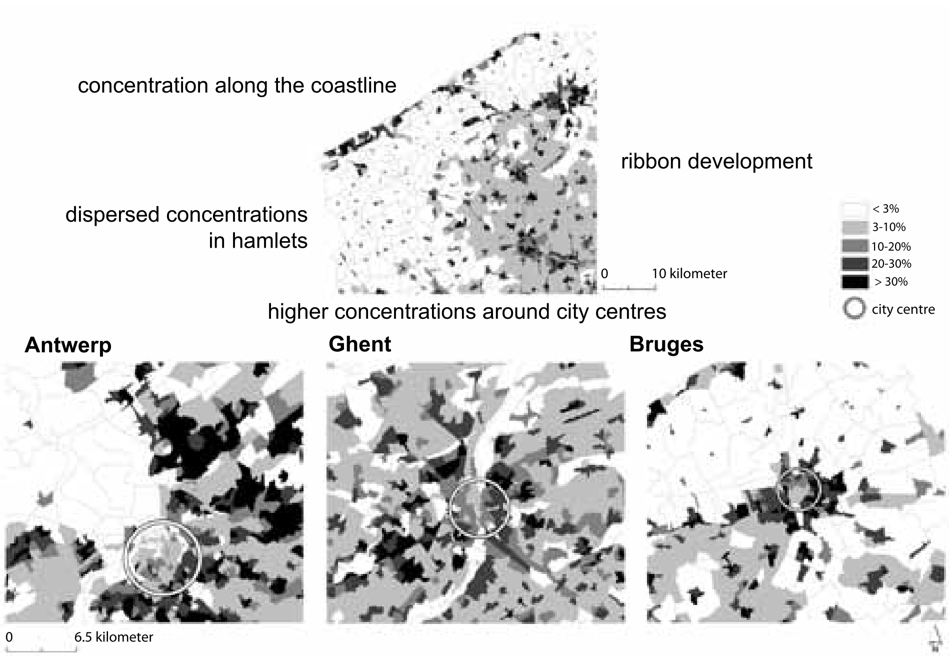


Figure 4.7 Regional distribution of garden area

The areas surrounding city centers and semi-urban areas are characterized by higher concentrations of gardens. Within more rural regions, gardens are mainly concentrated in hamlets and ribbon development. The figure gives a summary of the distribution of garden area in Flanders, visualized as the percentage of garden area in Flanders per statistical sector.

land uses and transformations in small-scale landscapes such as Flanders.

Combining the empirical data with an existing land use map by means of regression makes it possible to extrapolate insights at this small scale to a larger region. We refined the estimation of domestic garden area in the region of Flanders. Remarks are twofold. Firstly, such a regression step does not allow to generate data on the exact locations and sizes of individual gardens for the whole region that is analyzed. Secondly, the basic condition for this extrapolation, a reference land use map with a 'garden' category, may not be met in other regions or countries. Although not explored in this study, we expect that starting from a more general land use category like urban green would increase the margin of error.

In general, Flanders can be seen as a case study that is inspiring for other regions. Although the methodology was geared on existing data for Flanders, the reasoning behind this methodology is applicable elsewhere. The lack of data on domestic gardens does not only apply for Flanders or Belgium. Also elsewhere it is hard to get a clear idea on the spatial footprint and distribution of domestic gardens (Mathieu et al., 2007) and this for an entire region including peri-urban and rural areas as well as urban areas. Each region or country will need methodological refinements to gear the approach presented in this paper on the datasets that are at their disposal.

A bird's eye-view offers complementary mapping methodologies. Remote sensing techniques are promising in mapping domestic green. Object-oriented classification of high-resolution multi-spectral Ikonos imagery by Mathieu et al. (2007) in New Zealand proved great potential in providing a quick method for obtaining good quality data on domestic gardens in urban areas. So, we see opportunities in the combination of empirical data with high-resolution multi-spectral data for obtaining regional coverage areas of domestic garden area. However, the availability of imagery is a precondition for remote sensing, just as high quality ground truth data for calibration and validation. Moreover, we suggest empiricism to be essential in studying characteristics of small-scale and spontaneous land uses and transformations.

Spatial data opens the way to data collection on other garden related aspects. To test whether collected data on other aspects such as the use of fertilizers or pesticides, food production, the presence of trees, amounts of carbon storage within these garden trees, etc. is representative, reference data is needed. Estimating the total area of domestic gardens within a certain region is a first step. Moreover, spatial data allow to position the significance of aspects like the environmental impacts of the (ab-)use of fertilizers, the food production potential or the capacity for storage of carbon in lawn soils or garden trees in domestic gardens towards other land use categories like agriculture (Dewaelheyns et al., 2013; Chapter 6).

4.1 Just a matter of land use categorization?

The lack of a specific land use category 'domestic garden' hampers its data collection. In many land use typologies, the category 'domestic garden' blends in other land use categories. Gardens are traditionally considered as an indivisible part of the residential fabric. In Europe for example, the CORINE category 'discontinuous urban fabric' is an 'umbrella' category simply indicating the presence of domestic gardens. In their qualitative assessment of regional potentials to provide ecosystem services using CORINE land cover classes, Koschke et al. (2012) were not able to estimate the contributions of land cover types with minor regional importance (like fruit trees and complex cultivation patterns) due to a lack of data. So, studies working with this category, like Tavares, and Magalhães (2012), should be aware of the domestic garden fraction of this category.

In the case that the land use category 'garden' and derived spatial data do exist at the national or regional scale, precautions are necessary. Firstly, the reading of this category should be done with care. Because of its hybrid character (domestic gardens, semi-public and public green etc.) and its physical heterogeneity, the identification of domestic gardens is subject to interpretation, both in the field and on aerial photographs.

Domestic green may be hard to distinguish from public green when following identification protocols. Secondly, the garden category easily dissolves in an 'urban' category by upscaling and reclassification processes. Such processes reform existing land use maps to simplified formats, for computational reasons or to provide tailor made data and maps.

Categorization of domestic gardens as an urban land use or planning category leads to a biased image of reality and likely to a bias in land use and open space policies (Maruani and Amit-Cohen, 2007). Like Hasse and Lathrop (2003), we want to nuance the interpretation of urbanization and sprawl phenomena.

We demonstrated that 8 % of the Flemish area is covered with a land use that is not clearly represented by a land use category. About 21 % of the total area of residential cores exists out of domestic gardens. An all-inclusive policy is not possible if land use models or instruments for spatial planning and urbanism are geared on the existing data and acknowledged land use categories. Domestic gardens will not be taken into account. This may lead to underestimation of regionally important services and functions.

Studies modeling urbanization often speak in terms of built-up areas, even those starting from the biodiversity perspective. For example, Rojas et al. (2013) only take into account the increase of built-up surface, while not considering biodiversity values of the domestic gardens associated to (new) housing. Yet, several studies illustrated the value and potential of domestic gardens for biodiversity (Thompson et al., 2003; Gaston et al., 2005a; Smith et al., 2006; Tratalos et al., 2007; Goddard et al., 2010).

So, current spatial planning policies are locked in clearly defined and standard sectoral land use categories (Larsson, 2006). Census systems collecting statistical land use data are based on existing categorizations of space (Bomans, 2011). Non-orthodox land use categories like domestic gardens easily escape from policy attention since they are not captured by sectoral censuses. Reversely, this lack of policy attention prevents the adjustment of census systems. This phenomenon of circularity in data and information strategies is labeled as the 'categorization bias' by Bomans et al. (Bomans et al., 2010). The results from this study indicate that empirically collected spatial data has the potential to break through this categorization bias.

4.2 Gardens in the planning picture

We apparently seem to be faced with a planning paradox. On the one hand, domestic gardens can be considered as a luxury. They occupy a significant area in peri-urban and urban areas, while at the same time there is a growing body of opinion to built less space consuming. On the other hand, we do believe that the garden complex has strategic value, in relation to the urban fabric as well as in relation with the overall landscape. This strategic value is first and foremost indicated by a regional coverage of 8 % of the territory.

So, when striving for densification of the built environment, policy should proceed with caution not to lose the ecological and social surplus values of domestic gardens. It is important not to overlook the opportunities of domestic gardens for coping with challenges like climate change and food security. Yet, the presence and increase of domestic garden area should not be seen as an extenuation for ongoing urbanization.

The availability of spatial data is a precondition to start thinking about domestic gardens from a strategic perspective. Adding our work to studies collecting on spatial data of similar encroaching land uses, like the non-agricultural re-use of former agricultural buildings (Verhoeve et al., 2012) and horsification (Bomans et al., 2011; Zasada et al., 2013), illustrates the importance of collecting empirical spatial data as a trigger to get them on the agendas of policy and research. Fragmentation and urbanization bring along challenging tasks in Europe (Tavares et al., 2012). Studies like these not only add to the nuancing of land use categorization, but also give better insights in land use dynamics and new perspectives on our landscapes.

5 Conclusions

The presented research offers another perspective on densification scenarios. We argue for a better understanding of the stock of domestic gardens in order to make well-founded choices on urban densification. For this, Flanders can be considered to be an interesting case due to its (historically founded) garden area as well as its small-scale and multifunctional character.

The main message of this paper is to acknowledge and start from the spatial reality when developing spatial plans or urban development schemes. We hope that the insights in the spatial footprint of domestic gardens in Flanders as well as the developed methodology presented in this chapter will help to launch the debate on the strategic values of domestic gardens.

Chapter 5 is based on

Verhoeve, A.*, Dewaelheyns, V.*, Kerselaers, E., Rogge, E. , Gulinck H., (2014). Virtual farmland: grasping the occupation of agricultural land by non-agricultural land uses. Land Use Policy 42, pp. 547-556. * Both authors contributed equally.

Source: Anna Verhoeve

5. STEALING PAC-MANS: DOMESTIC GARDENS AS VIRTUAL FARMLAND

"The distinction between gardens and fields may be more apparent than real when considered in non-Euclidean terms."

Doolittle, 2004

In Chapter 4, domestic gardens were estimated to cover about 8 % of the Flemish territory. The growth of domestic garden area appeared to take place mainly within agricultural land. But no detailed figures were obtained on the intake of agricultural land by domestic gardens. In this chapter, the share of statutory agricultural land occupied by domestic gardens is analyzed.

1 A CHANGING COUNTRYSIDE AS A CHALLENGE FOR PLANNING

For centuries agriculture formed the basis of rural economy (Slee, 2005), shaped the rural cultural landscapes (Antrop, 2005) and had a pervasive influence in the organization of rural society and culture (Woods, 2005). Places of high agricultural suitability have been, and are, attractors of urbanization in most European regions (64 % of the EU-15 level 2 regions) (Primdahl et al., 2013). Rural areas under urban influence are characterized by an influx of people, capital and new lifestyles. Urban people move to the country for example in search of a 'rural' lifestyle, for retirement, as commuters, or as IT-based home workers (Phillips et al., 2008; Primdahl et al., 2013). This brings along what Antrop and Van Eetvelde (2008) call 'functional urbanization' of the countryside, or 'urbanization in disguise' (Praestholm in Antrop and Van Eetvelde (2008)), and the presence of a wide range of stakeholders (Slee, 2005; Kerselaers et al., 2013; Zasada et al., 2013). As a consequence, a variety of consumption functions increasingly occupies farmland (Oltmer, 2003; Slee, 2005; Koomen et al., 2008) making agricultural land a scarce and costly good (Busck et al., 2006; Primdahl et al., 2013; Zasada et al., 2013; Malucelli et al., 2014).

Spatial and rural policies play their role in controlling urban growth and land use changes, and in the protection of farmland (Duke and Aull-Hyde, 2002; Busck et al., 2008; Koomen et al., 2008; Kerselaers et al., 2013). Spatial planning practice frequently adopts the allocation approach by dividing the territory in different functional zones (Duke and Aull-Hyde, 2002; Witt, 2002; Ruotsalainen et al., 2004; Farinós Dasi, 2007; Tan et al., 2009; Kerselaers, 2012). In Flanders, like elsewhere, land use rights for specific types of land uses are clearly defined and related to sectoral land use categories like nature conservation, forestry and agriculture (Kerselaers et al., 2011) within such allocation plans (Laga et al., 2005; Van den Broeck et al., 2010; Gulinck et al., 2013).

Yet, rural policy needs a new focus on places rather than on sectors in order to include diversity in rural regions (OECD, 2006). The sectoral approach of spatial planning (Laga et al., 2005; Van den Broeck et al., 2010) and its data collection (Bomans et al., 2010b) are being criticized for their failure to appreciate complex dynamics of regional development. Several authors re-launch the call to replace the modernist legacy of spatial planning as unbiased representation of space through allocation plans by a more collaborative form of planning which engages the full array of stakeholders (e.g. Healey (1998); Graham and Healey (1999); De Roo and Porter (2007); Healey (2007); Albrechts (2013); Glass et al. (2013)). In planning practice the emergence of non-agricultural land uses within areas allocated for agricultural land use is increasingly noticed. This leads to the opinion that, as van Eupen et al. (2012) puts it, rural areas should be defined with regard to their specific 'multidimensional nature and character'.

2 Unconventional land uses

Land uses deviating from the official spatial planning policy are often the result of spontaneous, autonomous (Antrop, 1998) or unplanned processes (Anstey, 2009; Kuffer and Barrosb, 2011). They appear wherever local people take autonomous decisions to develop private activities on their own property (Præstholm and Kristensen, 2007; Busck et al., 2008). These processes bring disorder in the landscape and initiate the development of what Qviström (2007) calls 'places out of order'. Even if such autonomous actions appear solely at the scale of a single parcel (Primdahl, 2010; Verhoeve et al., 2012), they shape places.

While each single change or decision results in a rather negligible impact, the accumulation of all these individual changes over time and within a region may constitute a major impact (Theobald et al., 1997). They lead to cumulative effects or impacts (CE or CI) (European Commission, 1997; Folkeson et al., 2013; Scott et al., 2014). Such cumulative effects pose significant but complex challenges for planning (Scott et al., 2014) and currently there is only little consensus on their nature and meaning (Gunn and Noble, 2011). As Scott et al. (2014) summarize, cumulative impacts remain ill-defined (Cooper and Sheate, 2004; Bérubé, 2007; Folkeson et al., 2013) and under-researched (Theobald et al., 1997).

In rural areas, a part of the unplanned processes leading to cumulative effects can be considered the result of emerging urban and non-farming interests in rural landscapes. According to Paquette and Domon (2003), many of these interests are associated with individual domestic practices. They believe that the dynamic relationships between residential behavior, landscape, and rurality challenge planning policies and therefore merit closer investigation.

For the remaining, such land uses that are not related to professional farming but occupy agricultural land are called 'unconventional' land uses. These unconventional uses are often not captured by the standard categorizations of space and by the census systems geared upon them (Bomans, 2011). There are unconventional because they do not fit the strict and rigid but clearly defined land use categories applied in sectoral zoning approaches. This is in fact an action of excluding oddities and 'others', causing their values and the values of the resulting landscapes to be lost in-between the rural-urban divide and, consequently, to be ignored (Qviström, 2007). This blocks any active consideration of facilitating the full environmental and social potential of such spaces (Nadin, 2007; Adams et al., 2013).

The lack of data allows them to encroach almost unnoticed upon agricultural land. Their impact on the functioning of professional agriculture is still unclear, although farmers start to assign a growing pressure on the availability of agricultural land (Wauters et al., in press) and rising land prices (Angus et al., 2009; Kerselaers et al., 2013; Primdahl et al., 2013; Sklenicka et al., 2013) to unconventional land uses.

2.1 Data challenges

Data collection on unconventional land uses is challenged by several characteristics. Unconventional uses of farmland often occur at parcel level and may be morphologically similar to regular agricultural practices. Remote sensing and orthophotograph analyses may not be able to grasp the differences between professional agriculture and other uses. For example from distant observation it is difficult if not impossible to link an open air storage to professional farming practices or to for example a building contractor. In such cases, only terrain observation of human-made objects like signposts can give clear additional information on the type of user (Hersperger et al., 2012).

Some limitations of land cover approaches are related to time aspects. Several unconventional land uses in agricultural land are relatively new and appear almost overnight, whilst observation techniques and monitoring programs are characterized by a time frame of years. Also data processing and analysis requires time, adding up to the time difference between the appearance of an unconventional phenomena and its detection. This time difference leads to an undesirable delay in the recognition of such phenomena by spatial policy.

Examples of recent studies that sought to overcome the above discussed limitations are found in Australia (Anstey, 2009), the Netherlands (Daalhuizen et al., 2003; van der Vaart, 2005) and Denmark (Busck et al., 2008). These explorative studies collected empirical data on a small (time-place) scale. In Flanders, efforts were done to describe garden sprawl (Dewaelheyns et al., 2014), the occupation of rural buildings by non-agricultural economic activities (Verhoeve et al., 2012) and the occupation of pasture by hobbyhorses (Bomans et al., 2011a).

2.2 A specific focus on domestic gardens

Domestic gardens are a key example of an unconventional land use in Flanders. Especially in the countryside, the growth of garden area can be considered as a cumulative effect that is associated with residential behavior and domestic practices. About 33 % of the total Flemish garden area is situated mainly within rural areas (Chapter 4). The occupation of the rural land stock by domestic gardens is called 'garden sprawl' (Bomans et al., 2010b) or 'hortification' (Antrop and Van Eetvelde, 2008).

The presence of domestic gardens in the countryside is certainly not a new phenomenon nor is it a Flemish exclusivity. Domestic gardens are an important land use component in rural areas elsewhere (Phillips, 2005; Marco et al., 2008; Phillips et al., 2008). But there is almost no region where ownership of a house with a garden has been that heavily promoted by the government (Lauwers et al., 2012) (Chapter 3).

The creeping appropriation of space by private actors and the permissiveness of the government cluttered the rural areas in Flanders (Lauwers et al., 2012). As such, a part of the current garden area in the Flemish countryside is part of cultural heritage.

At the countryside in the UK, rural nature is partly defined by gardens (Phillips, 2005; Phillips et al., 2008; Phillips, 2014). These gardens are considered as a form of middle class colonization of the countryside (Phillips et al., 2008). Moreover, garden flora may be important in developing desirable rural spaces (Phillips, 2005). However, rural policies hardly pay attention to domestic gardens. Due to a mere dualistic vision of the countryside in which nature and agriculture is part of the open countryside and not present within rural settlements (Phillips et al., 2008), gardens fall beyond the reach of rural policies.

But the garden area in the countryside is still increasing. A part of this new garden area is related to new housing development, hence part of a legal urbanization according to statutory land use allocation plans (Dewaelheyns et al., 2014). Also unconventional processes contribute to garden growth in agricultural land. Gardens of existing houses are expanded by annexing (a part of) an adjacent agricultural parcel to the garden. This is facilitated by the Belgian Agricultural Holdings Act, which states that land owners are able to revoke up to 0.2 ha of the leased land to be used for family goals like a garden or playground, if this land is connected to his or her dwelling (1969 (update until 06-07-2009)). At the same time, former farm buildings are transformed to a dwelling with a garden or to a non-agricultural economic activity wrapped up in gardens. The re-use of former agricultural buildings as bed & breakfast or wellness centre (Verhoeve et al., 2012) is often accompanied with an increase of garden area (Chapter 4).

Within this context, planners and decision-makers entitled for rural land use planning seem to be challenged by the growing multidimensional nature of rural areas. Unconventional land uses like domestic gardens should be recognized as an important aspect of this. Systematic insight in their presence is vital for a sound understanding of the complexity of rural development. The question remains to what extent these unconventional uses affect the availability of agricultural land.

3 Research objectives

The overall goal of this chapter is to develop a methodology for mapping domestic gardens within the agricultural territory allocated by spatial policy. The latter is further called *statutory farmland*. Since there is a relation between the presence of domestic gardens and non-agricultural economic activities (NAEA) (Chapter 4) this land use is also considered within the analysis. The mapping of domestic gardens and NAEA in agricultural land allows the analysis and a better understanding of their presence.

The overall research objective is achieved by three specific research objectives: (i) to identify parcels with an inconsistent determination of land use in official datasets that are located within statutory farmland (further called 'inconsistent parcels'), (ii) to explore the actual land uses taking place in these inconsistent parcels, and (iii) to investigate whether this inconsistency can be explained by the presence of unplanned land uses.

4 Materials and methods

We used a two-staged methodology on the case-study Flanders, the northern region of Belgium. Spatial analyses on existing datasets on land use at parcel level were combined with an in-depth morphological interpretation of Google Streetview images (2011) and orthophotographs (Figure 5.1). The presence of good conditions for agriculture (Calus et al., 2008) combined with high levels of urbanization and domestic gardens makes Flanders a suitable region to study the occupation of agricultural land by domestic gardens and NAEA.

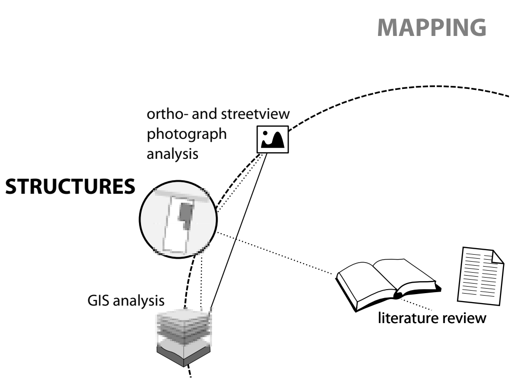


Figure 5.1
Overview of the methods used in Chapter 5
The methodology applied in this chapter combines spatial analyses on existing datasets on land use at parcel level with an in-depth morphological interpretation of Google Streetview images (2011) and orthophotographs.

4.1 Stage 1: comparison of official datasets

As Hersperger et al. (2012) state, a combination of census and registration records is useful to provide valuable data on land use. Using geoprocessing tools in ArcMap 10, we compared two official datasets on land use at parcel level. The first dataset, called 'Spatial allocation plan (Gewestplan)' (state on 02/05/2011) (RWO, 2011) is a generically applied allocation plan that divides the Flemish territory into statutory zones. This plan gives an ideal figure of land managed by the agricultural policy domain. There are two main critiques on the use of the allocation plan in spatial policy. First, it has a static and monofunctional character, while currently more dynamic planning instruments are available. Second, 'impurities' are known to exist in the allocations, e.g. the historical heritage of domestic gardens in rural areas (par. 2.2.). Yet, the spatial allocation plan is still used as a reference image within rural planning in Flanders. Until today, it is the only area covering and legally binding document with respect to land allocation in Flanders. For example, municipal spatial planning policies still use it for the approval of individual building and land use change permits.

The second dataset is the GIS-based Land Parcel Identification System (LPIS), a database developed to support implementation of the European Common Agricultural Policy (CAP) (Inan et al., 2010; European Commission, 2013; Sagris et al., 2013). The Flemish dataset of LPIS (Landbouwgebruikspercelen) (ALV, 2010) collects information on the agricultural parcels in Flanders that have been registered because the parcels receive CAP subsidies or as part of the Flemish implementation of the EU's nitrates directive. This database is considered a good approximation of the actual agricultural land use in Flanders (Danckaert, 2013).

The comparison between the two datasets allows the mapping of parcels with an inconsistently determined land use. In the following, we will call these parcels 'inconsistent parcels'. Such an inconsistency between different official data sources indicates a vagueness about the actual land use. This vagueness can be considered an 'information gap'. The focus on the inconsistent parcels is further used to study the intake of the Flemish agricultural territory by domestic gardens and NAEA.

4.2 STAGE 2: MORPHOLOGICAL ANALYSIS

An in-depth morphological interpretation was used to verify if the indicated inconsistent parcels are occupied by unconventional land uses. For each parcel the coverage by the actual land uses was indicated as an area percentage. Google Streetview images (2011) and orthophotographs (Agiv, 2012) were combined in a cross reference method to interpret and inventory the actual land uses. Since mid-2012, the SIGGIS Street & Birdview add-in application in ArcMap 10 (SIGGIS, 2013) creates the ability for an instant cross referencing. This Street view perspective provides additional information on the current land use derived from the type of fences, the inscriptions on billboards and the material of open air storage, and approaches on-field observation.

During the image interpretation we had particular attention for the two predefined land use categories 'domestic garden' and 'non-agricultural economic use', illustrated in Figure 5.2. For the category 'domestic garden', the farm yard and adjacent agricultural plot are converted to a garden layout, often with trees, hedges, fences, flowerbeds, footpaths and a lawn (Figure 5.2 left). The former farm buildings have a residential use or a soft NAEA, like wellness or bed & breakfast. For the category 'non-agricultural economic use', the example represents a ground-worker, a frequent occurring type of a non-agricultural economic activity (NAEA) on Flemish statutory agricultural land (Verhoeve et al., 2012) (Figure 5.2 right). Such

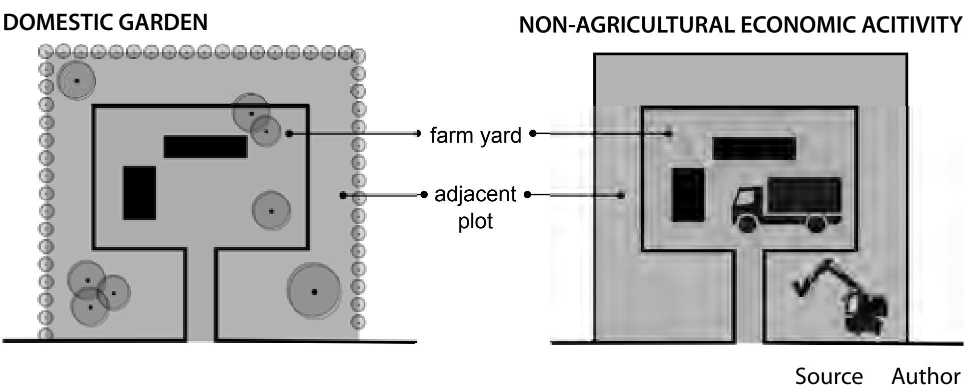


Figure 5.2 Illustration of a domestic garden and a non-agricultural economic activity at a farm parcel

Domestic garden (left) and non-agricultural economic activity (NAEA) (right) are the two types of land use conversions of statutory farmland studied in this chapter. Each example consists of two plots, a farm yard plot and an adjacent plot. The first example represents the conversion of agricultural land to a domestic garden. The second example represents a ground-worker of with activities outside the former farm buildings also take place on the adjacent plot.

non-agricultural activities not only take place within the former farm buildings. Also the farm yard and the adjacent plot are used to store building material and machinery. Piles of displaced ground, a row of large containers and a crane allow distinguishing the use of this plot from agricultural use.

These examples indicate that domestic gardens and NAEA's have specific morphological characteristics. During the data collection, domestic gardens were interpreted based on morphological characteristics related to the design or management. Several of these morphological characteristics were used to make a distinction between domestic kitchen gardens (for home production) and professional farmed fields (for professional production). Domestic vegetable growing takes place in a garden context as described above. Professional production normally contrasts by size and a higher homogeneity, compared to the smaller plots and larger diversity of kitchen gardens. Non-agricultural economic use was interpreted based on visible open air storage of materials and machinery and advertising signposts.

Besides domestic gardens and NAEA also other land uses were inventoried. Based on morphological characteristics, detailed information on these other land uses was collected in an additional descriptive field. Examples are pastures, greenhouses, fields, forest, buildings and nature[1]. Buildings were not inventoried separately (except for those parcels which are completely occupied by a building), but were taken into account when the area percentage was estimated.

The detailed character of the analysis imposed a time constraint, so the sample was limited to six municipalities. The selection of these municipalities was based on two criteria. The first criterion was the density of non-agricultural enterprises, expressed as number of non-agricultural enterprises per km^2 of statutory farmland. This figure was available for 38 municipalities and ranged between 0.2 and 4.6 with an average value of 1.54 (VLM, 2010; Verhoeve et al., 2012). The second criterion was the spatial importance of parcels with an inconsistently defined land use in relation to the total area of statutory farmland within the municipal boundaries. This information was obtained in the first research stage. The figures on both criteria were combined in a scatter plot for the 38 municipalities from the study of Verhoeve et al. (2012) (Figure 5.3). The distribution of the municipalities in the scatter plot captures the diversity for both criteria. An arbitrary number of six municipalities was selected in such a way that this diversity is present in the sample.

1 Identification based on the appearance of as natural looking areas

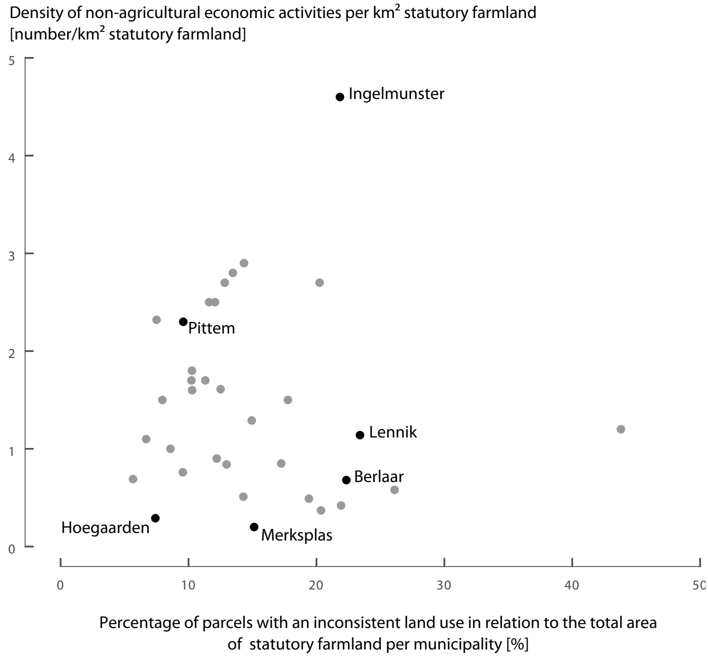


Figure 5.3
Characterization of case municipalities

The six case municipalities analyzed here capture the diversity of both the number of non-agricultural enterprises per km² of statutory farmland and the relative share of parcels with an inconsistent determination of land use in relation to the total area of statutory farmland within each municipality. The scatter plot represents the position of the six municipalities out of 38 municipalities (Verhoeve et al., 2012).

5 Results

5.1 Mapping the information gap

For the region of Flanders, a GIS comparison of the 'spatial allocation plan' and the Flemish LPIS data at the parcel level indicates a difference between the areas allocated for agriculture (statutory farmland) and the parcels actually in agricultural use (actual farmland). As such, a fraction of 15 % of the Flemish area of statutory agricultural land has an inconsistent land use.

Inconsistent parcels are present everywhere in Flanders (Figure 5.4), but there are strong regional differences in concentration. In the western part and the south eastern boundary of Flanders, the presence of inconsistent parcels is below the regional average of 15 %. The central part of Flanders corresponds to the average. The central eastern part has the highest fraction with seven municipalities that have a inconsistently determined land use fraction of more than 50 % of the Flemish area of statutory agricultural land. The Brussels capital region is not presented in the datasets, which explains the white enclave in the middle.

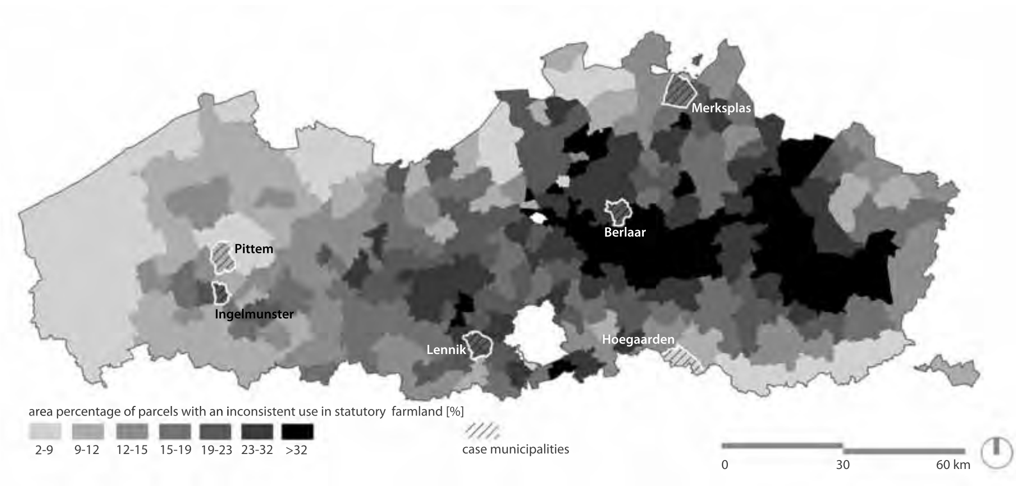


Figure 5.4 Distribution of parcels with an inconsistent land use

Parcels with an inconsistent land use are present everywhere in Flanders. The map represents the fraction of parcels with an inconsistent land use determination of statutory farmland in Flanders, expressed as a percentage of the area statutory agricultural land per municipality.

5.2 Filling the information gap

5.2.1 Inventory of actual land uses within the information gap

Table 5.1 provides an overview of the actual land use categories inventoried within the inconsistent parcels present in the six municipalities. The results indicate that almost 66 % of the inconsistent parcels is effectively characterized by an unconventional land use, such as domestic gardens, woodland, non-agricultural economic activities (NAEA), nature and buildings. The occupation of inconsistent parcels by domestic gardens ranges from 22.9 % to 46 % whereas the occupation by NAEA lies between 1.4 % and 10.5 %.

The summation of the land use categories 'arable land', 'greenhouses' and 'pastures' covers 32 % of the inconsistent parcels within the six municipalities (Table 5.1a). So, also agricultural land uses are present. The identification of 'arable land' and 'greenhouses' as being inconsistent land uses is probably due to the specificity of the Flemish Land Parcel Identification System (LPIS). Small farms (less than 2 ha) and farms that don't receive CAP subsidies are not registered in the LPIS (Bomans et al., 2010a). Greenhouses smaller than 2 ha are typically not registered.

Table 5.1 Uncoventional land uses and their coverage of farmland

Six unconventional and three agricultural land use categories were identified through orthophotograph and Google Streetview analysis. This analysis was carried out for all parcels with a land use that does not match official data sources, in the six case-study municipalities.

Table 5.1a The presence of the actual unconventional and agricultural land use categories identified through orthophotograph and Google Streetview analysis is expressed as a percentage of the total area of inconsistent parcels per municipality.

Case municipality	Unconventional land uses (% of the area of inconsistent parcels)						
	Nature	Forest	Domestic garden	NAEA	Building	Other	Subtotal
Berlaar	2.1	9.9	30.4	4.7	0.4	10.5	58.0
Hoegaarden	19.5	8.0	22.9	1.4	0.4	11.3	63.5
Ingelmunster	0.0	1.1	46.2	10.5	1.7	15.0	74.6
Lennik	0.1	9.6	43.8	3.0	0.5	2.6	60.5
Merksplas	1.3	24.0	28.2	3.6	1.3	7.6	66.0
Pittem	0.2	1.9	46.5	9.6	2.1	11.8	72.1
Weighted average	2.7	10.4	36.5	5.1	1.0	8.8	64.5

	Agricultural land uses (% of the area of inconsistent parcels)				Unknown (% of the area of inconsistent parcels)
	Greenhouse	Arable land	Pasture	Subtotal	
Berlaar	3.9	8.3	27.5	39.7	2.3
Hoegaarden	1.2	17.5	14.1	32.8	3.6
Ingelmunster	0.6	6.5	15.2	22.3	3.2
Lennik	0.04	6.9	31.9	38.8	1.4
Merksplas	1.3	11.8	16.6	29.7	4.2
Pittem	2.0	8.3	16.2	26.5	1.4
Weighted average	1.5	9.5	21.8	32.8	2,7

Table 5.1b The presence of the actual unconventional and agricultural land use categories identified through orthophotograph and Google Streetview analysis is expressed as a percentage of the total area of statutory farmland per municipality.

Case municipality	Unconventional land uses (% of the area of area of statutory farmland)						
	Nature	**Forest**	**Domestic garden**	**NAEA**	**Building**	**Other**	**Subtotal**
Berlaar	0.5	2.2	6.8	1.0	0.1	2.4	13.0
Hoegaarden	1.5	0.6	1.8	0.1	0.0	0.9	5.0
Ingelmunster	0.0	0.2	9.9	2.3	0.4	3.2	16.0
Lennik	0.0	2.2	10.0	0.7	0.1	0.6	13.7
Merksplas	0.2	3.6	4.2	0.5	0.2	1.1	9.9
Pittem	0.0	0.2	4.4	0.9	0.2	1.1	6.9
Weighted average	0.4	1.5	6.2	0.9	0.2	1.5	10.7

	Agricultural land uses (% of the area of area of statutory farmland)					Unknown (% of the area of statutory farmland)
	Greenhouse	**Arable land**	**Pasture**	**in LIPS, not considered in survey**	**Subtotal**	
Berlaar	0.9	1.9	6.2	77.5	86.4	0.5
Hoegaarden	0.1	1.4	1.1	92.1	94.7	0.3
Ingelmunster	0.1	1.4	3.2	78.6	83.3	0.7
Lennik	0.0	1.6	7.3	77.1	86.0	0.4
Merksplas	0.2	1.8	2.5	85.0	89.5	0.6
Pittem	0.2	0.8	1.5	90.5	83.0	0.1
Weighted average	0.2	1.5	3.6	83.5	88.8	0.4

The 21 % of the area of inconsistent parcels in use as pasture is probably in use by hobby farmers. The type of fences tells the difference between regular agricultural pastures and non-agricultural pastures. Professionals choose to use the cheaper barbed wire fence, whereas non-professional or hobby farmers typically use a whole range of fence types including wooden fences. So, not all parcels indicated by the GIS analysis as an inconsistent parcel can be labeled with certainty as 'being in unconventional use'. If we would assign all inconsistent parcels inventoried as pasture to hobby farmers, more than 86 % of this area is probably in non-professional agricultural land use, hence in use by hobby farmers.

5.2.2 Revisiting the statutory agricultural land stock

The area occupied by unconventional uses corresponds to an average of about 10 % of the statutory farmland per municipality (Table 5.1b). For each land use category, detailed figures are presented. These results indicate that domestic gardens occupy an area between 1.8 % and 10 % of the statutory farmland, on average 6 %. An area between 0.1 % and 2.3 % of the statutory farmland is occupied by non-agricultural economic activities. So, based on the in-depth investigation of the inconsistent parcels of six municipalities, at least 10 % of the statutory farmland has a non-agricultural land use. These results indicate that the actual availability of farmland is lower than the ideal figure provided by policy within the statutory spatial allocation plan. Also, the inconsistency between the official land use data sets can largely be explained by the presences of non-agricultural land uses.

6 Discussion

6.1 Methodological eclecticism

The combination of the orthogonal perspective (orthophotographs) with the Streetview perspective (images of Google Streetview) was very useful to support the data collection on domestic gardens and non-agricultural economic activities (NAEA). Streetview images give a better sight on human-made objects. The characteristics of such human-made objects can provide an additional layer of information on land use practices. This conclusion is also supported by a recent study of Hersperger et al. (2012).

Especially in Flanders with its dense transport infrastructure for motorized vehicles, the use of the Google Streetview add-in comes close to an in-field inventory.

It is faster than intensive on-field inventories while safeguarding a satisfactory degree of reality. In regions with a well elaborated transport infrastructure we certainly recommend to use Google Streetview images as a cross reference to orthophotograph analysis. The SIGGIS add-in (SIGGIS, 2013) proved to be convenient for this integration.

6.2 The information gap: a mismatch between current policy and reality

In this study, the comparison of the spatial allocation plan and Land Parcel Identification System (LPIS) revealed an inconsistency in the determination of the actual land use for certain parcels located within statutory farmland. This inconsistency indicates an information gap. Within the studied territory, 15 % of the statutory farmland has no registered agricultural use.

The results of the morphological analysis of these inconsistent parcels show the presence of a wide range of unconventional land uses, like domestic gardens, non-agricultural economic activities and nature development. This observation confirms the widely described trend that rural areas are becoming more and more multifunctional and complex (Fry, 2001; Hersperger et al., 2012; van Eupen et al., 2012).

Until now, insight in the fractions of allocated farmland under unconventional land use was limited. Within a small and very specific study area in Flanders, Bomans et al., (2010a) inventoried 44 % of the statutory agricultural land as occupied by a non-agricultural land use. This high percentage of impurities was mainly ascribed to houses and gardens of non-farmers and land used for recreational farming. Our results confirm the observations by Bomans et al. (, 2010a) and quantify in a more extensive way the area within statutory farmland occupied by domestic gardens. In the six municipalities domestic gardens occupy on average 6 % of the statutory farmland. Extrapolated to Flanders about 4.3 % of the total garden area (4,700 ha) currently occupies statutory farmland. This figure gives a first insight in the cumulative effect of garden area intake of agricultural land. Although further investigation is needed on the representativeness of these figures, this does raise the call to include rural areas in studies about the spatial coverage by domestic gardens. Currently the vast majority of such studies only deals with urban gardens (Loram et al., 2007; Van de Voorde et al., 2008; Goddard et al., 2010).

As Hajer and Zonneveld (2000) and Bomans et al. (2010b) already stated, we still understand little of countryside dynamics. Insight on what is going on in rural areas is considered vital if evidence-based policy is to guide the rural development (Slee, 2005). Our results confirm the statement by Paquette and Domon (2003) that the dynamics of residential behavior and domestic practices in rural areas, often unrelated to agriculture, challenge planning policies and merit closer investigation. The information on domestic gardens and NAEA obtained by this study should be subject of policy considerations on farmland preservation and land use planning, especially in regions where there is a strong competition for land.

6.3 Explaining the underestimation of unconventional uses

The obtained figures only present a minimum scenario, implying that the magnitude of unconventional use of statutory farmland is still underestimated. We propose two explanations for this underestimation.

The first explanation is related to methodological choices concerning the identification of inconsistent parcels. We restricted the actual land use inventory to parcels that were completely allocated to agricultural use in the spatial allocation plan and for which no actual agricultural use was declared in the Land Parcel Identification System (LPIS).

We did not consider parcels that were assigned a mixed allocation in the spatial allocation plan. This way, ribbon development (Verbeek et al., 2011; Verbeek et al., 2014) and residential allotments in the surroundings of hamlets and villages were excluded from the analysis. Allocation regulations for such ribbon development in rural living areas stipulate that all constructions need to be located within a building strip of maximum 50 m deep, measured from the building line. Yet, based on field knowledge we know that domestic gardens intrude much deeper into the agricultural land. Often these intruding garden shares contain a garden shed, for gardening equipment and firewood, a pool house, etc. So, domestic gardens also occur in the agricultural allocated parts of mixed parcels. Further research could focus specifically on these mixed parcels to extent the insights obtained from the present study.

Also the use of the LPIS can introduce an underestimation. Although the LPIS is considered to be a good approximation of the actual agricultural land use in Flanders (Danckaert, 2013), the possibility exists that also LPIS parcels are occupied by unconventional uses. We thus might expect that the relative importance is even higher in reality.

A third explanation can be found in the land use category 'pasture'. This land use was classified as an agricultural land use of statutory farmland, although it is reasonable to assume that a certain part of this pasture is no longer under professional agricultural use. This despite a particular attention for the pasture fencing during the in-depth analysis. Bomans et al. (2011a) indicated that about one third of the grasslands, corresponding to about 40,000 ha in Flanders, is occupied by hobby horses.

6.4 VIRTUAL FARMLAND

To turn the vagueness of the information on the actual and allocated use of farmland in Flanders to a framing concept that is applicable elsewhere, the concept 'virtual farmland' is introduced. Virtual farmland is the land within zones allocated for agriculture that is under an unconventional use.

Based on this definition, a distinction can be made between different stocks of farmland. The ideal stock of agricultural land reserved for farming by spatial planning policy is subdivided into an 'actually used', 'actually available' and 'virtually available' stock. In the actually available stock, the land is effectively available as farmland. In the virtually available stock unconventional land uses occupy land that is legally demarcated as agricultural land.

This conceptualization of virtual farmland provides a framework to investigate unconventional land uses that are currently hidden for policy. The adjective 'virtual' is used in analogy with Würtenberger et al. (2006), Qiang et al. (2013) and Allan (Allan, 1998) to point at an underestimated or 'hidden' part of a general conception. Further correspondence is found with the 'plan tare', as described by Bomans et al. (2010a) as those areas zoned for agriculture that are not in actual agricultural use. In addition to the use of the term virtual to point to a hidden characteristic, it also has a more inclusive meaning in linguistic terms. The overall 'common- sense' image on the availability of farmland is virtual as it incorporates both an actual present and available part and a deviating part.

An example of a more inclusive definition of a virtual reality is used by van der Ploeg (2003) in his description of the 'virtual farmer'. He uses the concept of virtual farmer to question the general shared idea on farmers used in different policy domains.

It is an attempt to incorporate the complexity of reality. In that sense, the aim and conceptualization of both van der Ploeg's virtual farmer and virtual farmland in this paper are similar. The concept of virtual farmland specifically refers to non-agricultural land use of statutory farmland. The concept can be broadened when using the term 'virtual land', to refer to all kinds of inconsistent use of different land use allocation categories.

The 'virtual farmland' concept also provides a methodological contribution. We present the comparison of official datasets as a 'quick scan' to get a first indication of virtual farmland parcels. Also Haldrup and Stubkjær (2013) refer to the usefulness of concepts to make progress in monitoring little known processes. The combination of the quick scan and cross-referenced in-depth analysis adopted in this study overcomes the difficulties to map unconventional land uses like domestic gardens. The fact that the quick scan does not depend on a land cover analysis is a major difference with standard land use monitoring methods which have proven to be insufficient in identifying unconventional land uses in complex and multifunctional rural areas. A regularly update of the original datasets used by the quick scan creates opportunities to monitor future unconventional land use changes. Building a time series of the yearly area of indicated virtual farmland could lead to an index. Therefore, we encourage a multi-temporal use of the quick scan.

6.5 Virtual farmland putting pressure on farmers

Until now, current policies in Flanders assume that farmers experience a great pressure as a result of the strenuous competition for land. Such spatial pressure on agricultural land is generally explained by large scale land intake by competing sectors (industry, infrastructures, housing, nature conservation, etc.) through planned and politically approved conversions. The insights on virtual farmland reveal a complementary type of pressure resulting from cumulative effects. The occupation of farmland by unconventional land uses leads to a decrease of the actual farmland availability. These unconventional and often small-scaled transformations of farmland can be related to the consumption function of the countryside (garden sprawl, horsification, non-agricultural economic functions, etc.).

Although this trend is widely acknowledged (Woods, 2005; Vouligny et al., 2009; Rogge and Dessein, 2013) little empirical evidence can be found that quantifies the magnitude and impact of these consumption-related functions (Slee, 2005).

Although this study provides insights in pressure in terms of area occupation, insights in other aspects are still needed to better understand the pressure from these unconventional land uses experienced by farmers (Jaarsma and Vries, 2013). One of the major issues that remains unclear is the extent to which these processes augment the average price of agricultural land.

6.6 Virtual farmland as a policy challenge

The concept virtual farmland illuminates an aspect of the multifunctional character of rural areas that is, until now, only little known by policy makers. The presence of virtual farmland challenges planning practices that currently largely ignore the presence of non-agricultural uses in statutory farmland. This could be mainly ascribed to the sectoral policy approach in rural areas. Our quantification underpins the spatial importance of the occupation of statutory farmland by unconventional land uses in general and by domestic gardens in particular. As such, virtual farmland can be interpreted as an erosion of the agricultural function of rural areas from inside out.

Also, the disappearance of agriculture from parcels allocated for agricultural functioning due to the transformation to domestic garden increases the pressure of agriculture on more vulnerable areas. In this respect the problem-solving capacity of current spatial planning systems and sectoral management can be questioned. These results endorse the widespread critique that sectoral zoning approach of spatial planning and territorial management fail to appreciate the complex dynamics in rural areas, as for example expressed Graham and Healey (1999).

The identification of virtual farmland can be interpreted as a hidden field of tension within all policy domains working with agricultural land availability. The primary focus on planned land use change (Kerselaers et al., 2013) by policy makers, agricultural stakeholders as well as researchers disregards the impact of unconventional conversions. In general, about 10 % of the statutory agricultural land appears to have an unconventional land use. This corresponds to an estimated 78,800 hectares of virtual farmland. At the same time, planned conversions of statutory farmland to housing, industrial areas etc. will effect 56,000 ha of statutory farmland in Flanders (Ministerie van de Vlaamse Gemeenschap, 1998).

Comparing both figures accentuates the relative importance of unconventional land uses. We therefore plead that policy makers as well as researchers pay attention to the pressure on agricultural land by unconventional land use changes.

Yet, we also detect potential within these unconventional uses, especially for such a highly complex and dynamic region as Flanders. Similar to the work by Qviström on disorderly places, attention for unconventional land uses and virtual farmland may lift the analysis of landscape transformations beyond the rural–urban divide. A more multifaceted analysis becomes possible, facilitating a more open discussion on land use and values within planning (Qviström, 2007).

To get grip on the complex rural reality, also the actors of these non-agricultural land uses should be engaged in more collaborative planning processes which engages to full array of stakeholders (Healey, 1997; Healey, 1998, 2007). So, besides considering domestic gardens as consumers of agricultural land, we can also look at the open and green space in rural areas that is provided by them. A similar approach was tested in the Westhoek (Flanders), where design was used to explore transformations from the consumption of the landscape to the delivery of ecosystem services by NAEA (Foré et al., 2012).

Insights in the presence of domestic gardens in rural areas open the way for additional perspectives on a multifunctional countryside. As Antrop and Van Eetvelde (2008) state, domestic gardens must be considered as important green spatial networks. To optimize the quality of domestic garden greenways, we can start thinking about local criteria for planning and designing multifunctional landscapes from the plot level onwards, as suggested by Pérez Campaña and Valenzuela Montes (2013) for a site in Granada, Spain. Guidelines on the selection of gardens plants could be part of such criteria, including attention for invasive species (Reichard and White, 2001; Bardsley and Edwards-Jones, 2007; Smith et al., 2007; Yemshanov et al., 2011) and plants that contribute to biodiversity (Helfand et al., 2006; Andersson et al., 2007; Andersson and Colding, 2014).

All this underlines the need for a more collaborative planning which engages the full array of stakeholders within rural areas (Healey, 1997; Healey, 1998, 2007), including private stakeholders owning a garden.

7 Conclusion

Chapter 4 already indicated that domestic gardens cover an important share of the Flemish territory. The results presented in this chapter proved that domestic gardens are also a non-negligible occupier of statutory farmland. The fact that their roots lie in the deliberate promotion of ownership of a house with a garden in rural areas (Chapter 3) explains a part of the impurities within agricultural land represented by the spatial allocation plan. Yet, these impurities continue to be supplemented with both planned gardens due to housing, and unconventional garden sprawl. This raises the call to expand studies on the spatial coverage by domestic gardens beyond the demarcations of urban areas.

The presence of unconventional land uses and their cumulative effects challenge spatial and agricultural policies. By focusing on the presence and types of unconventional land uses in statutory farmland, we contributed to the knowledge on the complex rural reality. Our definition of the concept 'virtual farmland' as statutory agricultural land under non-agricultural uses can be a powerful approach to theorize and make progress in monitoring the so far little known occupation of statutory agricultural land by unconventional land uses. Especially in regions with a strong competition for land, the quantification of virtual farmland provides a scientific basis to weigh different spatial claims. In addition, this concept also provides a framework to explore other types of inconsistently determined land uses, for example the residential use of nature conservation areas.

Especially in complex and fast changing rural areas, this exercise may shed a different light on discussions about the management of different spatial claims. Insights in what is going on within these agricultural zones are considered as vital if evidence-based policy is to guide the rural development into the future.

Chapter 6 is based on
Dewaelheyns, V., Elsen, A., Vandendriessche, H., Gulinck H., (2013). Garden management and soil fertility in Flemish domestic gardens. Landscape and Urban Planning 116, pp. 25–35.

The presented research was conducted in 2008.

6. GARDEN MANAGEMENT AND SOIL FERTILITY

"The garden suggests there might be a place where we can meet nature halfway."

Michael Pollan

This chapter maps the ecosystem function of 'nutrient cycling' in garden soils. The focus lies on fertilizer use and soil fertility states.

1 Introduction

The fabric of urban and residential areas does not solely exist out of buildings, roads and artificially surfaced areas. Unpaved land, including parks and gardens, makes up a large part of urban cores and of semi-urban residential areas, villages, hamlets and sprawled development (Gaston et al., 2005; Smith et al., 2005; Daniels and Kirkpatrick, 2006; Gill et al., 2008; Allen, 2003), resulting in complex mosaics of vegetation and multiple land use (Foresman et al., 1997). This paper focuses on domestic gardens: gardens intimately and spatially associated to a building, within the confines of a single parcel. They are essentially private elements, and so tend to be absent from public and political attention.

In Flanders, the northern part of Belgium, domestic gardens take up a significant part of urban as well as of suburban and rural areas. According to Chapter 4, about 8 % of the Flemish area is covered by domestic gardens, a figure comparable to the regional forest cover of 11 % (Van der Aa, 2007). As discussed in Chapter 1, there are a few studies giving figures for garden coverage in other countries. In Europe, domestic gardens take up between 22 % and 27 % of the total area within the administrative city boundaries of Edinburgh, Belfast, Leicester, Oxford and Cardiff (UK) (Gaston et al., 2005; Loram et al., 2007; Tratalos et al., 2007), and 16 % of the central part of Stockholm, Sweden (Colding et al., 2006). In Dunedin, New Zealand, the vegetated garden area occupies 46 % of the residential area, and 36 % of the total urban area (Mathieu et al., 2007).

1.1 The environmental impact of gardening

According to Mathieu et al. (2007), gardens are the least understood ecological habitat type compared to other types of urban green space. This being said, it is interesting to note that scientific literature strongly focuses on gardens in an urban context. Rural gardens are much less present in the research picture. In countries with dispersed housing and dilute urban sprawl, like Belgium (Kasanko et al., 2006), many gardens are to be found in a rural or peri-urban context.

Scientific literature shows a growing academic attention for characteristics, functions and services of gardens (Gaston et al., 2005; Cameron et al., 2012). In general, these papers seek proofs of positive contributions of gardens. Gardening is often promoted as an environmental friendly pastime (Cameron et al., 2012). But gardening, an intimate interaction between society and environment (Martin et al., 2004; Cook et al., 2012), can also have negative impacts on the environment (Steinberg, 2006). These include nitrogen excesses from (lawn) fertilizer usage (Baker et al., 2007; Lorenz and Lal, 2009; Livesley et al., 2010; Trudgill et al., 2010), the distribution of invasive species (Williams and West, 2000; Reichard and White, 2001; Bardsley and Edwards-Jones, 2007; Smith et al., 2007; Niinemets and Peñuelas, 2008), increased soil sealing (Stone, 2004; Perry and Nawaz, 2008; Verbeeck et al., 2011a; Verbeeck et al., 2011b) and water (ab-)use (Syme et al., 2004; Harlan et al., 2009; Breyer et al., 2012; Runfola et al., 2013).

The widespread character and popularity of gardening should trigger research on its environmental effects (Clayton, 2007). Of particular interest are the health and environmental impacts of the application of chemicals (essentially fertilizers, herbicides and pesticides) in gardens (Robbins et al., 2001; Grey et al., 2006). As Collins et al. (2000) state clearly, people mobilize nutrients and pollutants. The results of a survey by M.A.S.et al. (2007) questioning 500 inhabitants spread over 38 Flemish municipalities revealed that 49 % of the respondents use chemical products and/or mineral fertilizers in garden management in 2006. For comparison, about 88 % of the farmers used chemical nitrogen fertilizers and about 60 % used chemical phosphorus fertilizers in 2010 (Lenders et al., 2013).

The scarcity of academic information in English on gardens and their soils is stressed by several authors. Lorenz and Lal (2009) report the scarcity of data about soils in urban areas, and Kaye et al. (2004) point to a gap in the knowledge of regional biogeochemical fluxes because of the exclusion of urban lawns and gardens from analyses and monitoring programs. This exclusion of gardens is based on the assumption that the urban land area is too small to contribute significantly to biochemical fluxes. Research meanwhile illustrated the significance of territorial coverage by gardens, indicating the possibility of large fluxes.

So far, the overall influence of domestic gardens on the environment has not been systematically investigated. This is probably due to reasons which can also help to explain their absence from environmental and land use policies. The physical fragmentation in property and size of gardens (Zmyslony and Gagnon, 1998) results in an extreme heterogeneity in composition and management (Van Delm and Gulinck, 2011). Because of this diversity, it is a challenge to conduct a systematic data collection on environmental aspects of gardens. Next to this, access to data is limited because of the private character of domestic gardens. Collecting a body of data on garden management characteristics in regional perspective requires the involvement of a large number of individual garden owners.

Fertilization of garden soils is one of the key entries to bring domestic gardens on the agenda of regional environmental monitoring and policy. Research on this topic is often limited to fertilizer use on home lawns while literature review provides mainly information from the United States (US). The use of mineral fertilizers for maintaining lawns leads to nitrogen excesses (Zhu et al., 2004; Kaye et al., 2006; Lorenz and Lal, 2009) and contributes significantly to greenhouse gas emissions (Howarth et al., 2002). Both Livesley et al. (2010) and Bijoor et al. (2008) observed a peak emission of nitrous oxide due to the application of lawn fertilizer, with lawns emitting up to ten times more nitrous oxide than neighboring agricultural grassland (Livesley et al., 2010). Livesley et al. (2010) even suggest that reducing fertilizer application to lawns can help mitigate greenhouse gas emissions. An interesting alternative for mineral fertilizers is compost, offering a lower carbon cost alternative for supplementing a mineral nitrogen fertilizer (Lillywhite and Rahn (2008) in Cameron et al. (2012)) and displacing pollution, energy and other externalities associated with the extraction and transport of mineral fertilizers (Favoino and Hogg, 2008).

1.2 Research objectives

Addressing the ecosystem function of nutrient cycling, this paper explores the impact of domestic garden management on soil fertility. The focus lies on the use of fertilizers and soil conditioners, home compost and the removal of grass clippings. The paper seeks to initiate a methodology in combining the results of two independent sources of information: an internet survey on garden management and a database on garden soil fertility (Figure 6.1).

The specific objectives of the internet survey were twofold: (i) identify used fertilizers and/or soil conditioners, the destination of grass clippings, and the composting practices and (ii) quantify the applied amounts of the fertilizers and soil conditioners, and of the removed grass clippings.

The specific objective of the soil fertility study was to assess the soil fertility status of Flemish gardens, in comparison to that of arable land and pastures. Bringing together these results with scientific literature sheds light on the environmental impact of management practices in the complex of domestic gardens in Flanders and on the needs of further research.

2 Methods

To allow an analytical approach of the individual domestic garden in an environmental context, a garden is conceptualized as an input–output model (Van Leeuwen, 1981; Collins et al., 2000). The physical 'garden system' is defined in this paper as follows. A domestic garden is spatially related to a dwelling that is privately owned or rented. It is defined as the part of a residential parcel with exclusion of the associated house. Pasture for recreational farming or extensive woodlots, as well as storage space for building materials or refuse are excluded from this definition.

In accordance with Cameron et al. (2012), it is a precondition that residents have autonomy over the garden management, although responsibility can be delegated to professional gardeners. Allotment garden sites and dispersed gardens without spatial correlation to a dwelling are not considered.

Data is collected using two independent methods: an internet survey on garden management, and soil sample analyses on garden soil fertility collected in a database (Figure 6.1).

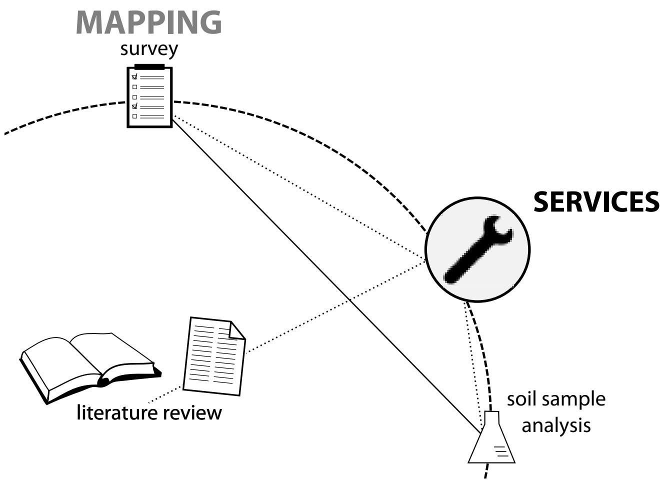


Figure 6.1
Overview of the methods used in Chapter 6
Data is collected using an internet survey on garden management, and through soil sample analysis. The full line in the figure indicates that the results from the survey and soil sample analysis are combined.

2.1 Internet survey

Data on the use of fertilizers and the processing or removal of organic garden waste was collected by an anonymous online survey among garden owners in Flanders (www.tuinenquete.be). This internet survey was part of a broader research project, in which data on 285 garden variables was collected. These variables include characteristics of the physical garden, garden management, and the household. From these 285 variables, those concerning the selected management categories (fertilizer use, compost and grass clippings) were extracted (Table 6.1).

The advantages of an internet survey are plural. Answers are automatically stored in a database, the whole survey can be conducted at high speed and low-cost (Reips, 2002; Malhotra and Birks, 2003; Roth, 2006; Couper et al., 2007) and a large number of respondents from different regions can be reached easily (Reips, 2002). There are also fewer organizational problems, the survey is easily accessible and participation is more voluntary compared to surveys by telephone or door-to-door (Roth, 2006). The internet survey was direct, meaning that the respondents were informed about the goal of the research (Malhotra and Birks, 2003).

Attention was given to self-selection, drop-out and survey design quality as suggested by Reips (2002). These are all known factors in the reliability of internet surveys. Efforts to avoid drop-out were among other things the organization of the questionnaire in thematic blocks, giving the respondents an idea on their progress within the questionnaire, leaving out non-relevant questions based on former answers and the prospect of a reward. To be able to pick up a feasible bias towards more passionate and ecological gardeners, the respondents had to score two theses

("*I see myself as a passionate gardener*" and "*I see myself as an ecological gardener*") in a Likert scale with five response alternatives (1 totally disagree – 5 totally agree). A scale of five is sound enough in terms of reliability and validity (Lozano et al., 2008). The terms 'passionate gardener' and 'ecological gardener' were deliberately not defined.

The design of the questionnaire was split up in three phases: (i) a trial questionnaire, (ii) a first questionnaire and (iii) the final questionnaire. The trial questionnaire was based on a full list of variables, composed by a group of thirteen environmental and/or garden experts. These variables were translated into unequivocal survey questions, since misinterpretation results in a bias (Malhotra and Birks, 2003). Comparison of quantitative results asks for uniformity in the answers. Respondents were offered both a range of units to choose from and illustrations on the volumes of well-known reference items in common garden management, like a bucket (10 l), a small (35 l), medium-sized (55–60 l) and large (70–75 l) collection tray of a lawn mower and a wheelbarrow (80–85 l).

The trial questionnaire and the offered range of units and illustrations were tested by means of four test-visits to voluntary garden owners. This resulted in an improved formulation of the questions and a selection of the easiest way for respondents to quantify fertilizers and organic waste (Table 6.2). The questionnaire was then built into a website and tested by twenty test-respondents during a period of two weeks to (i) verify the phrasing of the questions once more and (ii) to detect possible technical problems.

Once launched, respondents were invited by e-mail to participate in the survey. Initially, the addressed respondents were colleagues, friends, family and acquaintances. They were asked to further distribute the survey, a method called the 'snowball-effect' (Malhotra and Birks, 2003). As such, the data was collected for a non-random snowball sample. As a complementary promotion strategy, the questionnaire was linked to several websites and included in the Google search engine. After a predefined period the survey closed for participation but remained on-line for consultation. The MySQL-database was exported to Excel and prepared for data processing and analysis.

There is no information available on the characteristics of garden owners and tenants in Flanders, or on the overall population size of garden owners. To have some guidance for reflection on the number of completed surveys, we calculated

Table 6.1 Overview of the questioned variables related to garden management

During the internet survey, eight of the 283 questioned variables were specific quantitative management variables on nutrient cycling. These variables focus on the use of fertilizers, mowing and pruning.

Variables questioned by the internet survey
Use of purchased fertilizers and/or soil conditioners
Number of times a year soil fertilizers and/or soil conditioners are used in the garden
Fertilizers and/or soil conditioners, used during 2007: Compost (own home, garden centre, compost producer, local communal recycle centre or other), Peat, Organic fertilizer, Mineral fertilizer, Lime, Potting compost, Bark, Chopped wood
Frequency of lawn mowing
Use of mulch mowing
Destination of grass clippings: VGF-collection, home compost, collection on a pile or in a pit without the intention to compost, mulch layer on the lawn, local communal recycling centre, other destination outside the garden
Number of times a year the owner prunes
Destination of prunings: selective waste collection, collection on a pile or in a pit without the intention to compost, home compost, local communal recycle centre, used in the garden after wood chopping, used in recycle gardening, used in the fireplace, other

Table 6.2 The selected units for quantification variables

Respondents were assisted by providing the most comfortable units for answering quantity questions. These units were selected based on four test surveys. These units for quantitative management variables were used during the internet and door-to-door surveys.

Quantitative management variables	Selected units
Solid fertilizers and/or soil conditioners used in the garden in 2007	Kilogram
Liquid fertilizers and/or soil conditioners used in the garden in 2007	Litre
Grass clippings removed from the garden in 2007	Litre
Prunings removed from the garden in 2007	Bundle, length of 1 m, diameter of 30-40 cm

the minimal number of respondents (n_0) to consider for analysis so the necessary minimum sample size. Since the total number of garden owners and tenants in Flanders is not known, an infinitely large population is assumed. The following equation was used (California Department of Resources Recycling and Recovery, 2010): $n_0 = z^2p(1-p)/r^2$, with z = 1.96 (value for the 95 % confidence interval), p = 0.5 (estimator for the unknown participation level of 50 %), and r = 0.05 (5 % accuracy level). As such, a total of at least 385 surveys must be completed. The respondents who have been managing their garden for at least 12 months were retained for further analysis.

Statistical analyses were conducted by means of SPSS 15.0 at a significance level of 0.05. We assumed that the respondents were capable of estimating the amounts of fertilizers used and the amounts of organic waste exported. Since the main goal of this pilot survey was to form an idea of orders of magnitude rather than giving a detailed quantitative analysis, such approximate estimations are acceptable in our opinion. A help-page could be consulted anytime during the survey, explaining the term garden and the units for quantification. Descriptive statistics were used for the analyses of the quantifications.

2.2 Soil sampling and analysis

Soil fertility was assessed by means of data from the soil database of the Soil Service of Belgium (SSB). This database consists of more than 14,500 analyses carried out on soil samples from 1,817 gardens in Flanders, including both domestic and public gardens. These samples were taken between August 2007 and July 2009 (Table 6.3). The following eight parameters were analyzed: soil texture, acidity, carbon content, and the amount of phosphorus (P), Magnesium (Mg), potassium (K), sodium (Na) and calcium (Ca). For greenhouses, salt concentration was additionally analyzed. Nitrogen (N) was not measured since it is a mobile element: the moment of sampling influences the measured concentration and measurements only represent a snapshot.

Public gardens were analysed together with private gardens, since (i) the proportion of public gardens accounted for less than 5 % of the total database and (ii) their soil fertility status matched those of private gardens. The garden samples were not taken randomly, but originated upon request (i) by the establishment of new gardens, (ii) because of observations of poor plant growth or (iii) by interested home gardeners. The first group covers about 26 % of the total number of analyzed gardens.

Table 6.3 Number of soil samples and analyses

A total of 1,817 of gardens were sampled, and 14,536 analyzes on parameters were carried out. The table indicates per garden type the number of soil samples and analyses from domestic and public gardens in Flanders, carried out by SSB (August 2007 - July 2009).

Garden type or component	Number of gardens (equals the number of soil samples)	Total number of analysed parameters [a]
Garden under construction	483	3,864
Vegetable garden	393	3,144
Ornamental garden	420	3,360
Lawn	483	3,864
Greenhouse	38	342
Total	1,817	14,536

[a] soil texture, acidity, carbon content, amount of P, Mg, K, Na, Ca and salt concentration (only in greenhouses)

The observation of poor plant growth does not necessarily mean that less-fertile gardens are over-represented: unfavorable proportions between nutrients can be due to either a lack or an excess of fertilization. Both phenomena can lead to antagonisms in the uptake of minerals, causing symptoms of deficiency as well as of excess of nutrients.

The following parameters will be discussed: acidity (pH), carbon content (C) and the amount of phosphorus (P).

In the ornamental and vegetable gardens and in gardens under construction at least 25 subsamples of the soil were taken down to a depth of 23 cm. In lawns, at least 35 subsamples were taken down to a depth of 6 cm. The samples, each weighing at least 600 g, were stored in a cotton bag and labeled with a barcode. Next to the soil sample, information of the sampled garden was recorded on an information sheet. The pH was measured in a potassium chloride (KCl)-solution, resulting in a more stable measurement than one using an aqueous solution because the measurement is made independent of the moment of sampling (ISO 10390:2005). The carbon content was determined in accordance with the adapted Walkley–Black method and expressed in percentage by weight (Walkley and Black, 1934).

The P content was determined using Inductively Coupled Plasma after extraction in ammonium-lactate. The results were expressed in mg per 100 g of air-dried soil. Both the sampling procedure and the analytical methods used by SSB are BELAC-accredited (BELAC, 127-TEST).

In order to interpret soil analyses, SSB relies on soil fertility classes for the different soil fertility variables related to the agricultural standards of optimal plant growth. The agricultural standards provide a clear and interpretable reference. They make it possible to make comparisons with agricultural land. The soil fertility classes are based on extensive field research combined with 65 years of experience in the agricultural and horticultural sectors. The knowledge gathered from long- and short-term field trials is integrated in response and surplus functions, which are at their turn integrated in BEMEX, a fertilizer expert system (Vandendriessche et al., 1996). The soil fertility classes are defined for specific garden types or component (ornamental, vegetable, lawn, and greenhouse). These classes take soil texture and organic matter content into account.

For each garden type, seven soil fertility classes were distinguished ranging from 'very low' to 'very high'. The effective ranges of these fertility classes are given in Appendix B, taking soil type into account. The adjectives 'low' and 'high' mean that the soil fertility state is situated outside the optimal ranges. In the optimal range (i.e. the middle soil fertility class), most plants will show an optimal growth provided that rational fertilization and liming is applied. The optimal zone is not only an agronomic optimum (optimal plant growth), but is also an environmental optimum since it corresponds to a minimal amount of nutrient leaching (Elsen et al., 2010).

3 Results and discussion

3.1 Internet survey

During the period between October 17th 2007 and February 1st 2008, the first page of the survey was opened 5,942 times. This indicates that the snowball sampling method has worked. In total, 62 % of these respondents completed the inquiry, giving a total drop-out rate of 38 %. Analyzed per page, the highest drop-out rate (22 %) occurred at the first page. An analysis of the time records suggests that most respondents had a first look at the survey during working hours, probably to decide whether or not to participate with the survey at home after work.

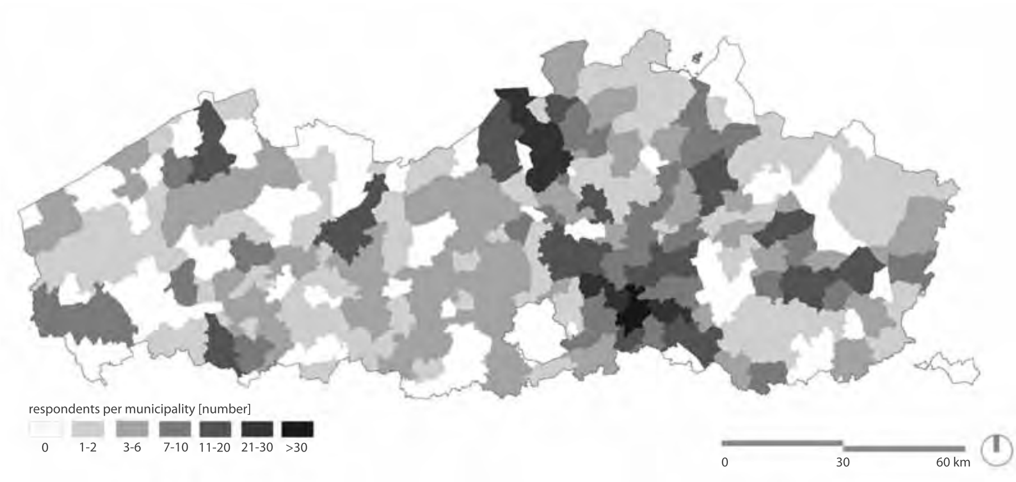


Figure 6.2 Distribution of the respondents of the internet survey
The respondents of the internet survey were non-uniform distributed over Flanders. There are higher concentrations in the city of Leuven and its periphery, as well as other urban areas. The map represents the geographical distribution of the respondents in Flanders, giving the number of respondents per municipality (N = 1,138).

This drop-out rate could have been avoided by giving model questions or a warming-up exercise in the survey introduction, as mentioned by Reips (2002). The low drop-out rates after the first page, ranging between 4.7 % and 0.3 %, might be the result of the measures built-in against dropout. From the initial 3,680 respondents that completed the survey, only 1,138 respondents were withheld for further analysis because of technical problems with the database. This number exceeds the minimal required sample size of 385 completed surveys. These respondents represent 1.39 km^2 of surveyed garden area. This is 0.13 % of the total garden area in Flanders according to Chapter 4. There was a non-uniform geographical distribution of the respondents, with higher concentration in the city of Leuven and its periphery (Figure 6.2), as well as in other urban areas.

The bar charts of the 'Likert' scores of all respondents (N=1,138) are shown in Figure 6.3. For both theses, "*I see myself as a passionate gardener*" and "*I see myself as an ecological gardener*", the largest group declares itself to be rather neutral. A minority, being 2 % and 4 %, had no opinion about their degree of respectively passion for gardening and ecological gardening. Since no skewness or edge peaks are observed, we expect to have no bias towards more ecological and/or passionate gardeners, of which one can assumes they would be more likely to complete the survey. See Appendix C for the socio-demographic profile of the respondents.

3.2 Fertilizers and/or soil conditioners

About half of the respondents (52 %) stated to apply fertilizers and/or soil conditioners at least once a year. Of these 592 respondents, 38 % uses fertilizers twice a year, and 10 % five times per year. Translated to garden areas, frequent use of purchased solid fertilizers occurs in 36 % of the surveyed garden area. For liquid fertilizers this is 35 % of the surveyed garden area. Less than once per year application occurs in 22 % of the surveyed gardens. In 11 % of the surveyed gardens, purchased fertilizers and/or soil conditioners are used only once when planting in the garden. No purchased fertilizers and/or soil conditioners are used at all in 15 % of the surveyed gardens.

More than half of the respondents who regularly use purchased fertilizers and/or soil conditioners can estimate the quantities used in 2007 (Table 6.1). They used on average 0.07 kg per m^2 of surveyed garden. For comparison, this is double the amount applied on grass areas registered by Jo and McPherson (1995) within two neighborhoods in northwest Chicago. Lime, compost and organic fertilizers are the most frequently used products, each being used in 30 % to 35 % of surveyed gardens (Figure 6.4). The majority of the compost used in gardens is home-made (70 %).

3.2.1 Grass clippings

Lawn is mown more than 10 times per year by 81 % of the respondents. Mowed grass lawns are sources of carbon dioxide (Lorenz and Lal, 2009). This statement is underpinned by Jo and McPherson (1995) who calculated a principal net carbon release from grass/lawn maintenance: at an annual mowing frequency of around 20 times, grass mowing returned annually 1.5 times the annual amount of carbon sequestrated by grass. The recorded annual mowing frequency in Flanders is half the frequency recorded by Jo and McPherson (1995), so we expect the net carbon release effect due to mowing to be less. In 35 % of the gardens, grass clippings were removed to a destination outside the garden in 2007 (Figure 6.5).

For the respondents able to quantify, the estimated amount of the grass clippings that was removed is 2.3 l per m^2 of garden (Table 6.5). The main share of exported grass clippings is removed with the selective waste collection of vegetables, fruit and other garden waste or is brought to the local recycle centre. A small fraction of the grass clippings was reported to be exported to the neighborhood as feedstuff for animal keepers or to be disposed as clandestine dumping.

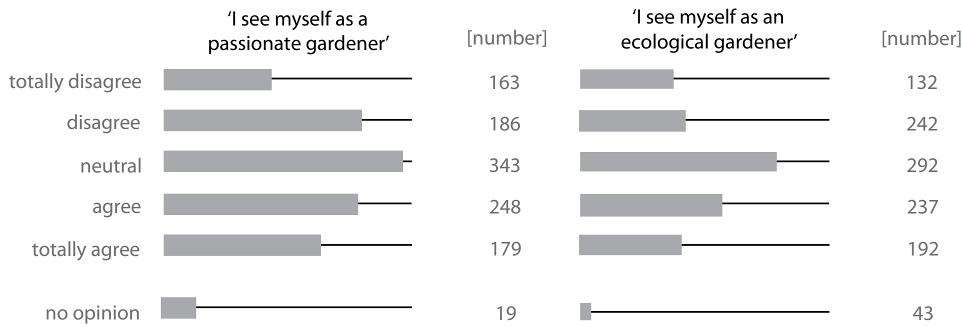


Figure 6.3 Results of the Likert-scores for the theses on passionate and ecological gardening

Most respondents did not appear to consider themselves as extremely passionate or ecological gardeners. As such, no bias is expected towards more ecological and/or passionate gardeners, of which one can assumes they would be more likely to complete the survey. The bar charts represent the Likert-scores (N = 1,138).

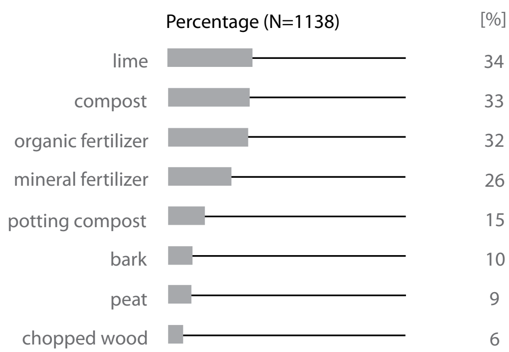


Figure 6.4
Overview of the used fertilizer and/or soil conditioners

Lime, compost and organic fertilizer are the most frequently used fertilizer and/or soil conditioners. The percentage gives the share relative to the total number of surveyed gardens (N = 1,138). Several products can be used in one garden.

Table 6.4 Estimated quantities of fertilizers used in 2007

The table gives an overview of the amount and intensity of used fertilizers and/or soil conditioners for Flanders in 2007. Only those respondents who were able to quantify imported amounts in 2007 were considered.

	Total	Average		
		per garden	per m² of garden	per km² of garden
Solid fertilizers and/or soil conditioners used in the garden in 2007 (N = 381) [kilogram]	33,232	87.2 (+- 17.24)[a]	0.067	67,058
Liquid fertilizers and/or soil conditioner used in the garden in 2007 (N = 248) [litre]	388	1.6 (+- 0.03)[b]	0.0008	811

[a] standard deviation 296.8; α=0.05; [b] standard deviation 5.6; α =0.05

The majority of the grass clippings, being 53 %, is processed within the garden through composting (53 %), as a mulch layer on the lawn (23 %) or collected on a pile or in a pit without the intention to compost (23 %).

3.3 Soil sampling and analysis

The geographic distribution of the soil samples in Flanders is shown in Figure 6.6. Per analyzed parameter, the distribution of the sampled gardens according to the different soil fertility classes is given. The effective ranges of the fertility classes of pH and carbon content per soil type for (i) gardens under construction, vegetable gardens and ornamentals gardens, (ii) garden lawns and (iii) greenhouses are given in Appendix B. Also the effective values of the fertility classes for phosphorus content are given per soil type.

3.3.1 Acidity (pH)

In general, the pH of the majority of the sampled gardens is higher than optimal pH levels according to the agronomic and environmental optimal standards (Table 6.6). For vegetable and ornamental gardens, an optimal pH lies between 5.2 and 5.6 in sandy soils, and between 7.2 and 7.7 in clay soils. For lawns, the optimal pH lies between 5.1 and 5.6 in sandy soils and between 5.7 and 6.4 in clay soils. In the category 'gardens under construction', 23.4 % of the gardens have a pH that is too low and approximately 60 % have high pH. Similar observations are made for vegetable gardens (67 % high), ornamental gardens (72 % high) and greenhouses (66 % high). Almost 73 % of the lawns have a high pH.

Table 6.5 Estimated quantities of grass clippings removed in 2007

The table gives the amount and intensity of removed grass clippings for Flanders in 2007. Only those respondents who were able to quantify amounts removed in 2007 were considered.

	Total	Average		
		per garden	per m² of garden	per km² of garden
Grass clippings removed from the garden in 2007 (N = 181) [litre]	347,354	1,919 (+-381)[a]	2.3	2,310,347

[a] standard deviation 2.616; α=0.05

The above results indicate that the majority of sampled gardens, especially lawns and ornamental gardens, have been limed excessively. Also frequent applications of organic fertilizers and soil conditioners (especially compost) contribute to the alkalization of the gardens. Too high pH values result in an impaired absorption of different nutrients (Pettinger, 1935; Lucas and Davis, 1961). Due to the lowered availability of micronutrients (Mn, Fe, Zn, Cu), lawns will become less vigorous and turn yellowish (Loué, 1986).

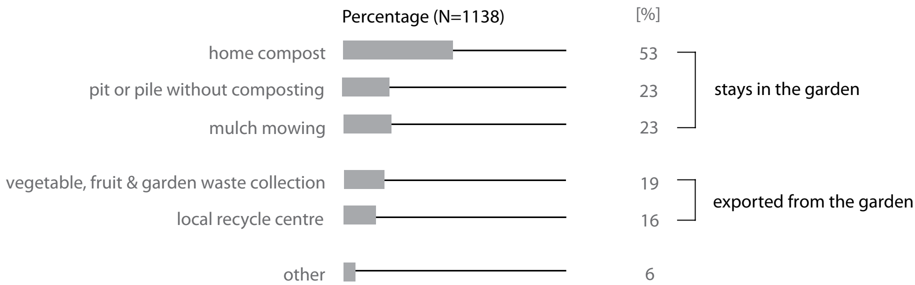


Figure 6.5 Destinations of grass clippings

Grass clippings end up in home compost in more than half of the gardens (N=1.138). In the majority of the cases, grass clippings remain in the garden. For one garden, grass clippings can end up in different destinations.

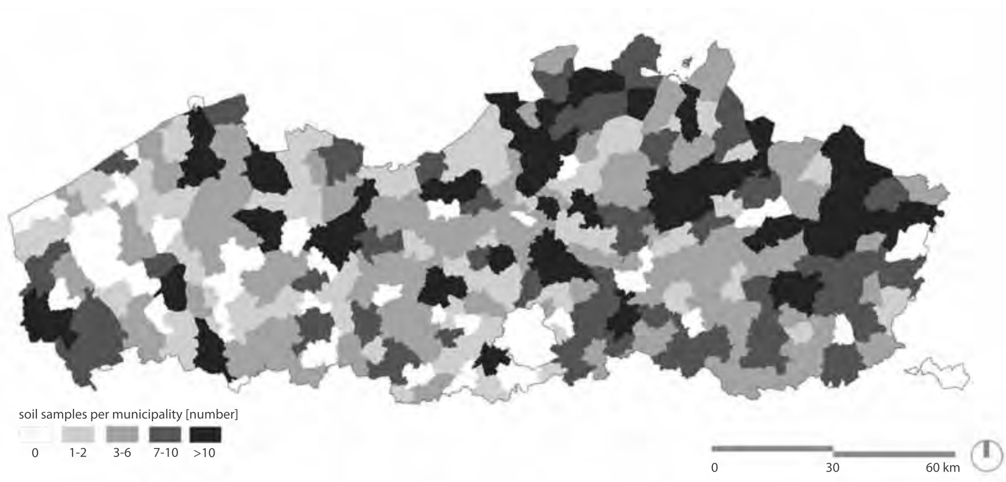


Figure 6.6 Distribution of the gardens with analyzed soils

The distribution of the gardens with analyzed soil samples is more dispersed than the respondents of the internet survey. Geographical distribution of the sampled domestic and public gardens (N = 1,817) in Flanders (August 2007–July 2009). Number of soil samples per municipality.

3.3.2 Carbon content (C)

Most garden types have a normal to high carbon content (Table 6.7). For gardens under construction, 40 % have a normal carbon content, while 27.6 % are low in carbon and 32.4 % have a high carbon content. In ornamental gardens, a higher proportion of the sampled gardens (42 %) has a high carbon content. In vegetable gardens, more than half of the sampled gardens (59 %) have a high carbon content. In contrast, most sampled lawns (79 %) have a carbon content that is too low. The results of the internet survey indicate a possible cause. Grass cuttings appear to be removed from the lawn in most gardens. The removal of grass clippings indeed reduces organic matter inputs into the garden soil (Craul (1999) in Lorenz and Lal (2009)). Only 23 % of the grass clippings that remain in the garden are left as a mulch layer on the lawn. These results indicate the potential of Flemish lawns to be mobilized as a net sink for atmospheric carbon dioxide (Lorenz and Lal, 2009; Zirkle et al., 2011). Jo and McPherson (1995) indicated that the carbon storage within the top 100 mm of soil profile can be as high as in the entire vegetation biomass above ground in urban residential green space.

3.3.3 Plant nutrients: phosphorus (P)

In general garden soils are characterized by high phosphorus contents (Table 6.8). This is the most pronounced in vegetable gardens of which more than 89 % have a high phosphorus content. Also in greenhouses the majority of the analyzed samples (68.5 %) have a high phosphorus content; 37 % even have very high phosphorus content. These (very) high concentrations of phosphorus are probably due to excessive fertilization. The results of the internet survey confirm high inputs and frequent use of fertilizers and soil conditioners. Also compost, with an average P-content of 7 kg P_2O_5/ton fresh weight and a dry matter percentage of 70 % (700 kg DM/ton of fresh weight) (Vlaco, 2012), was applied in 20 % of the gardens according to the respondents.

These figures correspond well with average figures from the Netherlands: 696 kg/DM ton fresh weight and 6.3 kg P_2O_5/ton fresh weight (van Dijk & van Geel, n.d.). The high phosphorus values do not necessarily have a negative influence on the plant growth, but they do indicate that gardeners on average could do with less phosphorus fertilization.

Table 6.6 Results of the soil acidity analysis

For the majority of the sampled gardens, the pH is higher than the optimal pH level. Distribution (in %) of the sampled gardens according to soil acidity classes (pH), 2007-2009 (N=1,817). The effective ranges for the soil acidity classes are given in Appendix B.

Soil acidity classes (pH)	Gardens under construction	Vegetable garden	Ornamental garden	Lawn	Greenhouse
very low	2.5	1.3	1.2	2.3	2.6
low	9.5	7.4	4.8	2.9	2.6
rather low	11.4	6.4	7.4	8.5	13.2
optimal	17.0	18.1	14.5	13.5	15.8
rather high	17.6	19.1	18.3	14.9	18.4
high	20.7	27.5	24.8	23.6	26.3
very high	21.3	20.2	29.0	34.3	21.1

Table 6.7 Results of soil carbon analyses

While most garden types have a normal to high carbon content, most sampled lawns have a low to very low carbon content. Distribution (in %) of the sampled gardens according to the different soil fertility classes for carbon content, 2007-2009 (N=1,817). The effective ranges for the soil fertility classes for carbon are given in Appendix B.

Soil fertility class for C	Gardens under construction	Vegetable garden	Ornamental garden	Lawn	Greenhouse
very low	7.9	2.3	4.5	26.9	0.0
low	7.7	2.5	6.4	37.1	2.6
rather low	12.0	5.9	11.0	14.7	15.8
optimal	40.0	30.3	35.7	18.2	39.5
rather high	27.1	46.1	31.9	2.1	18.4
high	5.0	12.9	10.0	0.8	23.7
very high	0.3	0.0	0.5	0.2	0.0

3.4 General discussion

The results presented here shed new light on gardens as a dynamic type of land use. They also provide indicative orders of magnitude and eventually trends on fertilizer use, composting and grass clippings removal. The data suggest that management of domestic gardens risks to contribute to negative externalities to the environment. The environmental impacts of the garden management depend on management practices at the level of the single garden. As individual and private units of space, gardens risk to be neglected as trivial items in perspective of regional strategic interests. However, the use of fertilizers and the production of organic waste in each of the individual gardens adds up when looking at the garden complex (Chapter 2). The total environmental impact of all garden management actions by individuals will be clearer when looking at domestic gardens as a regional system.

The 36 % surveyed garden area with frequent fertilizer and/or soil conditioner usage in 2007 equals to 396 km^2 garden area in Flanders. Combined with an average amount of 67,000 kg of solid fertilizer and/or soil conditioner used per km^2 garden in 2007 (Table 6.4), this results in an average amount of solid fertilizer and/or soil conditioner of 26.5 million kg used in the Flemish garden complex in 2007. In combination with the soil analyses, these results underpin excessive use of fertilizers. Based on more than 1,800 soil samples from domestic and public gardens, the pH, carbon (C) and phosphorus (P) levels are well over the growth optimum.

A comparison of the results for gardens with the results for professional agriculture (arable land and pasture, Table 6.9), shows that domestic garden soils have on average a higher pH. The results from the internet survey already revealed that lime was used in almost 35 % of the surveyed gardens. Excessive liming, leading to highly alkaline soils, has a negative effect on the nutrient availability in the soil due to impaired nutrient availability (e.g. due to too high pH) (Figure 6.7) and consequently poor nutrient absorption. A high pH (in general a pH > 7.4) results for example in reduced availability of several nutrients, particularly phosphorus (P), zinc (Zn), iron (Fe) and Manganese (Mn) (Fernández and Hoeft, 2009).

Especially vegetable and ornamental gardens are better supplied with carbon compared to arable land (Table 6.9). Due to the shallow tillage depth in gardens as compared to conventional arable farming, the carbon content needs to be maintained in a smaller volume. As a small management unit, it is easier to keep the organic matter in individual domestic gardens up to standard through applications

Table 6.8 Results of the soil phosphorus analyses

Garden soils are characterized by high phosphorus contents. Distribution (in %) of the sampled gardens according to the different soil fertility classes for phosphorus content, 2007-2009 (N=1,817). The effective ranges for the soil fertility classes for phosphorus are given in Appendix B.

Soil fertility class for P	Gardens under construction	Vegetable garden	Ornamental garden	Lawn	Greenhouse
very low	4.8	1.3	1.7	4.3	0.0
low	6.2	1.3	4.0	8.9	2.6
rather low	5.6	2.3	5.5	14.1	10.5
optimal	21.3	5.9	19.0	21.3	18.4
rather high	34.4	15.5	31.4	30.8	18.4
high	19.7	27.2	27.1	16.8	13.2
very high	8.0	46.5	11.3	3.8	36.9

of compost, organic fertilizer, manure, green manure or garden waste. The survey results already indicated a frequent (often yearly) incorporation of fertilizers by half of the respondents. Compost and organic fertilizers are the most frequently used products, next to lime.

The general low carbon content of lawns (79 % below optimal range of carbon content) invites to elaborate further on the possibilities of lawn soils to function as carbon sink. Based on the results of the soil analyses and taking into account the soil type, it is calculated that on average 18,000 kg C per ha of lawn is sequestrated in the soil (until 6 cm depth). Comparing this with the optimal carbon content per soil type (e.g. the upper limit of the optimal fertility class for lawn, being 4.2 for loam and 5.5 for all other soil types) reveals that an additional 20,729 kg per ha of lawn could be sequestrated. So, in optimal conditions, lawn store a total of 38,732 kg C per ha of soil.

When extrapolating this potential to the Flemish garden complex containing 435 km^2 of lawn[1], it becomes clear that an additional 901,712 ton of carbon could be sequestrated in Flemish lawns. So, the garden complex has potential as carbon sink. The SSB carbon simulator (Tits et al., 2012) calculates a total carbon content between 35,000 and 40,000 kg C per ha cropland for a standard crop rotation (wheat, sugar beets, potatoes) on a loam soil with 1.2 to 1.4 % carbon (until 23 cm depth).

1 This figure is estimated in Chapter 7, paragraph 5.1. Based on the results of the internet survey, the estimated average lawn size is calculated and multiplied by the garden area percentage containing a lawn.

Garden soils are also capable of processing and storing nitrogen (Groffman et al., 2004). This is however mortgaged by excessive compost applications, since it contributes significantly to nitrogen fertilization (Tits et al., 2012). While soils with a low organic matter content (i.e. low carbon content) are known to not function optimally (Oades, 1988; Paul et al., 1997), soils with high carbon content are characterized by a high nitrogen supplying (Tits et al., 2012). In such soils, high amounts of mineral nitrogen are released throughout the year. This will not only result in high mineral nitrogen stocks in spring. The excess of mineral nitrogen present in the soil will leach to the groundwater after the growing season, especially in vegetable plots and other parts not vegetated during winter. In ornamental gardens and orchards, deep plant roots may take up the leached mineral N from the deeper soil layers in springtime when the sap flow and nutrient uptake restart.

A high carbon content of garden soils could have a negative impact on the groundwater quality. The survey clarified that 70 % of the used compost is home-made, meaning that there is little to no control and limited knowledge on the composition. The use of home compost is generally seen as a positive act towards the environment and promoted by several government organizations. Compost itself is considered as a valuable fertilizer (e.g. Favoino and Hogg (2008)), not only increasing the carbon content but also supplying nutrients for the plants.

Although for most nutrients the processing and usage of home compost in the garden recycles nutrients 'on the spot', we need more detailed information on the practices and carbon and nitrogen contents of applied home compost to broaden the understanding of the complete nutrient cycles in gardens. Such knowledge is essential in making reliable conclusions on the environmental impact of fertilization practices and home compost usage in gardens and to prevent the negative sides of home compost usage.

Finally, the phosphorus content in domestic garden soils and arable land and pastures is equally high. If the phosphorus content is too high, the absorption of microelements like zinc is hampered. Phosphorus concentrations that are too high can also cause environmental problems by leaching to the phreatic and surface water. Leaching of phosphates usually occurs in most but not all sandy soils, which are poor in iron and aluminum (thus with little sorption capacity) (Elliott et al., 2002). The high phosphorus concentrations in garden soils strengthens the idea that the intensive fertilization in domestic gardens may have a negative impact on the water quality, but this is so far not supported by research concentrating on gardens.

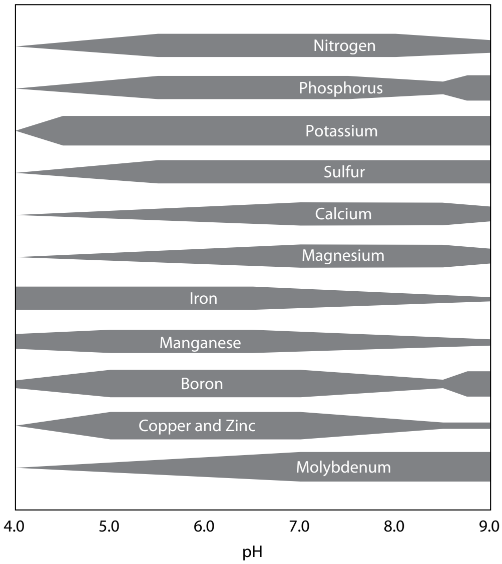


Figure 6.7 Effect of pH on nutrient availability in soils

A high pH limits the availability for several nutrients and leads to poor nutrient absorption. The graph represents the availability of nutrients in relation to pH: the wider the dark bar, the greater the nutrient availability.

Source Own adaptation from Fernández and Hoeft (2009)

Table 6.9
Comparison of soil fertility states between arable land, pasture and gardens

Vegetable and ornamental gardens are better supplied with carbon compared to arable land. Distribution (in %) of the sampled gardens, arable land and pasture according to the different soil fertility classes for acidity (pH), carbon content (C) and phosphorus content (P), 2007-2009 (N=1,817). The effective ranges for the soil fertility classes are given in Appendix B.

Soil fertility classes	Garden			Arable land			Pasture		
	pH	C	P	pH	C	P	pH	C	P
very low	1.9	10.8	3.1	0.7	10.0	0.2	0.7	12.9	1.2
low	6.1	14.0	5.3	8.9	18.8	0.7	4.5	26.8	5.5
rather low	8.7	11.3	7.2	30.0	23.5	1.5	13.4	15.8	10.0
optimal	15.7	31.1	17.4	38.8	37.7	10.7	36.6	31.3	20.1
rather high	17.3	25.5	28.3	14.8	9.4	33.8	24.0	9.9	39.9
high	24.0	7.1	22.1	5.1	0.6	39.4	15.4	2.2	19.0
very high	26.3	0.2	16.6	1.7	0.0	13.7	5.4	1.2	4.3

On the positive side, our survey results indicate that gardens can play a role in the waste recycling process. The 14 % surveyed garden area with removal of grass clippings from the garden equals to 154 km^2 garden area in Flanders in which grass clippings were removed in 2007. Combined with an average amount of 2,310,000 l of grass clippings removed per km^2 in 2007 (Table 6.5), the amount of grass clippings in Flanders exported in 2007 is estimated at nearly 356 million l. Organic garden residue is kept in the garden in 85 % of the surveyed gardens, indicating the importance of gardens as recycling units. New ways of valorization of garden waste can be bio-energy production (e.g. Yu et al. (2002)). As Refsgaard and Magnussen (2009) state, it is a challenge to reduce the residue flow.

The combination of methods presented here, a regional wide internet survey with detailed soil analyses, has proven its strength in collecting explorative and indicative environmental data on a landscape component that is, for the moment, rather unknown and inaccessible. We succeeded in obtaining a minimum level of representativeness. Both the number of respondents as the number of gardens sampled for soil analyses were sufficient to represent an infinite large population. Based on the bar charts of the degree of passion for gardening as well as of ecological gardening, we assume no bias among the respondents towards more of less passionate or ecological gardeners.

Although the soil analyses were based on almost 1,800 sampled gardens in Flanders, the soil samples were not taken randomly. A bias towards malnutritioned gardens is possible, since a part of the soil analyses was requested by garden owners upon observations of poor plant growth. Also, the soil samples of public and private gardens were analyzed together.

For the soil fertility analysis, we used agricultural optimal growth standards defined by SSB. Their advantage is twofold: the provision of a clear and interpretable reference and the possibility to make comparisons with agricultural land that is professionally managed. These standards however can also be questioned. In the light of the multiple ecosystem services supported by gardens (Appendix A), the soil fertility state of garden soils could also be interpreted in terms of e.g. nature conservation and potential biodiversity. This could mean lower levels of soil fertility for optimal performance. Developing soil fertility classes for a selection of ecosystem services could certainly be a step in specialized research on domestic gardens.

The fact that the soil samples were not taken in the gardens that were surveyed by means of the internet survey excludes the possibility to calculate correlations between management practices and soil fertility levels. This could be considered a weakness of the presented work, but it is not considered a major issue given the fact that domestic gardens are hitherto rather underexplored. Soil sampling and analysis along with standardized management diaries in representative case studies can boost future investigation of the specific interactions between management practice and garden soil fertility.

Although the results of this research should be evaluated for their indicative value, they clarify the need for more detailed environmental research in the garden complex. Reliable data and meaningful indicators are necessary if we want to start thinking about transforming individual gardens into an environment-friendly garden complex. Important determinants of biogeochemical fluxes in gardens are the individual management decisions at the household scale (Kaye et al., 2004), like fertilization levels. Pimentel (1991) already stated that homeowners are more likely to overuse pesticides compared to professionals.

Our comparison of soil fertility states between arable land and gardens indicates that similar findings might account for the use of fertilizers and/or soil conditioners in Flanders. While agriculture is extensively monitored and subjected to regulations concerning fertilizer use, garden owners are free to act as they please. Since Baker et al. (2001) stated that the most effective nitrogen management strategies are those specifically tailored to individual ecosystems, garden-tailored management plans can be a valuable pathway towards a more environmental-friendly garden complex that ultimately supports the delivery of a wide range of ecosystem services.

An interdisciplinary examination of residential landscapes is needed to understand the feedback and trade-offs of these complex adaptive social-ecological systems as a whole (Cook et al., 2012). Management actions taken at the individual garden level are based in culture, attitudes and beliefs; constrained by institutional and socioeconomic factors (Kaye et al., 2006) and influenced by complex human drivers (Zmyslony and Gagnon, 1998; Kirkpatrick et al., 2007; van den Berg and van Winsum-Westra, 2010).

One of the most important challenges in urban ecology is identifying links between social and ecological processes (Collins et al., 2000; Grimm et al., 2000; Kaye et al., 2004) and, in the case of domestic gardens, motivating individual owners to contribute to collective goals. The 'ecological land use complementation' concept of Colding (2007) provides an interesting framework of thinking about participatory management approaches in terms of the garden complex.

4 Conclusions

Research on the environmental aspects of individual gardens fits into a broader framework of regional and urban development and planning, sustainability, and the relationship between society and natural resources. For the broader land use categories like agriculture, nature and forest, clear information exists about their 'environmental' landscape, thanks to explicit policy and monitoring programs. This allows landscape planners to insert environmental information in environmental and landscape strategies from local to regional level. The garden complex is underrepresented in such strategies but should surely be put on the agenda of landscape planning worldwide. Current lack of knowledge on the distribution of cover and use characteristics of the garden complex, and on the environmental impact of domestic garden management, can be turned in a new frontier of landscape research.

By combining a regional wide internet survey with detailed soil analyses, we succeeded in filling in a first small part of the knowledge gap about the environmental significance of 8 % of the Flemish territory covered by domestic gardens. Excessive and/or improper use of fertilizers, the lack of indicators for over-fertilization that are easily measurable and accessible for gardeners, and a lack of governmental regulation and control on the amounts of fertilizers used in domestic gardens can be factors that contribute to negative environmental effects of gardens.

The recorded quantities of home composting in Flanders prove the impacts of sensitization campaigns. Sensitization on fertilizer use in gardens is thus certainly a realistic pathway. Existing and new sensitization campaigns should be adjusted according to new insights into the environmental impacts of the use of compost and other fertilizers. For instance, most gardeners consider the use of 'natural' products (like compost or stable manure) to be harmless and applicable at all times, but most of them may not be aware of the relative slow breakdown of these products that puts an environmental restriction on frequent applications. A similar reasoning accounts for the use of pesticides. Besides sensitization, monitoring could reach out handles for the development of regulations, as it is the fact for agriculture.

The need for detailed and ongoing monitoring is clear. Currently, it is not sufficiently known which factors determine the nature and amount of the applied and exported products used in gardens. These could be factors like the proportion of lawn area within the garden, but also socio-ecologic and socio-economic factors or other yet undefined factors. Since the fragmentation and heterogeneity in property and management is one of the reasons for the restricted knowledge on gardens, easily accessible and efficient survey techniques are a necessity. The good response of the online survey in this study gives hope for the development of an extended garden monitoring program.

The garden complex should be better acknowledged in policies of environment, agriculture and nature, in spatial and urban planning and design, and in climate change adaptation. Environmental benefits and impacts are just a few aspects of gardens. Also other issues like home food production, biodiversity, recreation and wellbeing are related to them. The question is which role the garden complex exactly plays and how it is possible to increase its positive contributions to society and the environment, while decreasing negative impacts. This is plenty of challenge for research.

Chapter 7 is based on
Dewaelheyns, V., Lerouge, F., Vranken, L. , Rogge, E. (2014). The potential of small and multifunctional spaces for food production: a conceptual model for food production in domestic gardens. Working paper 2014/07 in the Bioeconomics series, available at https://ees.kuleuven.be/bioecon/working-paper-series/BioeconWP_2014_7.pdf

7. THE ADAPTIVE CAPACITY OF HOME FOOD PRODUCTION

"While we petrify and prettify our own backyard,
our eating habits are despoiling those of other."

Carolyn Steel, 2009, in 'Hungry City. How food shapes our lives'

The roots of domestic gardens lie in sedentary home food production. The ecosystem service 'production of cultivated crops' is further analyzed in this chapter.

1 INTRODUCTION

There is an increasing attention for food production outside the traditional agricultural area (Jarosz, 2008; Barthel and Isendahl, 2013; Algert et al., 2014). But this attention largely bypasses domestic gardens (Madaleno, 2000; Gray, 2011; Taylor and Lovell, 2014). Not only food production, also other services delivered by garden space fail to receive proper attention (Davies et al., 2011; Cook et al., 2012).

1.1 FOOD PRODUCTION IN DOMESTIC GARDENS: A CALL FOR REVALUATION

Domestic gardens can be interpreted as multifunctional micro spaces with trade-offs and synergies between functions (Stoorvogel et al., 2004). Throughout history, food production has been a most important part of gardening worldwide, in developing (WinklerPrins, 2002; Siviero et al., 2011) and developed countries (Reyes-García et al., 2012a; Taylor and Lovell, 2014). The Food and Agriculture Organization of the United Nations (FAO) still explicitly draws upon home gardens and traditional gardening to improve household food security in African and Asian countries (Marsh, 1998; FAO, 2012). As such, domestic gardens can be seen as an adaptable and accessible land resource for food production worldwide, holding potential to reduce vulnerability and improve personal food security (Seeth et al., 1998; Buchmann, 2009; Barthel and Isendahl, 2013).

During the past decades food production in domestic gardens regained attention from policy (Ghosh, 2012), e.g. in local food system planning (Martinez et al., 2010) and food self-provisioning (Marsh, 1998; FAO, 2012), and research (Kortright and Wakefield, 2011; Taylor and Lovell, 2014) Some recent studies, mainly from the US, use scenarios to assess the contribution of private land and residential gardens to the total food production area and food needs (Grewal and Grewal, 2012; Taylor and Lovell, 2012; McClintock et al., 2013). Others deal with food self-provisioning by exploring the motivations of individuals and limitations imposed by policies (Alber and Kohler, 2008; Jehlicka et al., 2013; Smith and Jehlička, 2013).

The contribution of domestic gardens to food production has proven to be difficult to measure (Niñez, 1987; Martinez et al., 2010; Kortright and Wakefield, 2011). Their private character (Phillips et al., 2008; Kortright and Wakefield, 2011), limited accessibility (Pérez Campaña and Valenzuela Montes, 2013) and large variation in appearance, management and use (Niñez, 1987; Van Delm and Gulinck, 2011; Dewaelheyns et al., 2013) impedes surveying and research efforts. Consequently, insights in the food production potential of gardens remains limited.

Domestic gardens are complex social-ecological systems (Baker et al., 2007; Barthel et al., 2010), with gardeners as key decision-making agents (Cook et al., 2012). The choices and actions of gardeners are influenced by a variety of drivers and constraints. These constraints can be personal (e.g. attitudes, values, personal ideals, preferences and beliefs (Stern, 2000; Cook et al., 2012; Kurz and Baudains, 2012)), or imposed by the biophysical context (e.g. climate, soil characteristics, hydrology and ecology (Kaye et al., 2006; Kurz and Baudains, 2012)) and the social context (e.g. norms, culture, income and informal institutions in the neighborhood (Colding and Folke, 2001; Nassauer et al., 2009)). Cleveland and Soleri (1987) stressed the necessity of analyzing internal dynamics of both gardens and households, the relationship between the two, and the relationships of both with external social, economic, political and environmental issues that determine the households' control over gardens.

1.2 Research objectives and approach

The main objective of this chapter is to gain insight in the current and future potential of domestic gardens for food production. This potential is studied by analyzing the household's decision to allocate space and time to food production. The specific objective is to develop a methodological framework to capture, quantify and interrelate the most relevant determinants and constraints of potential food production in domestic gardens.

To investigate the degrees of freedom in the decision space of a household, an economic model is developed. This development is fuelled by innovative data on food production in domestic gardens and values associated with gardening. Both quantitative and qualitative data were collected, using internet and door-to-door surveys as well as focus groups and expert interviews (Figure 7.1).

The model and collected data inspired a reflection on the adaptive capacity of domestic gardens for food production at the household level. This model should facilitate the discussion on the inclusion of domestic vegetable gardens within future food strategies.

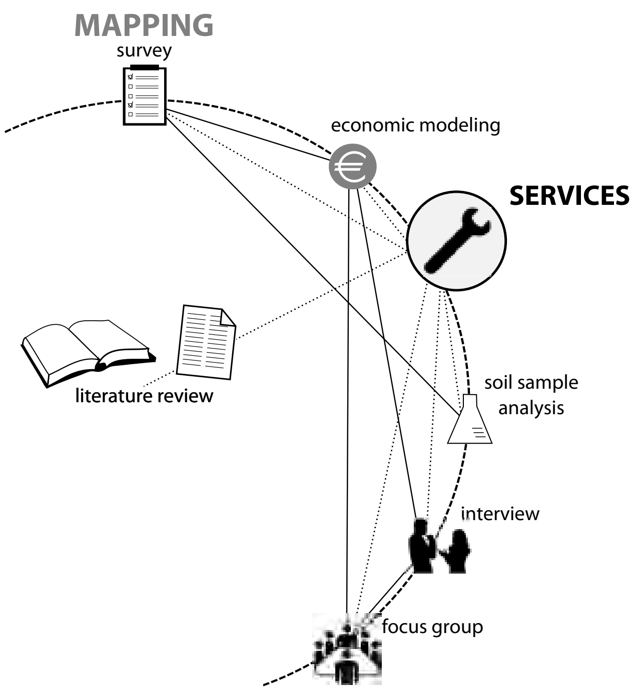


Figure 7.1
Overview of the methods used in Chapter 7

An economic utility model was developed to investigate the degrees of freedom in the decision space of a household. Data is collected on home food production and values associated with gardening. Both quantitative and qualitative data were collected, using internet and door-to-door surveys, focus groups and expert interviews.

2 Theoretical model and hpotheses

2.1 Theoretical model

We develop a theoretical model that describes trade-offs and synergies in area and time between food production and other functions in domestic gardens. An econometric approach (Chen and Wang, 2013) was considered appropriate. Such approach was for example also applied by Vranken and Swinnen (2006) in the analysis of determinants of household farms' participation in land rental markets in transition countries.

With 'food' we refer here to vegetables and fruit, hence cultivated crops. The term 'other functions' is considered an umbrella term that will not be defined further in this chapter. This term could include other ecosystem services: other provisioning functions, like genetic materials through the preservation of old varieties (Batello et al., 2010) and firewood as an energy source (Kaoma and Shackleton, 2014); regulating services, like the sequestration of carbon in garden trees (Davies et al., 2011); and cultural services, like spiritual experiences (Freeman et al., 2012) and the gaining and exchange of gardening knowledge (Barthel et al., 2010) (Appendix A).

In this model utility theory is used to analyze the choice problem of households when they are confronted with the questions if and how much area and time they would allocate to home food production in the garden. In econometric terms, the choice problem for a consumer-producer is presented as a problem of maximizing a utility function subject to one or more constraints.

After the definition of the main variables of food production in domestic gardens, we step-by step integrate these into an economic model. Next, we describe their constraints as well as the assumptions we made. Finally, we discuss hypotheses on trade-offs and synergies between available garden area, time and preferences of the household.

2.1.1 Main variables of the model

The model includes five main variables: time (T), area (L), consumed produce (C), utility (U) and input (z) (Figure 7.2). Each variable is broken down into several components. We describe their interrelations at a household level.

The total available time of a household is represented by the variable time $\overline{T}$, and is divided in three components. The total time available for the household includes time used for producing home grown food in the garden t_h, the time used for working (i.e. earning a wage) t_w, and all the remaining time available for all other non-wage earning activities (e.g. leisure, housekeeping, socializing, resting, non-food gardening...). A household's capital contains an endowment M (real estate, savings,...) and a wage income determined by the wage w and t_w.

$$\bar{T} = t_w + t_h + t_o$$

The total domestic garden area available to a household $\bar{L}$ can be used either for food production or non-food related activities. The area assigned to food production is denoted L_h, while L_o is the area assigned to all other activities[1].

$$\bar{L} = L_o + L_h$$

The total food consumption used by the household C includes food bought on the market (in general terms) c_1 as well as home garden produce c_2. Home garden produce c_2 can be inserted in the model as the difference between the total food consumption C and bought food c_1. If the household is completely self-sustainable through home produce, c_1 equals 0 and no additional food needs to be bought from the market.

$$C = c_1 + c_2$$

Utility is defined as the whole of material and non-material benefits from a garden and from food consumption. The utility U of a household owning a garden is considered as a function of the food consumed by the household C, and of the remaining area and time available for providing other leisure uses and services, L_o and t_o respectively. In other words, the household utility depends on food consumption, and of the area and time allocated to other services consumed by the household.

$$U(c_1, c_2, t_o, t_h, L_{o,} L_h)$$

1 For simplicity, we assume a functional and spatial distinction between these two types of garden use. More ambiguous forms of use (e.g. mixed use of space for home food production and garden display) can be dealt with in future research.

2.1.2 Constraints

Household members maximize their utility subject to some constraints (Figure 7.2). Household members divide their available time $\overline{T}$ between time for working t_w, time for other, non-wage earning, activities t_o, and time spent producing home grown food t_h. Time spent earning a wage t_w can be expressed in function of the total available time minus the time spent for home food production and for other activities. Due to a limited amount of wage employment opportunities, there is a maximum amount of time that can that can be allocated to earning an income t_w.

$$t_w = \bar{T} - t_h - t_o$$

$$\bar{T}_w^{max} \geq t_w$$

Also the garden area $\overline{L}$ is constrained. The total amount of area that each household can allocate to either food production or provision of other services, is limited. In the model, the available garden space is either allocated to food production L_h or to other uses L_o,and we assume both to be mutually exclusive.

Growing fruit and vegetables in the garden requires an amount of material input (z). This input is defined as the aggregated cost for different inputs such as seeds, fertilizers and pesticides used for home food production. As such, domestic produce c_2 is considered a positive function of area L_h and time t_h allocated to production and of input z.

$$c_2(L_h, t_h, z)$$

A final constraint is defined by the assumption that the overall household budget allocated to buying food from the market at a price p should not exceed the sum of endowment M and income as a product of wage w and t_w.

$$M + w[\bar{T} - t_h - t_o] \geq pc_1$$

$$M + w[\bar{T} - t_h - t_o] \geq pC - pc_2(L_h, t_h, z)$$

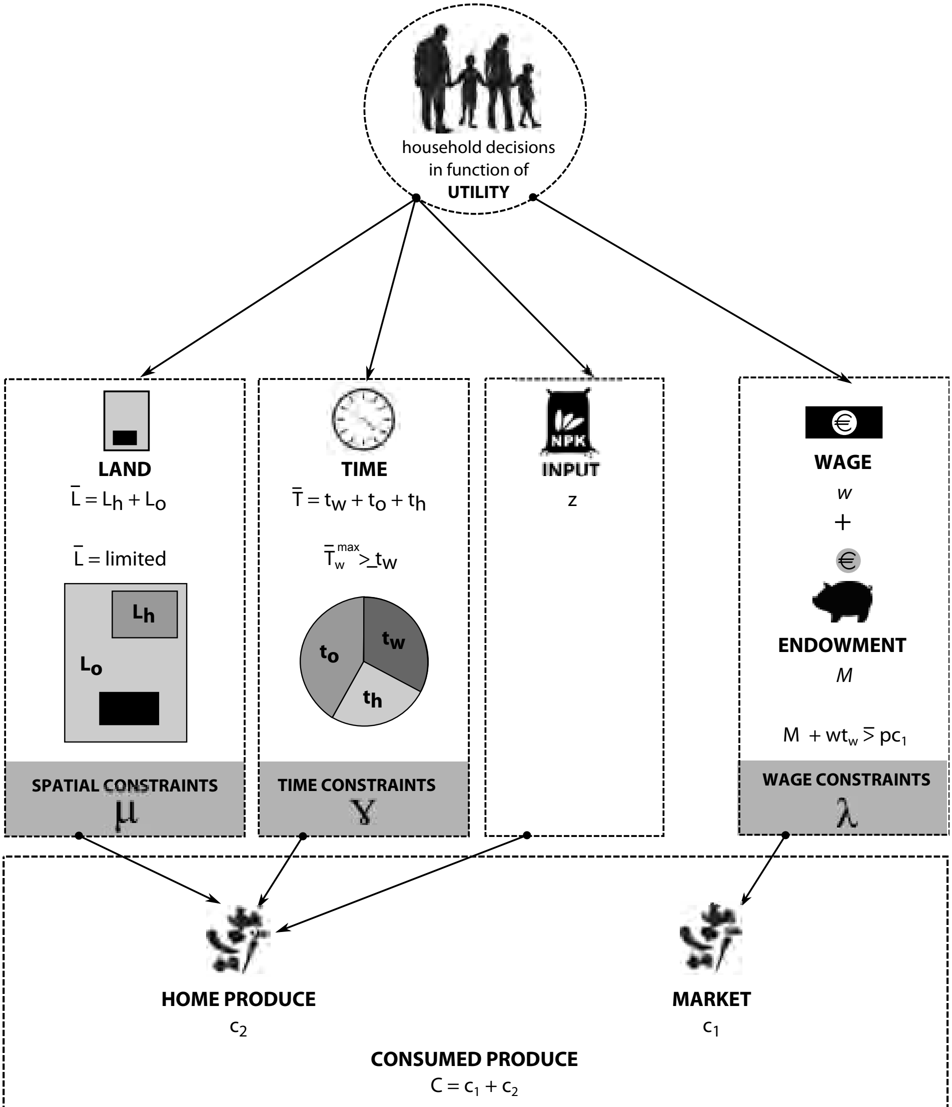


Figure 7.2 Main model variables and their constraints

The household's utility of home food gardening can be understood by focusing on the main variables: area of land (L), time (T), input (z), wage (w) and endowment (M) and consumed produce, including both home produce (c_2) and food bought at the market (c_1). The variables area of land (L), time (T) and wage (w) and endowment (M) are constrained by spatial, time and wage constraints. The garden area (L) is limited and needs to be divided between food production (L_h) and other functions (L_o). Also time (T) is limited, and needs to be divided over time for wage earning (t_w), time for home food gardening (t_h) and time for other, non-wage earning, activities (t_o). Finally, the overall household budget allocated to buying food from the market at a price p should not exceed the sum of endowment M and income as a product of wage w and t_w.

2.1.3 *Relations between the model variables*

To understand how constraints influence the households decisions on home food production, we need to solve this constrained extremum problem. Therefore we apply the Lagrange multiplier method (Chiang, 1984). This approach bypasses the need to explicitly solve the constraints. The problem is reformulated into a free extremum problem, which can be solved using relatively simple derivatives.

The Lagrange multiplier itself has an economic interpretation as the marginal utilities associated with the constraints. A marginal utility is the gain from an increase in the consumption of a good or service.

The Lagrange form of the utility function contains the function and the constraints on capital, area and time, which are multiplied by the Lagrange multipliers λ, μ and γ. These respectively represent capital constraints (λ), area constraints (μ) and time constraints (γ).

$$Z = U\big(C, t_o, t_h, L_{o,} L_h\big) + \lambda[M + w[\bar{T} - t_h - t_o] - pC + pc_2(L_h, t_h, z)] \\ + \mu[\bar{L} - L_h - L_o] + \gamma[\bar{T}_w^{max} - T + t_h + t_o]$$

To solve the constrained extremum problem, this Lagrange form of the utility function Z is derived to the Lagrange multipliers, as well as to the principal factors of the model L_h and t_h. As such, the first-order condition for the free extremum problem consists of the following five equations:

1. $Z_\lambda = M + w[\bar{T} - t_h - t_o] - pC + pc_2(L_h, t_h, z) = 0$

2. $Z_\mu = \bar{L} - L_h - L_o$

3. $Z_\gamma = \bar{T}_w^{max} - T + t_h + t_o$

4. $Z_{L_h} = \frac{\partial U}{\partial L_h} + \frac{\partial U}{\partial c_2} . \frac{\partial c_2}{\partial L_h} + \frac{\partial U}{\partial L_o} . \frac{\partial L_o}{\partial L_h} + \lambda p \frac{\partial c_2}{\partial L_h} - \mu = 0$

5. $Z_{t_h} = \frac{\partial U}{\partial t_h} + \frac{\partial U}{\partial c_2} . \frac{\partial c_2}{\partial t_h} \mp \frac{\partial U}{\partial t_o} . \frac{\partial t_o}{\partial t_h} + \frac{\partial U}{\partial t_h} + \lambda \left[-w + p \frac{\partial c_2}{\partial t_h}\right] + \gamma = 0$

2.2 Hypotheses

The first condition explores the relation between income and consumption. Lower financial means are associated with a general lower consumption. Given the spatial slant on this chapter, food prices, dietary behavior and their relations are not studied here. The food price variable is part of the model, so future research can elaborate on this. For now, briefly a context is given to nuance the relation between financial means and food consumption.

In their analysis of differences between food choice, eating behavior, and food liking between normal and obese low-income women, Dressler and Smith (2013) found that a variety of complex factors interact to influence eating behavior of women living in similarly impoverished environments. Where health was influential in food selection for normal women, cost was a priority for obese women. De Vriendt et al. (2009) found for young and middle-aged Belgian women that a rise in nutrition knowledge was associated with a significant rise in the consumption of vegetables and fruit. This nutrition knowledge was mainly determined by educational level, age and occupation.

The second and third conditions reflect the spatial and temporal constraints, respectively.

The fourth condition explores the relation between garden space and domestic food consumption, and can be expressed as follows:

$$\frac{\partial c_2}{\partial L_h}\left[U_{c_2} + \lambda p\right] + U_{L_h} \geq \mu + U_{L_o}$$

with Uc_2 the marginal utility of the consumption of home garden produce; and U_{L_h} and U_{L_o} the marginal utility of allocating domestic garden area to respectively food production or other activities. The above equation learns that a household would allocate more space to food production in its domestic garden as long as the left hand side of the equation is larger than the right hand side. This implies that a more binding capital constraint (λ) leads to more area being allocated to home grown production. In addition, increasing food prices (p) and a higher marginal utility of consuming home grown produce (i.e. the more one enjoys consuming home grown produce for example because it is considered more tasty or healthy) lead to more area being allocated to home grown production.

Also, a higher partial productivity of home production and the higher the marginal utility of space being allocated to home grown production (i.e. the more one enjoys the visual appearance of a kitchen garden), the more it repays to allocate more garden space to food production. In addition, a higher marginal utility of L_o (i.e. the more one enjoys the visual appearance of, for example, an ornamental garden) and a more binding area constraint (μ) lead to less garden area allocated to home production.

The fifth condition explores the relation between time allocation and domestic food consumption, and can be expressed as follows:

$$\frac{\partial c_2}{\partial t_h}\left[U_{c_2} + \lambda p\right] + U_{t_h} \geq U_{t_o} + \lambda w - \gamma$$

with U_{t_h} and U_{t_o} the marginal utility of allocating time to respectively home grown food production or other non-wage earning activities. The above equation learns that a household would allocate more time to food production in its domestic garden as long as the left hand side of the equation is larger than the right hand side. Less income opportunities (higher λ) and lower wages increase the time invested in home food production t_h, and the other way around. In addition, a higher partial productivity of home food production, higher food prices and a higher marginal utility of devoting time to home food production (i.e. the more one enjoys working in the kitchen garden) will also increase the time invested in home food production t_h. Finally, a higher marginal utility of t_o will decrease the amount of time spent on home grown production, while a higher marginal utility of consuming home grown produce will increase the time invested in home food production.

A more binding capital constraint (λ) will also affect the decision on how much time to spend on home grown food production. The impact is however not clear ex ante and depends on the magnitude of the wage the garden owner can earn as well as the labor productivity of home grown food production. A very productive gardener who can only earn a relatively low wage will increase its time allocated to home grown food production when faced with a more binding capital constraint. On the other hand, an unproductive gardener with high wage earning opportunity will spend more time on wage earning activities than on home food production when confronted with a more binding capital constraint. Now, t_h and L_h are tightly related to each other.

Increasing L_h by expanding the kitchen garden is often associated with an increase in t_h, as one needs to invest more time to maintain this larger garden. Even so, the emphasis can be on increasing L_h if time restrictions (γ) are more binding, increasing t_h if spatial constraints (μ) are more binding, or both.

2.3 Scaling up to the garden complex

The garden complex sums of all single domestic gardens within a certain area (Chapter 2). From a spatial viewpoint, this is the whole of individual garden areas $\Sigma\ \overline{L}$, comprising all area used for food production $\Sigma\ L_h$, and all area for other uses $\Sigma\ L_o$. The consumption of produce of all gardens can be summed as $\Sigma\ c_2$. Similarly, all time spent on home food production can be summed as $\Sigma\ t_h$. As such, this concept allows for a straightforward up-scaling. While the garden complex as a whole $\Sigma\ \overline{L}$ can be an extensive interconnected area, the decision space of the individual households is often strictly confined to the physical space of the households' property $\overline{L}$.

3 The challenge of data

To test the hypotheses coming out of the model, we collected data on the spatial composition, food productivity and gardening practices within domestic gardens. We collected both empirical quantitative and qualitative data.

3.1 Quantitative data

Quantitative data is used to evaluate and discuss variables of the model. Data on food production and garden management were collected by an anonymous online survey in 2007 among garden owners in Flanders[2]. From the 285 variables collected within the full survey, 47 were specifically related to food production. The drop-out rate of the internet survey was 38 %. A total of 1,138 respondents were withheld for further analysis.

More detailed quantitative data on garden design and food production was collected by a face-to-face survey during garden visits within the case municipality of Herent (Flanders) in 2007. Herent is characterized by a strong morphological but rather weak functional urbanization (Mérenne-Schoumaker et al., 1998). A stratified random sampling (EPA, 2002; Mandana, 2002; Lauridsen, 2004) based on geographical data was used to define which neighborhoods would be visited.

2 See Chapter 6 for more information on the internet survey.

In total, 25 garden visits were conducted and analyzed. A socio-demographic profile of the respondents for both surveys is provided in Appendix C.

3.2 Qualitative data

Qualitative data is used to illustrate to what extent the constraints are binding and effecting the decisions on the amount of land and time allocated to home garden production. The qualitative data also allow to investigate the marginal utility of L_h and t_h.

A total of 37 respondents were consulted (including 21 experts and 16 garden owners) about their ideas, feelings and opinions about the garden complex (experts) and on gardens and gardening (garden owners)[3]. The experts were selected via purposive sampling: we expected to receive as much information as possible from these persons. They are all professionally active in the broad field of action related to domestic gardens (public servants at the municipal, provincial and Flemish level working on public green, spatial planning and urbanism; staff members of interest groups on rural development, agriculture and ecological gardening; etc.). They were questioned through open in-depth interviews about the concept of the garden complex; and possibilities and pathways to bring this concept into practice (Appendix D). The interviews lasted on average about one hour and were conducted between June 2013 and January 2014.

The 16 private garden owners all lived in the province Vlaams-Brabant. They were involved by two focus groups, each consulting 8 participants. Each focus group was assigned a different phase of the garden lifespan (management phase and (re-) designing phase). The garden owners were recruited from a qualitative panel, and selection criteria and quota ensured a balanced composition of the groups with respect to garden size and type; respondent's gender, age and level of education; and age of the children. The focus groups were moderated by an experienced moderator. Four main aspects were discussed: the emotional and rational relation with the garden, the categorization of gardens, the gardeners' moments and criteria of decision making and a discussion on how people think about a number of existing and new sensitizing actions. These included regulations on the area of sealed surface, initiatives to support the sharing of gardening equipment and the idea of a 'garden doctor' giving tailor-made garden advice (Appendix D). The focus groups took place January 27th, 2014 and lasted each about two hours.

3 See Chapter 8 for more information on the qualitative data.

The qualitative data were analyzed according to the grounded theory approach using inductive open and axial coding (Strauss and Corbin, 1998). During the coding process data were broken down into discrete objects like ideas, phenomena and feelings, and given a name. These objects are further called concepts. Next, these concepts were further analyzed and aggregated into distinct categories. Finally, the concepts and categories were re-assembled by identifying links and cross-cuts between categories. The authors used several techniques to ensure neutrality throughout the data collection and analysis (Strauss and Corbin, 1998) and to prevent bias that could result from the work of one single researcher. These techniques include triangulation, a multi-staged process, partly collective data analysis and validation.

4 Empirical results and discussion

We used the quantitative and qualitative data to foster the model development. The qualitative data allow to gain insights on variables lacking quantitative data.

4.1 Current home food production and its share in the household consumption

Some degree of measurement error is assumed on the survey results, e.g. due to difficulties to accurately estimate production quantities. The production figures and their financial values reported are estimates. Nevertheless, they provide a good starting point to test the validity of assumptions underlying the model and the hypotheses coming out of the model.

4.1.1 Current food production in domestic gardens

First, we discuss food production in Flemish domestic gardens (c_2), based on results from the internet survey for Flanders (Table 7.1). Vegetable gardens are present in 37 % of the surveyed gardens and fruit production in 51 %. Nuts are the third most represented produce group with 31 %. Only 28 % of the surveyed gardens has a food productivity (c_2) of zero, meaning that a vast majority of gardens delivers some kind of nutritional produce. In terms of productivity, 1,310 kg (1.3 ton) of vegetables were produced in 2007 per ha of vegetable garden as well as 216 kg (0.2 ton) of fruits per ha of garden (Table 7.2). For referencing, the professional Flemish agricultural sector produced about 50 ton vegetables per ha of vegetable cultivation area and about 41 ton per ha of fruit cultivation area in 2007 (Platteau, 2009).

In 73 % of the surveyed gardens that produce food, the produce is mainly for home consumption. Home consumption (with occasional distributing or selling to other households) occurs in 20 % of the producing gardens. Therefore, we assume home produce to equal home consumption c_2. This contrasts for example to Brazil, where a majority of the households (71 %) indicated that products from gardens are given away to a network of family, neighbors and friends (WinklerPrins, 2002).

Second, we discuss the results from the garden visits in Herent (Table 7.3). A total of 664 kg of vegetables was produced within the 25 surveyed gardens of Herent, corresponding to a productivity of 178 kg per ha of surveyed garden and 2.3 ton per ha of vegetable garden. These garden productivity figures (surveyed for vegetables, potatoes and fruit separately) are solely based on the quantities given by those respondents able to identify and quantify their yields in 2007.

4.1.2 Share of the home produce within the household consumption of fruit and vegetables

The Herent garden visits provide figures on the output per type of produce. As such it allows to calculate the share of garden output within household consumption in terms of weight (Table 7.4).

Compared to the produce bought for home consumption by Flemish households in 2007, the garden produce in Herent amounts to 28 % of the household vegetables consumption and 29 % of the households consumption of potatoes (Table 7.4). Home garden produce (c_2) of vegetables and potatoes thus covers about one third of the amount bought at the market (c_1). For fruit this is much less. Many popular fruits (e.g. bananas, oranges and mandarins) are difficult to grow in temperate climates.

4.1.3 Monetary values of food production in domestic gardens

For a select number of products, the Herent visits allow to calculate the monetary value of the output and its share within household consumption and expenses based on output per type of produce. These data give insights in the monetary significance of c_2.

The monetary market value of the yearly output lies between 17 euro for carrots and 700 euro for potatoes for 2007 (Table 7.5). For five of the eight products, the equivalent financial value of the home produce exceeds 20 % of the total household

Table 7.1 Food production in gardens for Flanders

Fruit is produced in 51 % of the questioned gardens, vegetables in 37 %. For seven produce classes, results on the presence and total produced quantities are given based on the internet survey results (N=1,138).

Produce	Gardens with presence	Total quantity removed from the gardens
Vegetables	37 %	13 tonnes
Fruit	51 %	21 tonnes
Potatoes	20 %	1.7 tonnes
Nuts	31 %	3.4 tonnes
Eggs	25 %	69,100.00 pieces
Meat	5 %	808.00 kg
Fire wood	29 %	4,100 m^3
No production	28 %	

Table 7.2 Productivity of gardens for Flanders

The productivity of kitchen gardens is given for four produce classes, based on the internet survey results (N=1,138).

Produce	Productivity of kitchen gardens [unit/ha] (2007)	Extrapolation for Flanders (based on the garden and kitchen garden areas)
Vegetables	1,310 kg/ha vegetable garden	11,251 tons
Fruit	216 kg/ha garden	25,896 tons
Potatoes	2,566 kg/ha vegetable garden	22,042 tons
Nuts	83 kg/ha garden	8 ton

Table 7.3 Productivity of gardens for Herent

The productivity of kitchen gardens is given for three produce classes, based on the garden visits in Herent (N=25).

Produce from the vegetable garden	Total	Per garden	Per ha garden [a]	Per ha vegetable garden [b]	Per family member (N=64)
Vegetables [kg]	664.5	26.58	177.7	2,292.5	10.4
Fruit [kg]	295	11.8	78.9		4.6
Potatoes [kg]	680	27.2	181.8	2,346	10.6

[a] total garden area of 3.74 ha; [b] total vegetable garden area of 0.26 ha

expenses, with apples (27 %), tomatoes (27 %) and potatoes (25 %) as front runners (Table 7.6).

Compared to the results from Reyes-García et al. (2012a) for home vegetable gardens in the Iberian Peninsula, the gross monetary value (pc_2) realized within the analyzed gardens in Herent were overall lower. We believe that the financial profile of the gardeners can be one of the reasons for the differences. The gross financial value of home gardens per manager in the Iberian peninsula represents almost three months of the official minimum salary in Spain (Reyes-García et al., 2012a), whereas the respondents from Herent have a higher income level (wage w) and produce less financial benefit pc_2.

A second explanation could be the rather low number of different vegetable types cultivated per garden in Herent compared the Iberian gardens. Reyes-García et al. (2012b) found a positive correlation between increases of crop diversity and the gross monetary value generated by the home garden. Reyes-García et al. (2012a) also found that garden managers do not seem to organize their gardens and cultivation plans in order to maximize monetary benefits (pc_2). Knowing that the vegetable garden L_h covers a mere 10 % of the garden area $\overline{L}$, indicates that also the respondents from Herent do not strive for maximizing the monetary benefits from their garden.

4.2 Non-productive use value of gardening

Gardens do not only provide utility because of home production, e.g. the service of providing cultivated crops, but also because of leisure activities, e.g. cultural ecosystem services. The qualitative data provide insights in this non-production use value (aesthetic and recreational value) of a garden for a household. This use value is defined by consumer preferences.

We discuss the value of having an own garden, the consideration of gardening as a burden or a hobby, and motivations for home food gardening.

4.2.1 One's own garden: a valuable space

For the majority of the Flemish households, it is important to have a garden. Being or becoming a owner of a house with a garden is an integral part of the way of life for a Belgian household (De Decker, 2011a). The significance of a garden contains multiple aspects of 'experience', like relaxation, contact with nature, relation with food and prestige (Table 7.7).

Table 7.4 Share of garden output within household consumption of vegetables

Kitchen garden produce of the surveyed gardens of Herent (N=25 gardens surveyed; in total covering 64 family members) is expressed as a share of the total Flemish consumption in 2007. The latter is the sum of the home produce and produce bought for home consumption per person.

	Produce	Produce per family member [kg]	Produce bought for home consumption per person by Flemish households [a] [kg]	Percentage of the total vegetable consumption [%]
General	Vegetables	10.4	36.6	22.1
	Fruit	4.6	54.8	7.7
	Potatoes	10.6	36.1	22.7
	Onion	0.4	4.3	8.5
Specific fruits and vegetables	Beans	1	0.6	62.5
	Paprika	1	1.3	43.5
	Tomato	3.4	3.2	51.5
	Carrot	0.3	5.9	4.8
	Apple[b]	2.9	6.5	30.9
	Pear[c]	1.2	2.5	32.4

[a] in 2007. Flemish Centre for Agriculture and Fisheries marketing (VLAM),
Source: GfK PanelServices Benelux for VLAM; [b] reference is Jonagold; [c] reference is Conference

Table 7.5 Monetary value of kitchen garden produce (2007)

The monetary value of kitchen garden produce is calculated using the average product prices in 2007 (source: NIS Household budget survey 2007, reference value for fresh vegetables) for the surveyed gardens in Herent (N=25).

Produce	Total output in 2007 [kg]	Average product prices in 2007 [euro/kg]	Total output in 2007 [euro]	Number of gardens where produce is grown	Output in euro per garden where the produce is grown in 2007 [euro/garden]
Potato	680	1.030	700.40	6	117
Onion	25	0.937	23.43	4	6
Beans	65.5	4.48	293.44	8	37
Paprika	64	3.486	223.10	4	56
Tomato	220	2.172	477.84	4	119
Carrot	23	0.767	17.64	8	2
Apple	185	1.947 [a]	360.20	5	72
Pear	80	1.549 [b]	123.92	1	124

[a] reference price for Jonagold; [b] reference price for Conference

This corresponds to several of the cultural ecosystem services, including both the physical or experiential use and intellectual representations of ecosystems. Respondents did not only consider these experiences from the individual perspective. The garden is also seen as a nourishing meeting place for family, friends and neighbors.

The most prominent association garden owners made with the domestic garden was 'freedom'. This freedom is reflected in the autonomy Flemish gardeners have in deciding which services and functions are present in the garden, and how the garden is managed. Such gardening autonomy has been illustrated internationally (Robbins et al., 2001; Kinzig et al., 2005; Cooper et al., 2007; Goddard et al., 2013).

Respondents indicated that there is no tradition in top-down (governmental) interfering with garden design and management in Flanders. This implies that the consideration of which trade-offs are made between food production and other services provided by the domestic garden is a personal one, influencing the magnitude of U_{L_h} and U_{L_o}. Such considerations are determined by the utility of gardening perceived by the household, what is reflected in consumer preferences.

> "So, where for one [person] the visual aspects are important, the other [person] values the significance of the garden. The way someone lives and experiences everything is expressed within the garden"
>
> *Employee of a NGO concerned with rural development*

Consumer preferences are a major factor in determining the use of the garden space. This is in line with Kortright and Wakefield (2011) who found out that it is not the available garden area that is the determining factor in enabling food growing in the garden, but the priorities the household expresses over the garden area. Depending on the stage in their life, households express different requirements for their garden space.

Also context is a determining factor in decision making. Context-dependent effects were observed by Verbeeck et al. (2011a), who found that gardens in the vicinity of parks were characterized by higher levels of impervious area. Access to a nearby communal playground for children allowed relatively more garden space to be allocated to food production L_h or to aesthetic values L_o (Kortright and Wakefield, 2011). In addition, informal institutions and neighborhood norms are powerful determinants for the individual choices on garden lay-out and management (Nassauer et al., 2009; Cook et al., 2012).

Table 7.6 Share of kitchen garden produce in the households' expenses for food

The total monetary value of home produce (Table 7.5) is compared with the total expenses for purchased produce for the surveyed gardens in Herent (N=25). The average expenses of the Herent households for the purchase of food is based on the average expenses per Flemish household in 2007. Source: NIS Household budget survey 2007, reference value for fresh vegetables.

Produce	Financial value of the total output [euro]	Total expenses for fruit and vegetables for N=25 households in Herent [euro]	Percentage of the financial value of home grown produce versus average expenses [%]
Potato	700.40	2,075	25.2
Onion	23.43	600	3.8
Beans	293.44	1,100	21.1
Tomato	477.84	1,300	26.9
Carrot	17.64	525	3.3
Apple[a]	360.20	950	27.5
Pear[b]	123.92	725	14.6

[a] reference price for Jonagold; [b] reference price for Conference

Table 7.7 Significance of one's garden

The respondents mentioned seven categories and eight concepts in relation to the significance of their domestic garden. These are based on the qualitative data.

Categories	Concepts
Gardening is personal	Individual experience, philosophy, identity, taste
	Collective experience
	Considerations on the multifunctional lay-out
	Different life phases require different needs
	Unlocking hidden capacities
Contact with nature	Contact with green and nature
	Being outside
	Independence
Relation with food and food quality	
Prestige	
Freedom	
The garden is a place to relax	
The garden is a place to work	

4.2.2 Food gardening: a hobby or a burden?

We hypothesized that people who perceive kitchen gardening as a pleasant occupation will increase their utility by producing extra food in their garden. This is reflected in U_{t_h} and U_{t_o} in the fifth condition. People gaining utility from spending time or land to vegetable gardening are expected to make different choices in the allocation of t_h and L_h compared to people experiencing home food gardening as a burden, or than people gaining more utility from ornamental gardening. Several studies consider food production in domestic gardens in developed countries to be a sheer recreational rather than an economic activity (Domene and Saurí, 2007; Reyes-García et al., 2012a; Jehlicka et al., 2013).

4.2.3 Motivations for home food production

The qualitative data indicated several motivations for managing a part of the garden as kitchen garden (Table 7.8). These include self-sufficiency and tradition. The relevance of tradition should not be surprising since having a vegetable garden was deliberately stimulated by housing policies and government incentives (Meert, 2000; De Decker, 2011b; Meeus et al., 2013). Given the broader scope of the interviews and focus groups on the garden compex and gardening, these insights on drivers for home food gardening are preliminary.

> "I inherited the practice of vegetable gardening."
>
> *Man, 60 years, municipal worker*

The respondents did not mention the quality of garden produce as a motivation. Yet, according to literature home food produce is stimulated by the perception that own food is better than commercial fruit and vegetables in terms of taste and nutrition (Calvet-Mir et al., 2012; Reyes-García et al., 2012a; Jehlicka et al., 2013). Food sovereignty and economic independence are also important reasons (Calvet-Mir et al., 2012).

4.3 Use of garden space

The results from the internet survey for Flanders indicate that for a third of the surveyed gardens, the area of vegetable garden L_h covers up to one fourth of the garden area $\overline{L}$ (Table 7.9). Almost half of the gardens holds a vegetable garden. Also, half of the respondents has fruit trees in the garden.

The results from the garden visits of Herent (Table 7.10) fit these results for Flanders in terms of magnitude. The spatial dominance of lawn relative to other garden components, including vegetable garden and sealed space, is apparent in the visualization based on the Herent survey data (Figure 7.3). Presence of and coverage by vegetable gardens roughly match the results from Belém (Brasil), where 22 % of the garden space was devoted to vegetable cultivation (Madaleno, 2000).

An extrapolation of the area of actual productive vegetable gardens L_h can be made for Flanders. Based on the internet survey (n=1,138), the total garden area $\overline{L}$ containing a vegetable garden is calculated. First, the estimated average size for a vegetable garden is calculated using the lower and upper limit of the area classes. Then, this average size is multiplied by the garden area percentages containing vegetable gardens. This results in an estimated $\sum L_h$ area of 86 km^2 of vegetable garden for Flanders.

Table 7.8 motivations for home food gardening

The respondents mentioned several categories and concepts related to motivations for home food gardening. These are based on the qualitative data.

Categories	Concepts	
Own vegetable garden	Motivators	Tradition and past obligations (e.g. 'kleine landeigendom'
		Yields
		Being self-sufficient
		Search for authenticity
	Characteristics	Short supply chain
		Food safety
	In need for an economic valuation of home-grown produce	
Relation with food	Barbeque with family and friends	
	Food processing, for example for the freezer	
Place within food strategies for cities and food planning		

5 THE IMPACT OF CONSTRAINTS FOR TIME AND LAND ON FOOD PRODUCTION IN HOME GARDENS

The interrelation between the allocation of area and time invites to further explore how capital, area and time constraints are affecting decision on the area (L_h) and time (t_h) for food production in domestic gardens (all in *ceteris paribus* terms). Given the emphasis of this paper on the spatial perspective, we discuss three strategies to bypass the spatial constraints represented by μ (Figure 7.4). We solely consider soil-bound solutions. We associate time constraints (represented by γ) to each of the three strategies.

5.1 STOCK OF FOOD PRODUCTIVE SPACE WITHIN THE SINGLE GARDEN

While in principle the total garden space can be used for home garden production, this is seldom the case in reality. Part of the non-productive garden space (L_o) is transformable to home garden production (L_{oo}) while other parts are less (or not) transformable (L_{os}). The smaller the non-transformable part of the garden, the less likely the area constraint will become effectively binding.

In Flanders, the main components of non-productive garden space are lawn and sealed surface (Table 7.9). A lawn is an example of transformable garden space (L_{oo}). Its transformation requires virtually no cost and effort. Combined with its omnipresence, large spatial coverage, uniform and unsealed character, but also its rather negative environmental reputation (Giner et al., 2013) in terms nutrient and other inputs and of quantities of mowing, it represents the most prominent transformable space in a typical garden.

Transformations from lawn towards more food productive vegetable gardens are realistic (Seymour, 1976; Airriess and Clawson, 1994; Haeg, 2008). An extrapolation similar to the one for vegetable gardens results in a total lawn area of 435 km² in Flanders showing potential for food production.

In terms of coverage, sealed surfaces are the second most important garden component (Table 7.9). We assume that these sealed surfaces are a non-transformable part (L_{os}) of the gardens non-productive space (L_o), i.e. that garden owners will not break out their terraces, driveways and garden paths. Therefore, the area of sealed surfaces puts a distinct physical constraint on the decision space of a household. An increase of the sealed surface would substantially limit spatial adaptation possibilities. This is an interesting insight in the impact of sealing on the potential of gardens for the delivery of ecosystem services.

Table 7.9 Presence and coverage of garden components for Flanders

About 42 % of the gardens contains a vegetable or kitchen garden. The relative spatial coverage by garden components is given for Flanders, based on the results from internet survey (N=1,138).

Garden components	Percentage of the surveyed gardens					
Percentage of the individual garden area	Absent [%]	<25%	25-49%	50%	50-75%	>75%
Lawn	0.5	17	29.8	21.1	24.6	6.9
Flowerbeds	3.9	67.4	24.3	2.3	1.6	0.4
Vegetable garden	58.3	33.1	6.7	1.1	0.4	0.3
Poultry yard	67.8	28.4	2.5	0.5	0.4	0.3
Sealed surfaces	3.3	83.7	11.2	1.1	0.4	0.2

Table 7.10 Presence and coverage of garden components for Herent

In Herent, vegetable gardens are present in 56 % of the surveyed gardens. The presence and average area of garden components is given for the surveyed gardens of Herent (N=25).

Garden component	Presence [% of gardens]	Average area [m2]
Lawn	100	515.4
Flower beds	96	99.5
Shrubs	80	105.9
Vegetable garden	56	187.4
Poultry yard	36	549.7
Sealed surfaces	100	144.2

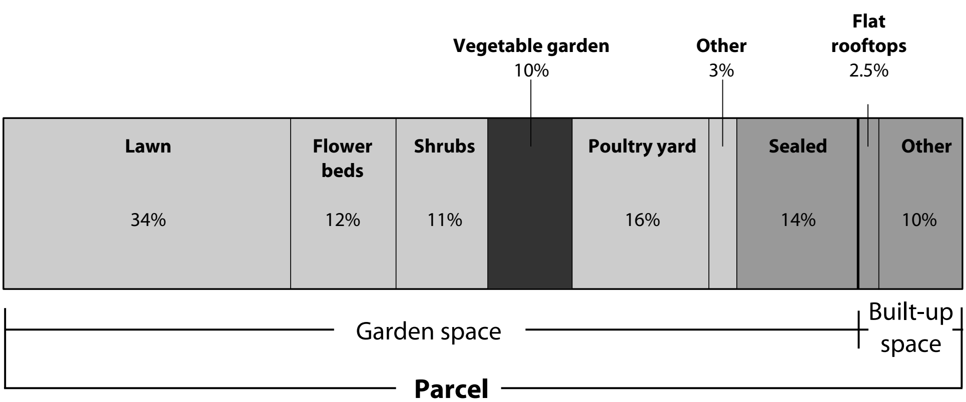


Figure 7.3 Garden space usage for Herent

Summary of the use of garden space for the surveyed gardens in Herent (N=25) reveals that gardens cover on average about 10 % of the garden space. This use profile is based on the average area per garden component.

Verbeeck et al. (2011b) found an average increase of impervious area by 1.3 m^2 per year for residential parcels due to gradual autonomous development for Flanders. This sealing evolution restricts the potential for increasing L_h within the own garden. If the area of non-transformable garden space is low, it becomes less likely that the area constraint will be binding. As such the decision space of the household on how much time to allocate to home gardening and on how much food to buy or produce themselves becomes larger.

5.2 Stock of food productive space outside the single garden

In practice, the finite single garden space $\overline{L}$ is not always an absolute limitation. The individual land constraints (represented in the model by μ) may be bypassed by available L_h outside the own garden.

5.2.1 Managing non-adjacent land

We present two different strategies to increase L_h with non-adjacent land outside the own garden. The first strategy is managing the vegetable garden of family, friends and neighbors. This strategy can be considered as a response within the garden complex, as it involves existing domestic gardens.

Capability for garden management can decrease due to time constraints γ, for example when the available time for gardening (t_o and t_h) decreases. Possible reasons are an increase of t_w, for example in the two-income family model, or a decrease of t_h as soon as it becomes difficult to maintain the garden yourself, for example in an ageing household. Likewise, a decreasing t_w causes the available time t_o and t_h to increase, for example at retirement or when becoming unemployed. This time can then be spent in the own garden, or in the garden of others. Several studies indicate that home gardening is mainly conducted by retired people (Airriess and Clawson, 1994; Domene and Saurí, 2007; Reyes-García et al., 2012a). This group has not only time but also knowledge (Madaleno, 2000).

There is an interaction with the available t_w, t_o and t_h over different households. The garden owner can rent out a part of the garden to others. Garden produce might be shared amongst the garden owner and garden manager which can be considered as an in-kind rental payment. In-kind rental payment is a payment in a form other than cash, in this case garden produce.

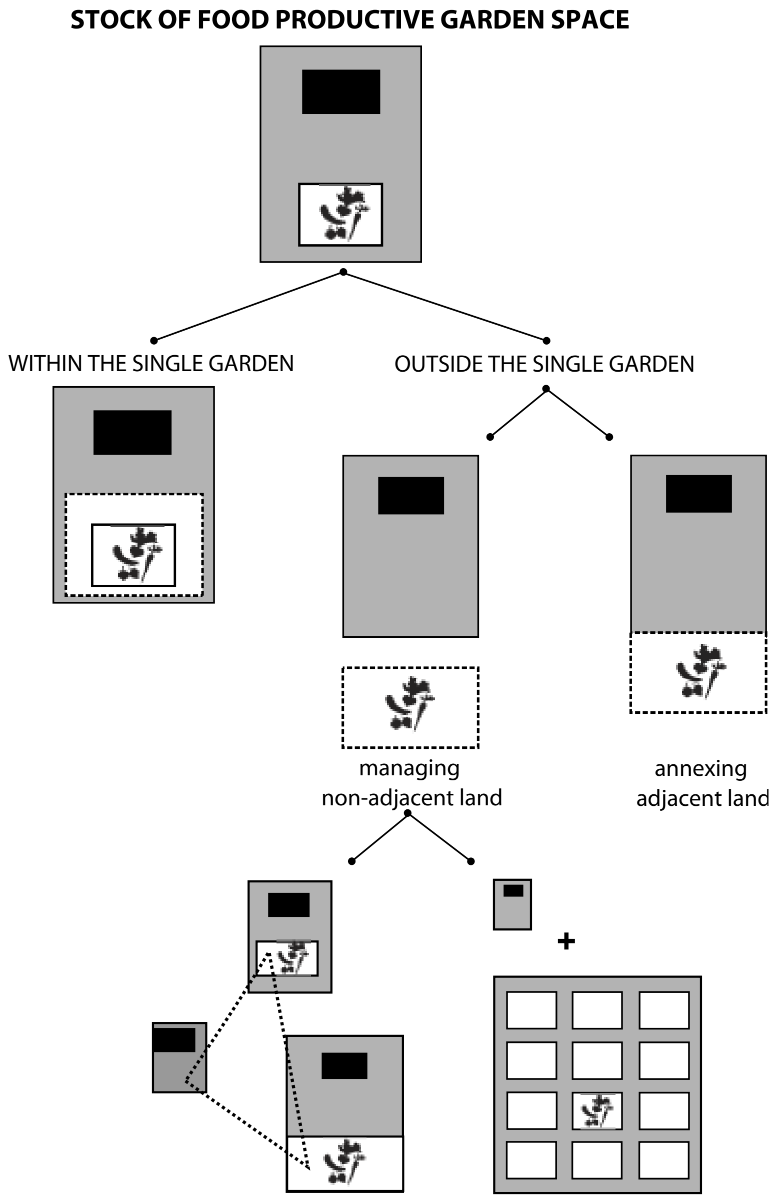


Figure 7.4
Strategies for bypassing spatial constraints on home food gardening

There are three soil-bound strategies to bypass the spatial constraints on home food gardening, visualized within a response tree. People can look for kitchen garden space within or outside their own garden. In case of the latter, the own garden can be extended by annexing adjacent land, or non-adjacent land can be managed by cultivating vegetable gardens of friends or family, or by renting an allotment garden.

If the capital constraint is binding, this rental payment will relax the capital constraint of the owner who rents out part of the garden which in turn decreases the amount of land and time allocated to garden food production by the owner even more. Such renting is already illustrated by Meert (2000) with the example of a grandson maintaining his grandmother's vegetable garden in exchange for a part of the produce.

> "In [...] there are many elderly that have a garden but who can't manage it. They can loan that garden to people that would want to manage it."
>
> *Head of a city green management department of a medium scaled city*

The second strategy is joining a co-gardening project or allotment garden. Within such projects, the social interactions and the distribution of the gardening (and the time it allocates t_h) amongst several households are seen as important surplus values (Table 7.11). This second strategy thus includes land outside the garden complex in its strict definition.

> "The new allotment gardens in the city increasingly have a communal character [. . .] you have the 'garden clusters', where one cluster is jointly managed by 4 to 5 families. The obvious advantage for young families is that you only have to go there once or twice a week"
>
> *Staff member of the city spatial planning department*

5.2.2 Annexing adjacent land

The individual extension of the total garden area $\overline{L}$ is also possible by annexing adjacent land through renting or buying. The annexed land may already be part of the garden complex, e.g. when buying garden space from neighbors.

We discuss further the annexing of non-garden space, and focus on agricultural land. Gardens in the Flemish countryside or peri-urban areas are currently being expanded by annexing (a part of) an adjacent agricultural parcel to the garden (Chapter 4). The intake of farmland as domestic garden is facilitated by the Agricultural Holdings Act. According to this law, owners of farmland can revoke at any time up to 0.2 ha of their land from their tenant farmers, to the benefit of the own household, on condition that this fraction is connected to the own dwelling parcel .

Table 7.11 Motivations for co-gardening

Interaction and the search for collectivity were the two main categories that emerged from the qualitative data when the social surplus of joining co-gardening projects for garden owners was discussed. These two categories and the related concepts presented here are based on the qualitative data.

Categories	Concepts	
Interaction	Sharing and exchanging	Gardening material
		Yields
		Seeds
		Knowledge and experiences
		Garden sharing
	Social contact	
	Temporary gardening support	
Search for collectivity		

5.3 Summarizing the spatial potential for home food production

The strategies discussed above are visualized in a triangle plot (Figure 7.5). We start from an arbitrary situation of garden space usage for one garden (S0). We assume a percentage of 30 % sealed surface L_{os}. This area restricts the decision space of the household for vegetable gardening. The transformable unsealed garden space L_{oo} covers 50 % of the garden and includes about 10 % flowerbeds, and about 40 % of lawn, both rather easy to convert to productive garden.

If the owner wants to increase L_h he can transform of a part of Los L_{oo} to L_h (strategy 1, S1) In our illustration, 30 % of the lawn area is transformed to L_h, raising from 20 % to 50 %. The sealed surface area L_{os} remains 30 %. Whether the transformable garden space L_{oo} will be effectively used as a land stock for food production and to what extent will be decided by the individual household. This consideration depends on the available vegetable gardening knowledge, the time that the household is willing to allocate for home food gardening t_h, defined by the size and sign of U_{t_o}, and the area it is willing to dedicate to home food production L_h, defined by U_{L_o}.

Alternatively, if the household prefers not to give up (a part of) their lawn, it can look for outside their garden by renting in land or joining a co-gardening project (strategy 2, S2). Within the own garden, the proportions between L_h, L_{os} and L_{oo} do not change (e.g. the point remains at its place). Yet, the owners now manage an extra parcel of L_h, so we increased the size of the point. The social surplus gained by joining a co-gardening project is indicated by the dotted circle.

Finally, an enlargement of the total garden area $\overline{L}$ can be done by annexing adjacent land (strategy 3, S3). Let's assume that the total area of the adjacent land is used as a vegetable garden. The relative shares of sealed surfaces L_{os} and unsealed surfaces other than vegetable garden L_{oo} will decrease, while L_h will increase.

6 General discussion and conclusion

Increasing demand for food, raising energy prices, growing land scarcity, climate change and other factors put pressure on food systems (Tscharntke et al., 2012; Fraser et al., 2013). As food security is an essential point of interest with respect to the adaptive capacity of our society, the strategic importance of local food systems cannot be ignored.

6.1 Significance of the model design

In this chapter, we want to reinforce insights in the potential contribution of domestic gardens to the adaptive capacity of (local, urban) food systems. Attention for the food productive role of domestic gardens is rather limited, especially in the developed world. The intrinsic complexity of functions and services provided by domestic gardens may be one of the reasons. Their fragmented and private character impedes a comprehensive understanding of their relevance. A few studies, however, have gained insights in the productivity and gross financial benefits of vegetable gardening (Reyes-García et al., 2012a; Reyes-García et al., 2012b; Algert et al., 2014). Understanding the potential of the garden complex in building adaptive capacity requires insights in food production decisions within the garden complex.

This is captured in the model by exploring direct linkages between the household utility and constraints in land and time with respect to home food production. Utility theory helps to understand consumer preferences and provides insights on how to unlock or at least safeguard the existing food productive potential, in financial and spatial terms, of domestic gardens. The most noted result of home

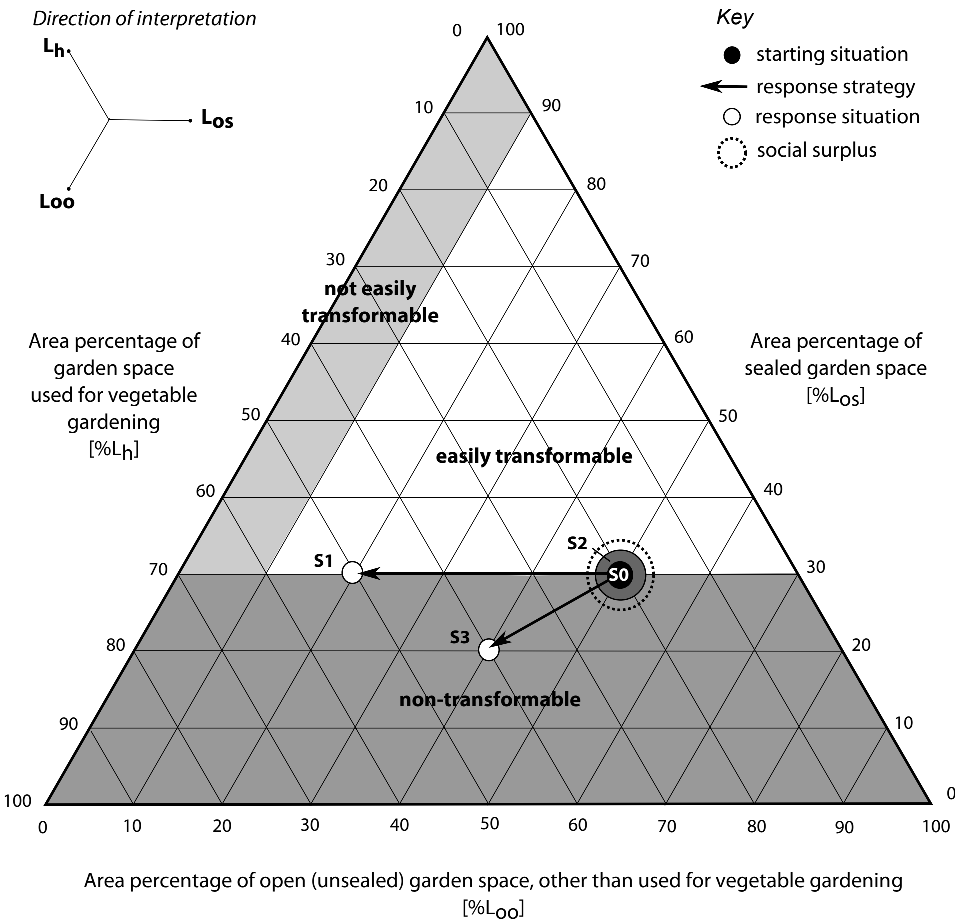


Figure 7.1 Triangle plot on the spatial potential for home food production

The spatial potential of home food production is captured in three spatial strategies to enlarge the garden space area for food production. These can be summarized in a triangle plot. S0 represents the arbitrary starting situation. The first spatial strategy (S1) is the increase of the vegetable garden area (L_h) within the own garden by transforming unsealed garden space (L_{OO}). The second spatial strategy (S2) looks for land for vegetable gardening (L_h) outside the own garden, for example by joining a gardening project or managing land of friends or family. The third strategy (S3) increases the area of vegetable garden (L_h) by annexing adjacent land. This way, the relative share of sealed surface lowers, as the total garden area increases.

garden produce of 25 households was for vegetables and potatoes, where the amount of home garden produce is equivalent to about one third of the amount of these products bought at the market.

6.2 Insights in the potential for food production within domestic gardens

Land potentially available for food production could increase within and outside the individual garden. Provisionally, it is estimated that about 350 m^2 of vegetable garden is needed to provide the vegetable needs for a household of four persons (Seymour, 1976). For the 6 million inhabitants of Flanders, this translates to 525 km^2 (or 52,500 ha) of vegetable garden. Currently 86 km^2 of the Flemish garden space is used for vegetable production. Using an additional 439 km^2 (or 39 %) of the Flemish garden space for garden food production theoretically allows Flemish households to become self-sufficient in vegetables consumption.

Technically spoken, lawn could be easily transformed into vegetable gardens. In reality, the lawn has a distinct value for people, ranging from cultural and aesthetic experiences, to a place for relaxation and play of the children. So, people may be reluctant to giving up a part of their lawn. Future research could focus on the identification of barriers for the transformation of lawn area. For now, we make abstraction of such barriers. The estimations of lawn area for Flanders (435 km^2) can be added up to the current estimated area of vegetable gardens. This results in a potentially food productive area of 521°km^2, almost equivalent to the required area of 525°km^2. The spatial potential exists to nearly provide in the vegetable needs of all Flemish inhabitants depending solely on domestic gardens.

This reflection obviously applies to the larger spatial level of the garden complex and ignores some aspects of demand. At the household level, the available garden area is unequally distributed. It is also impossible to grow the entire diversity of preferred vegetables and fruits in the garden, e.g. because of climatological limitations. There are also additional constraints on the available garden space, like historical pollution with heavy metals.

Despite these restrictions we can state however that the potential of domestic garden area for food provision is far from marginal. With reference to professional agriculture, Danckaert et al. (2013) made theoretical estimations of the space needed for the local production of food currently consumed by the Flemish population. Per Flemish inhabitant, an area of 3.5 m^2 appeared necessary per day.

Based on their calculations, these authors found that the necessary area of 808,700 ha is higher than the current area of statutory farmland. Bringing the garden complex in the discussion on local food production could shed light on alternative territorial alliances.

6.3 Reflections on safeguarding the adaptive capacity of home grown produce

The insights in the spatial potential of domestic gardens for food production indicate that domestic gardens should not be neglected within discourses on adaptive capacity. For example, the model shows how increasing food prices or increasing preferences with home grown produce (because for example its low carbon footprint) may lead to more garden area to be allocated for food production. This adaptive response is subject to the constraints and preferences of the household and is reduced when more garden space is sealed and not or not easy transferable to home garden production. Safeguarding the unsealed space that is easily transferable to home grown food production increases the adaptive capacity and hence the resilience of the social-ecological system in question.

The 'victory gardens' clearly illustrate the contribution of home food systems to the adaptive capacity of society. During World War II, the victory gardens provided in 44% of the fresh produce in the US (Pothukuchi and Kaufman, 1999). They were an effective response initiated and stimulated by policy (Ginn, 2012) to a heavy shock in the society.

Part of the adaptive capacity lays in the short feedback loops between production and consumption, also present in domestic gardens. Producing your own vegetables can be implemented at short notice, on the precondition that sufficient space remains available and the effort is effectively coordinated.

> "If we go to a period in which attention for food production in the garden is really needed, as it was the case for the generation of our grandparents, it remains to be seen if we are doing well with those very small gardens."
>
> *Staff member of the city spatial planning department of a large-scaled city*

Sufficient transferable garden space is not the only precondition for mobilizing the adaptive capacity of home food gardening. Gardening requires gardening knowledge, influencing the land and labor productivity of home grown food production. Safeguarding this knowledge and its exchange amongst family and neighbors increases the adaptive capacity. This is illustrated by the case of Cuban urban agriculture (Buchmann, 2009). During the communist regime, the agricultural system in Cuba was determined by a high wealth, high degree of connectedness, a low diversity and high dependence of the international economy all preconditions for a high vulnerability to shocks (Rodríguez, 1987; Gunderson and Holling, 2002; Fraser et al., 2005; Fraser, 2006).

The collapse of the Soviet Union, being Cuba's most important trading partner, has lead to the implosion of Cuban food systems due to the loss of high-tech agricultural practices (Maal-Bared, 2006; Febles-González et al., 2011). Subsequently, this lead to the start of the Special Period, marking a shift in household decision-making towards home garden food production to increase the individual adaptive capacity (Buchmann, 2009). This evolution was part of the Economic Reanimation (Febles-González et al., 2011). The emergence of private markets provided an incentive to cultivate formerly barren patches of land and gardens (Alvarez and Puerta, 1994). To be able to cultivate, local gardening knowledge had to be rebuilt again through collective learning, which allowed an increase in food production a few years after the collapse in the early 1990ies and resulted in a reorientation toward agroecologgy (Palma et al., 2013).

Capturing and exchanging information between actors in a social-ecological system can be defined as safeguarding the social-ecological memory, and is a major source of community resilience (Barthel et al., 2010). In Flanders, public policies have stimulated homeownership of a single family house with garden and provided allotment gardens amongst the workers and lower-middle class in the 19th and 20th century (Meert, 2000; Segers and Van Molle, 2007; De Decker, 2011a; Segers and Hermans, 2011).

Policy makers also pursued the dissemination of gardening knowledge amongst the population, especially in the post World War II period (Chapter 3). A number of mid-field civil society organizations were established to that end. Men had to learn modern horticultural techniques and how to make cultivation plans, while women followed cooking lessons and learned how to preserve vegetables through brining and sterilization (Segers and Hermans, 2011). These educational goals were pursued by a range of levers, including lectures and the publication of books and brochures (Segers and Hermans, 2011); model gardens (Segers and Hermans, 2011); the mobilization of status and identity (Meeus et al., 2013) through shows and competitions (Segers and Hermans, 2011); and even imaging in television series (Emmery, 2009).

With the decline of such dissemination efforts, gardening knowledge is diminishing with negative consequences for the resilience of social-ecological systems.

The mobilization of the garden complex in the development of adaptive local food systems could result in negative interaction or trade-offs with other ecosystem services provided by gardens. The management of such multiple ecosystem services across landscapes is considered a key challenge of ecosystem management and land planning (Raudsepp-Hearne et al., 2010). Filling in the umbrella term 'other functions' used in the model with specific ecosystem services like pollination, carbon sequestration or water flow regulation, allows studying possible trade-offs and synergies between these spatially related ecosystem services in gardens. The ecosystem service bundle approach (Bennett et al., 2009; Raudsepp-Hearne et al., 2010) offers perspectives for such studies that would allow improving the management of multifunctional landscapes (Kareiva et al., 2007).

7 Future research

At first sight, food production in gardens is worth consideration. This paper illustrates the productive potential of domestic gardens and their potential contribution to the adaptive capacity of food systems. A more comprehensive database on garden produce is needed to better assess the food production potential and adaptive capacity of domestic gardens. There is a lack of monitoring of home grown food production and consumption. A continued assessment of the adaptive capacity of food provisioning within domestic gardens needs comprehensive panel data, which could be gathered during monitoring programs. Logbooks kept in a (semi-) autonomous way and calibrated portable scales (Algert et al., 2014) could be useful as well as mobile applications (apps). Survey efforts should be spread in time or at least supplemented with alternative approaches to assess garden production (Niñez, 1987).

To safeguard the productive and adaptive potential of domestic gardens, it is also crucial to understand households' decisions to allocate space and time to home grown food production. More information about household preferences to allocate time and space to a kitchen garden or to other activities would help to refine the model developed in this paper. One could for example rely on choice experiments for this. Such experiments could quantify the households marginal utility in relation to area and time allocated to home produced food. Also the impact of food prices should be further elaborated on in the frame of the presented model.

Input (*z*) is another important variable that we currently could not unravel due to lack of data. Yet, it is a crucial variable to evaluate sustainability questions. Several studies indicate negative environmental impacts from the (mis-)use of inputs (Robbins et al., 2001; Syme et al., 2004; Dewaelheyns et al., 2013). Where home food production is part of a food strategy, the environmental aspects of production are of special interest (Madaleno, 2000; Kortright and Wakefield, 2011). Especially since garden management is not monitored nor regulated for the use of fertilizers and chemicals, as is the case for agriculture (Dewaelheyns et al., 2013). Future research should aim at raising understanding in input usage and its environmental impact.

Input use is influenced by habits, the available gardening knowledge and experiences. We believe that the exchange of knowledge in society plays an essential role. Gaining insights in the capturing, organization, prevalence and exchange of gardening knowledge is a crucial research track to better understand the input variable. Cleveland and Soleri (1987) already found that a lack of understanding of and adaptation to local conditions results in garden design and management strategies unsuited for the local environmental and social conditions.

> "My daughter also gardens, as long as it goes well.
> As soon as something goes wrong, I have to solve it"
>
> *Man, 67 years, retired*

Throughout the acquisition of new data, the model developed in this paper can be refined. Such refined model can then inform policy on the potential role of domestic gardens in food strategies, as well as on opportunities and pitfalls that have to be considered. When provided with the proper data, the model should be able to deliver quantitative estimates of the identified trade-offs. Although developed based on insights generated from a case in the developed world, we think that this model – when tweaked – could also be applicable in developing countries.


Source: Elke Vanempten

ENVISIONING
THE GARDEN COMPLEX

"Without leaps of imagination, or dreaming, we lose the excitement of possibilities. Dreaming, after all, is a form of planning."

Gloria Steinhem

8. A TOOLBOX FOR GARDEN GOVERNANCE

"De intrinsieke, bijna ingebakken woonwens van de Vlaming is een grondgebonden woning met een voordeur op het maaiveld, een buitenruimte (bij voorkeur een tuin) om de kinderen veilig te laten spelen en een slaapplaats voor de auto op maximaal vijf meter van het huis. (...) Laten we die woonwens gewoon aanvaarden en kijken hoe we ermee kunnen omgaan."

Canfyn (2011)

Chapter 8 *envisions* the garden complex and is situated at the 'social' side of the social-ecological system. We seek to map a wide range of possibilities for addressing the garden complex. At the same time, we also want to trace why currently gardens are underused, i.e. what are barriers to garden governance.

1 Introduction

Domestic gardens provide multiple ecosystem services (Appendix A) and their cumulated areal coverage is considerable (Chapter 4). Yet, they are private landscapes that are autonomously managed by a countless number of gardeners (Zmyslony and Gagnon, 1998; Davies et al., 2011; Van Delm and Gulinck, 2011)). As gardens are a substantial part of the ever increasing urbanization process (Cooper et al., 2007; Niinemets and Peñuelas, 2008; Kiesling and Manning, 2010), an urgent call rises for better insights in their management.

As discussed in Chapter 1, domestic gardens are complex social-ecological systems (Barthel et al., 2010; Cook et al., 2012) that, according to some authors, stand model for studying social-ecological complexity in other systems (Bhatti and Church, 2001; Baker et al., 2007). Governing such a complex environmental resource in a sustainable way is a challenge. Understanding this challenge and identifying pathways that lead to sustainable governance is a key task (Ostrom et al., 1999), not only for the garden complex but for all kinds of environmental resources.

1.1 An environmental perspective on garden management

Garden management decisions have a cumulative impact on the environmental quality (Kiesling and Manning, 2010), human well-being, ecological functioning, and the provision of ecosystem services (Thompson, 2004; Goddard et al., 2010a; Cook et al., 2012). Most research looking for beneficial garden services focuses on the role of domestic gardens for biodiversity (Helfand et al., 2006; Tratalos et al., 2007; Van der Veken et al., 2008; Warren et al., 2008; Kendal et al., 2012; Goddard et al., 2013). Other acknowledged positive effects are related to climate change, like carbon sequestration in soils and vegetation (Pouyat et al., 2002; Groffman et al., 2004; Davies et al., 2011), storm water run-off decrease (Pauleit and Duhme, 2000), and mitigation of the heat island effect (Oliveira et al., 2011; Skelhorn et al., 2014).

Acknowledged negative impacts include greenhouse gas emissions and nitrogen excesses from (lawn) fertilizer usage (Baker et al., 2007; Lorenz and Lal, 2009; Livesley et al., 2010; Trudgill et al., 2010), the distribution of invasive species (Williams and West, 2000; Reichard and White, 2001; Bardsley and Edwards-Jones, 2007; Smith et al., 2007; Niinemets and Peñuelas, 2008), increased soil sealing (Stone, 2004; Perry and Nawaz, 2008; Verbeeck et al., 2011a; Verbeeck et al., 2011b) and water (ab-) use (Syme et al., 2004; Harlan et al., 2009; Breyer et al., 2012; Runfola et al., 2013). Such negative outcomes are generally ascribed to inexperience of the general public with environmental issues (Thompson, 2004; Cooper et al., 2007; Goddard et al., 2010b).

The cumulative outcomes of garden management occur post hoc as an accretion of disaggregated, small, autonomously made and uncoordinated decisions (Odum, 1982). Often they are neither optimal, desired, intended nor preferred by society (Odum, 1982; Stern, 2000; Cooper et al., 2007). Within the context of market economics, Kahn referred to this phenomenon as the 'tyranny of small-decisions' (Kahn, 1966). Because environmental problems are sensitive to small decisions effects (Odum, 1982; Robbins et al., 2001), this concept has been adopted in the discourses of environmental and land management in general (Odum, 1982; Thompson, 2004) and of gardening in particular (Cooper et al., 2007; Goddard et al., 2010b, 2013).

1.2 From a tyranny of small decisions to a resource by small actions

The 'tyranny of small gardening decisions' should not be considered insurmountable. Modest and incremental changes in garden management may greatly benefit the environment and society (Helfand et al., 2006; Baker et al., 2007; Fissore et al., 2012; Goddard et al., 2013). Kiesling and Manning (2010) observed clear benefits from the cumulative effect of many gardeners who choose ecological gardening methods. Gardens provide a substantial head start on migration for many native plants through the process of 'assisted migration', as shown by Van der Veken et al. (2008). Theoretical calculations by Davies (2011) illustrated that tree planting in gardens could generate a total additional carbon storage of 927 tons in above-ground vegetation in the city of Leicester (UK). But the study by Visscher et al. (2014) indicated the need for governance to realize this potential, especially in smaller gardens.

This leads to the hypothesis that the 'tyranny of small gardening decisions' has potential to be transformed to a 'resource by small gardening actions'. We broadly define a 'resource by small gardening actions' as the positive cumulative outcome of individual garden owners adopting sustainable and pro-environmental gardening practices that aim at supporting the provision of ecosystem services (Figure 8.1). As such, private land could become a 'collective good' through its contribution to societal goals. A similar search for generating collective value from private land was conducted by Leinfelder (2007).

Inspiration for a possible pathway to translate the garden resource idea from theory to practice is found in the field of environmental governance. Lemos and Grawal (2006) define environmental governance as interventions that aim changes in environment-related knowledge, institutions, decision making, and behaviors. They refer to the set of regulatory processes, mechanisms and organizations that political actors use to influence environmental actions and outcomes. Stakeholders from the government as well as actors from communities, businesses, and NGOs are involved. We introduce 'garden governance' as a subdivision of environmental governance. Garden governance includes governance strategies focusing on domestic gardens and aiming at the enhancement of a 'resource by small gardening actions'.

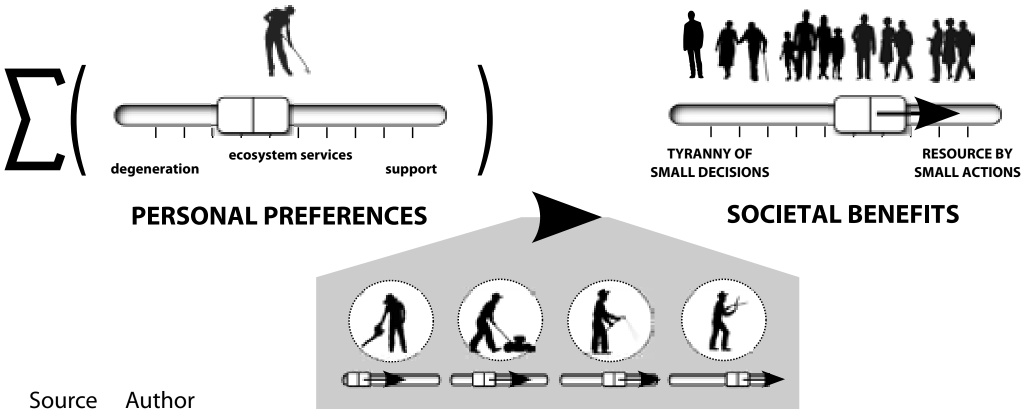


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Figure 8.1 From a tyranny of small decisions to a resource by small actions

At the level of the individual garden, the personal preferences of a gardener define garden lay-out and management. These affect the degenaration or support of potential ecosystem services. By changing garden management or lay-out, individual gardeners can shift from the degradation to the provisioning of ecosystem services (preferred way) or the other way. This shift is represented by a slide bar. The cumulative effect of garden management can result either in a 'tyranny of small decisions' or in a 'resource by small actions'.

1.3 Research objectives and approach

The main goal of this chapter is to explore possibilities and limitations of addressing the garden complex in spatial and environmental strategies. This exploration yields understanding why certain actions take place and others don't. This understanding is essential in the development of any policy or program focusing on the garden complex.

Therefore, a wide-ranging insight should be generated in stakeholders' opinions, ideas and meanings related to the garden complex. We look at the whole range of possibilities and limitations rather than searching consensus on a few. Cowling et al. (2008) already stated that social assessments are important because they provide insight into the perspectives of the owners and beneficiaries of ecological systems giving rise to a service.

First, we identify barriers that could hamper the development of a 'resource by small gardening actions'. Second, we identify levers that can be used to overcome these barriers. Third, we explore possible pathways of garden governance to realize the strategic potential implicitly present in the garden complex.

To bypass the initial consideration of domestic gardens as idiosyncratic objects, the concept of the garden complex is particularly useful (Chapter 2). It clarifies the importance of gardens at the regional level and allows us to focus on the cumulative management impacts of sustainability and resilience issues at a local, regional, national and even continental scale.

The gained insights will clarify how stakeholders should proceed if they want to develop the garden complex as a resource by small actions. It will help them to know which barriers will need to be overcome and which levers could be used to do so. Future research can examine the degree of consensus on these barriers and levers identified here. This will add to the global understanding of the strategic value of hybrid, daily-life landscapes that appear all over the world.

2 Data and methods

Berkes et al. (2003) plea to recognize the importance of qualitative analysis in the quest for sustainable resource management. It helps to understand the systems' behavior, which can help to guide management directions.

So, an inductive qualitative research design was used. This serves the research objectives by its possibility to explore phenomena related to gardening, such as feelings, thought processes and emotions. Information about the opinions, emotions and reasoning on domestic gardens and gardening is essential in gaining insights in barriers and levers related to sustainable and pro-environmental gardening. As I wanted to catch novel insights, I allowed the theory to emerge from the data by organizing the interpretation of raw data into a theoretical explanatory scheme (Strauss and Corbin, 1998). Allowing a theory to emerge from the data is referred to as the grounded theory approach (Strauss and Corbin, 1998).

The qualitative data need to capture the variety of these opinions and emotions, so this can be built into a theory. The searched variety was captured by gathering data on the same phenomenon in different ways (Strauss and Corbin, 1998) and by selecting respondents that actively contribute to the understanding of a resource by small gardening actions (Creswell, 2003). Qualitative research does not aim at collecting data from a random selection of a large number of data points, to obtain statistical information about the opinions of an entire population. Instead, the aim is to choose a small number of respondents that will give in-depth data (Koontz, 2003; Messely, 2014).

2.1 Data sampling

2.1.1 Respondents

The concept of the garden complex was used as a starting point to question 40 respondents from a broad group of stakeholders (Table 8.1). This was considered sufficient according to the method of theoretical sampling (Glaser and Strauss, 1967; Miles and Huberman, 1994) since data-saturation was achieved (Mortelmans, 2007), i.e. the data collection stopped yielding additional relevant insight into the research topic.

Sampling for qualitative research benefits from a purposefully selection of respondents that will help the researcher to understand the problem and the research question as good as possible (Patton, 2002; Creswell, 2008). In the selection of respondents, a maximum mix and variety of people was looked for. This variety includes both public and private stakeholders, and the representation of a range of sectors and policy levels related to gardens and territorial and environmental policies.

Three stakeholder groups were involved: (i) experts, i.e. people working in the broad field of action of domestic gardens, (ii) individual private garden owners and (iii) 'outdoor designers' with expertise in garden and landscape architecture and urbanism. Only the second group was questioned from the perspective of being a garden owner.

A multi-method approach (Lemieux et al., 2014) was used, in which data from interviews and focus groups were triangulated with data from a design workshop (Strauss and Corbin, 1998; Golafshani, 2003; Koro-Ljungberg, 2008; Reynolds et al., 2011; Cox, 2014) (Figure 8.2). Each of the used methods and the selection of the involved respondents is discussed further

2.1.2 Interviews

Over a period of six months (June 2013-January 2014), 21 interviews with experts were performed. These experts were selected via purposive sampling, i.e. respondents from which we expected to receive as much as information as possible (Maxwell, 1997; Guarte and Barrios, 2006; Teddlie and Yu, 2007). The experts covered a wide range of professional backgrounds related to domestic gardens (public officers working on public green, spatial planning and urbanism; staff members of interest groups on rural development, agriculture and ecological gardening; etc.) and

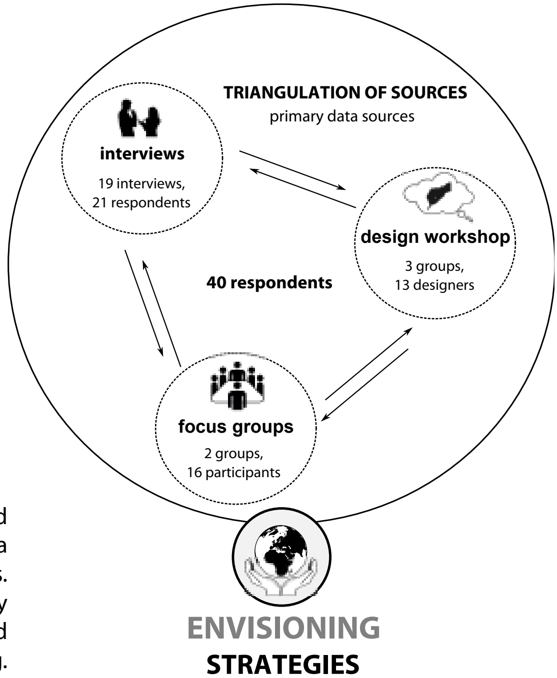

Figure 8.2 Methods and data triangulation used in Chapter 8

A multi-method approach was used to collect data via interviews, a design workshop and focus groups. The data from these three primary data sources were triangulated during the data analysis and coding.

Table 8.1 Background of the respondents

In total, 40 respondents were involved in the data collection. This table gives an overview of their professional organizations and a description of their field of action.

Background of the respondents		**Number**
Regional level (Flanders)		
Education	Garden and landscape architecture, urbanism	3
Policy	Nature and forest; spatial planning	2
Research and policy advice	Nature and forest; planning; housing; knowledge center for cities	5
Interest groups	Agriculture; rural development; ecological gardening	3
Project realization	Agriculture and nature development; social housing	2
Provincial level (e.g. province, actors from the civil society)		
Policy	Environment	1
Project realization and civil society	Housing and industrial sites; nature and biodiversity	2
Municipality & city level		
Policy	Public green; spatial planning and urbanism	6
Private actors		
Freelance garden- en landscape architect		9
Freelance garden journalist		1
Garden owners		16
Total number of respondents		40

represented three scale levels of policy and practice (municipality, provincial and regional level) (Table 8.1).

The experts were questioned through semi-structured interviews about the concept of the garden complex; possibilities and pathways to bring this concept into practice; and about the idea that contribution to common societal goals can be made through individual actions (Appendix D). The interviews were conducted in a semi-structured way. This allowed asking open questions on a number of predefined topics, while giving space to the respondents to express their opinions and experiences.

The interviews were conducted in two separate rounds. An evaluation of the first five interviews allowed refinement of questioning and phrasing for the next 14 interviews. An interview lasted on average about one hour. The interviews were transcribed literally.

2.1.3 Focus groups

In two focus groups, 16 private garden owners living in the province Vlaams-Brabant were consulted. The focus groups were guided by an experienced moderator and took place on January 27th, 2014. Each focus group lasted about two hours.

The main goal of the focus groups was to gain better insights in gardening habits and in feelings and opinions related to domestic gardens. Each focus group was assigned a different phase of the garden lifespan (management phase and (re-) designing phase). Four main aspects were discussed: the emotional and rational relation with the garden, the categorization of gardens, the gardeners' moments and criteria of decision making, and a discussion on how people think about a number of sensitizing actions like regulations on the area of sealed surface, initiatives to support the sharing of gardening equipment and the idea of a 'garden doctor' giving tailor-made garden advice (Appendix D). The videos and live reports were used for analysis.

The 16 participants were recruited from a qualitative panel. The use of selection criteria and quota ensured a balanced composition of the groups. Criteria included garden size and type, respondent's gender, age, level of education, and age of the children. People that were employed in the agricultural or garden sector, media and marketing research, or that had cooperated to qualitative marketing research (in general during the past 3 months and specifically on gardening during the past 12 months) were excluded.

2.1.4 Design workshop

In a design workshop, 13 designers divided in three groups were challenged to rethink the role of domestic gardens within an existing neighborhood. A design workshop is a type of focus group (Morgan and Krueger, 1998; Scott, 2011) in which the participants use design as a means to find answers to the research question (Cox, 2014). Using design in an explorative way leads to insights in alternative pathways for zoning, design and management of an area (Schreurs and Martens, 2005; Schreurs, 2006).

The design assignment was to rethink the existing condition of an ordinary allotment in Flanders, starting from the concept of 'garden complex'. Specific design questions to be handled by the participants included the purpose the garden complex could be mobilized for, the barriers to overcome, the levers and instruments needed, and a stakeholder analysis. We deliberately did not define a specific design task. Letting the design groups determine their themes and priorities themselves allowed us to discover for which themes they preferentially would mobilize the garden complex. All participants received site data collected by the principal researcher and a collection of maps.

The design workshop took place on November 25th, 2013, and lasted one day. Each design group was moderated by an experienced moderator with attention for group dynamics (Reed, 2008). The designers were selected in close collaboration with a non-governmental organization (NGO) of outdoor designers using purposive sampling, i.e. designers from whom we expected to receive as much information as possible (Maxwell, 1997; Guarte and Barrios, 2006; Teddlie and Yu, 2007). With 'outdoor designers' we refer to designers working outdoors: garden and landscape architects, urbanists and spatial planners The collaboration with the NGO also allowed a balanced and well-considered composition of the design groups (Reed, 2008). Criteria for the final group compositions were the field of action (garden, landscape or urbanism), personal interests (ecology, social, style) and character (thinker, puller, go-getter) of the participants.

2.2 Data analysis and coding

The qualitative data were analyzed in a multi-staged process (Figure 8.3), supported by Nvivo. As stated before, a multi-method approach (Lemieux et al., 2014) was used, in which data from the interviews and focus groups were triangulated with data from the design workshop (Strauss and Corbin, 1998; Golafshani, 2003; Koro-Ljungberg, 2008; Reynolds et al., 2011; Cox, 2014) (Figure 8.2). This triangulation of data sources strengthens the outcomes of the analysis (see also par. 2.3). We used the inductive coding approach with an open, an axial and a selective coding phase (Strauss and Corbin, 1998).

First, data of the first five interviews were analyzed using open coding: the data were broken down in discrete objects like ideas, phenomena and feelings, and given a name. These objects are further called concepts. Since this is an exploratory study, all objects have been included. These concepts were then further analyzed and aggregated into distinct categories. In the axial coding phase we re-assembled the concepts and categories by identifying links and cross-cuts (Rogge et al., 2011; Messely et al., 2012; Kerselaers et al., 2013; Messely et al., 2013). This gained a more profound and comprehensive understanding of the data. Although described here as rather distinct phases, the processes of open and axial coding are closely intertwined in reality. The selective coding phase integrated the refined categories into a theoretical scheme, which visualizes the main components and their interrelations.

The concepts, categories and theoretical scheme resulting from the first five interviews were repeatedly re-evaluated by incorporating new data (from the remaining interviews, focus groups and design workshop) in the coding process. The resulting theoretical scheme represents the 'grounded theory' that emerged from the data.

2.3 Ensuring neutrality through triangulation

Triangulation was an important aspect of this research design. It ensures neutrality throughout the data collection and analysis (Strauss and Corbin, 1998) and prevents bias that could result from the work of one single researcher (Golafshani, 2003; Koro-Ljungberg, 2008).

Triangulation was done through *triangulation of sources* (the use of different three data sources: interviews, design workshop and focus groups), *triangulation with multiple analysts* (peer review by colleagues), *expert audit review* (peer review by external researchers) and by *validation* (part of the research-by-design exercise redone by other designers) (Patton, 2002).

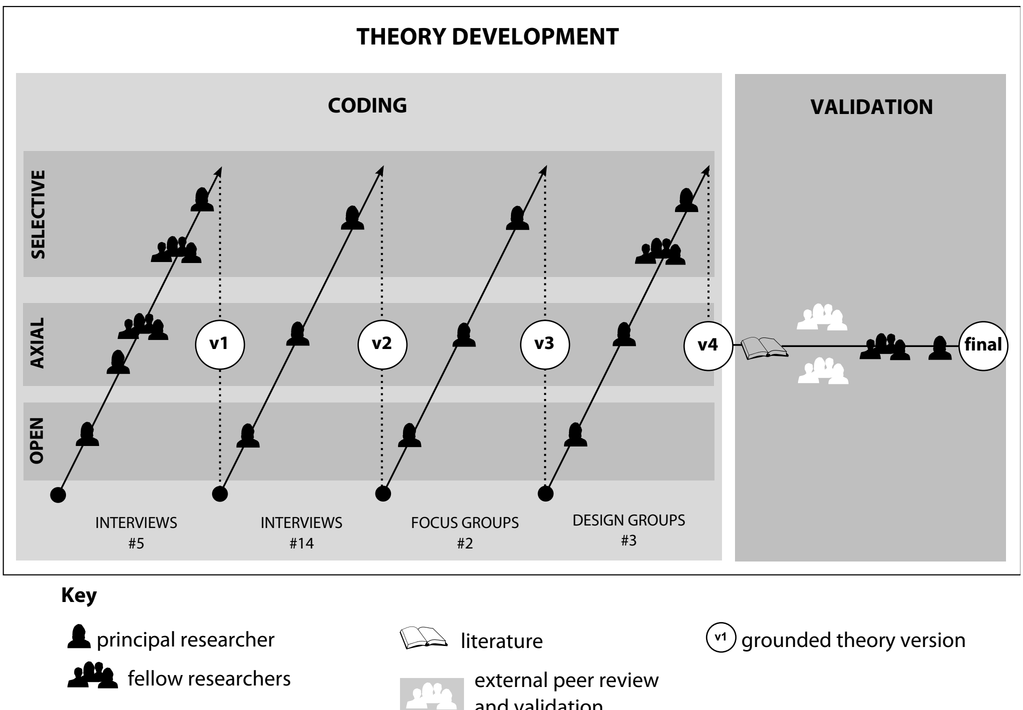

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Figure 8.3 The process of theory development

Throughout four consecutive rounds, the different coding phases (open, axial and selective) were applied. New data was incorporated each round and the three primary data sources (interviews, focus groups and design workshop) were triangulated. Also triangulation with multiple analysts was applied, e.g. peer review by colleagues and an expert audit review, e.g. peer review by external researchers.

3 RESULTS

In total, 22 categories and 261 concepts were found (Appendix E). We identified eight barriers that (could) prevent the transformation from a tyranny of small gardening decisions to a resource by small gardening actions. These barriers are perception, individualism, (non-) policy, non- & undervaluation, private property, premature responsibility, conflicting interests and spatial reality.

To overcome these barriers, five stimulating levers (enable, engage, exemplify, encourage and explore) and four regulating levers (standards, agreements, planning instruments and European directives) were identified. These levers can be part of 'mix and match' toolbox, allowing the development of tailor-made strategies that combining appropriate levers. Each combination of levers should be suited for the pursued goal, the considered site and the target group.

The need of a soliciting vision to frame any strategy pursuing a 'resource by small gardening actions' was An additional insight gained from the analysis. These three core elements (barriers, levers and vision) are captured within a grounded theory (Figure 8.4) and reported further into detail.

3.1 A RANGE OF BARRIERS

Eight barriers were identified that (could) hamper the development of a resource by small gardening actions (Figure 8.5). These barriers appeared to be closely linked with the type of stakeholder (Appendix E, Tables E.1-E.3). The first and second barrier (perception and individualism) are related to private stakeholders. The third and fourth barrier, ((non-) policy and non-& undervaluation) are related to public stakeholders. The four remaining barriers (private property, premature responsibility, conflicting interests and spatial reality) are general barriers.

3.1.1 BARRIER 1: PERCEPTION

The first barrier 'perception' is perhaps the most important barrier for private stakeholders. Several respondents indicated that garden owners experience a pressure to have a 'neat and tidy' garden, especially for front gardens (i.e. in public sight). Respondents referred to both neighbors and parents as people formulating such pressure. They pointed out that a sustainable garden often looks like a neglected garden. Weeds and moss between the stones and in the lawn, and a lawn that is not frequently mowed are negatively perceived.

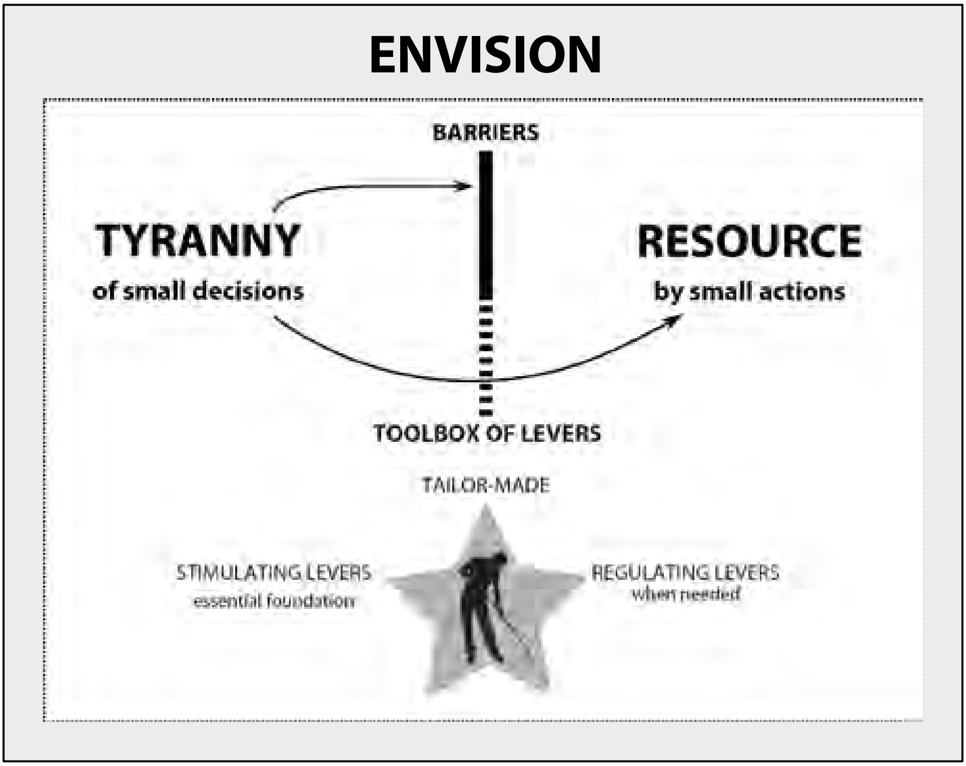

Figure 8.4 The resulting grounded theory on a resource by small actions

There are barriers that prevent the transformation of a tyranny of small decisions towards a resource by small actions. But there is also a toolbox of levers, which can be used to develop tailor-made strategies. This toolbox includes stimulating levers (essential foundation of any strategy) and regulating levers (when needed). This is framed within an envisioning of the garden complex. This resulting scheme represents the results of the coding process.

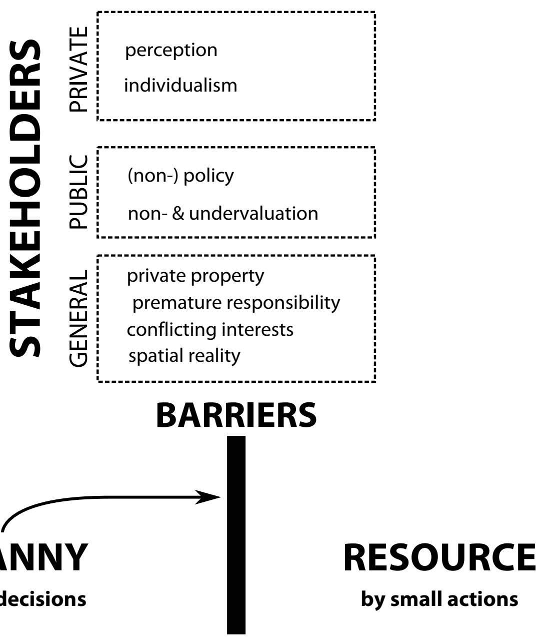

Figure 8.5
Eight barriers hampering a resource by small actions

The eight barriers that were identified throughout the coding process can be grouped according to the stakeholders they apply on (private, public, and stakeholders in general).

"I have new neighbors that allowed everything to grow.
I friendly asked them to mend their garden and now it goes well."

Man, 60 years, municipal worker

A second perception related problem is that people promoting sustainable gardening often have a very 'green' image. During interviews they were referred to as 'open sandals and woolly socks types'. The respondents indicated that this sometimes prevents them from being taken seriously. Furthermore, ecological gardening was perceived to be more expensive and time demanding than conventional gardening.

"You have to change the line of thought of people. Also that the ecological story is not the story of the 'open sandals and woolly socks' people, because especially older generations are reluctant to this"

Staff member of garden and landscape architecture education

3.1.2 Barrier 2: Individualism

The second barrier for private stakeholders is individualism. Respondents indicated that households consider their garden as a personal paradise. They referred several times to garden fencing by hedges and gates as an expression of this individualism. Respondents also discussed the individual reflex of Flemish households by stating that Flemish people often reason from a self-interest perspective. People within a two-worker family would prefer to come home in peace and quit. A lack of confidence in the fellow men and in the government was also mentioned.

"We have a very individualistic oriented society:
we all want our own house and garden"

Staff member of the city spatial planning department

3.1.3 Barrier 3: (non-) policy

The third barrier is mainly related to public stakeholders. Respondents agreed that domestic gardens are no priority in Flemish policy: there is (almost) no policy dealing with domestic green. They named election fever, the lack of a garden sector and the lack of a recent tradition in interference in domestic gardens as possible reasons.

"We certainly have not a culture in Flanders to put limits to
what people can do with their private property"

Researcher on plasnning and housing

Respondents indicated several consequences of this non-policy. There is no coherent and integrated policy vision on domestic gardens, nor is there a policy framework in which such visions could be embedded. This lack of policy attention prevents knowledge and experience to be collected and transferred. Specific garden administrations and means (in terms of budget, manpower and time) are also lacking.

The fragmentation of legislations and jurisdictions related to gardens is considered restrictive, as well as the existing juristic bottlenecks. Regulations and norms related to gardens that do exist are often present at the municipal level, and therefore considered liable to ad-hoc priorities of permit granters. The lack of a 'garden sector' was ascribed some advantages as it allows a more easy functioning since actions will appear less intimidating and threatening. Nevertheless, respondents state that there is no need for a central policy regulation on domestic gardens.

> "There may be people responsible for preparing a municipal green plan, thinking 'maybe we should explore the share of domestic green?', but who don't continue working on that idea because of the lack of a policy framework, and because it is a delicate subject. So it remains ignored"
>
> *Staff member of nature and forest policy, Flemish level*

3.1.4 Barrier 4: non- and undervaluation

Also the fourth barrier is related to public stakeholders. This is the barrier of non- and undervaluation of domestic gardens. Respondents referred to the dominance of the built environment over green and open land uses. They also stated that the perception 'green costs money' is not met by a proper valuation of green and open land uses. It was also noticed that people don't make an economic valorization of their garden. Finally, respondents believed that the lack of knowledge keeps domestic gardens undervalued.

> "Developers don't always see the importance of green, even if it may be rewarding in the long run, and increase the real estate's value. But of course, elements like a terrace and a garden are expensive square meters in a city"
>
> *Staff member of the city spatial planning department*

3.1.5 Barrier 5: private property

First, respondents stated that the private ownership of domestic gardens makes policy stakeholders hesitant to intervene in domestic garden management since it will be difficult to impose anything. In Flanders, almost no gradations exist between private and collective use and property, nor is there a nuanced consideration of rights of use and rights of ownership according to the respondents. This was ascribed to the historical roots of private homeownership in Belgium (Chapter 3).

> "It is a delicate subject: people's garden, it must be about the touchiest subject in Flanders I can think of, next to the car"
>
> *Staff member of project realization on agriculture and nature development*

3.1.6 Barrier 6: premature responsibility

Second, respondents indicated that at the moment it would be premature for policy and private garden owners in Flanders to develop initiatives stimulating a resource by small gardening actions. Lack of data, knowledge, experience and monitoring strategies were named as limiting factors. Also, placing too much individual responsibility with inexperienced individual gardeners would not be beneficial according to the respondents.

> "There are so many cultivars offered [in garden centers] that will last for two years when people plant them in their garden, and then they die. But people will try any fertilizing cocktail I can think of to rescue these plants"
>
> *Staff member of garden and landscape architecture education*

3.1.7 Barrier 7: spatial reality

A third general barrier that was mentioned is the spatial reality. Rethinking existing neighborhoods was considered difficult, as well as the disassociation from an established housing ideal and liberty. This is especially the case in Flanders, where the financial and economic functioning is grafted upon the issuing of mortgages and private housing construction within an historically embedded 'ownership society' (Van den Broeck et al., 2010; Dehaene, 2013; Meeus et al., 2013) (Chapter 3).

Respondents also thought that the spatial fragmentation and the inherent diversity of existing garden blocks hamper a more comprehensive view on domestic gardens. Finally, respondents believed that the invisibility of domestic gardens, hidden behind buildings, also hampers the transformation towards a resource by small gardening actions.

> "Existing neighborhoods, how are you going to… […] If you have to wait until some enthusiast tries to mobilize his neighborhood for an idea…. I'd rather see a task for the government"
>
> *Head of a city green management department*

3.1.8 Barrier 8: conflicting interests

Also conflicting interests were mentioned to be a general barrier. The respondents referred to the competitiveness of commercial interests. The interests of salesmen in garden centers (e.g. sales figures) were considered different from sustainability goals. Also, the supply of products and plants in garden centers was considered too extensive and without a well-founded and correct advice.

Next to this, the analysis indicated some friction between garden architects, working at the smallest scale, and designers working at the landscape scale. It appeared difficult to switch between scales. Garden architects seem to reason from the perspective of the individual owner and private property, while people working at the landscape scale rather made abstraction of individual profits, thinking more in terms of collectivity.

Finally, also policy visions were assumed to differ between different scale levels. Whereas Flemish policy on nature rejects the use of non-native species in the public space, municipal green management offices still prefer to use specific non-native species from a practical point of view (suitability for use in dry conditions, sealed soil, tree shape, etc.).

> "My only fear is that you have some very commercial plant breeders that think: the more I can sell in short term, the better for me"
>
> *Staff member of garden and landscape architecture education*

3.2 A 'MIX AND MATCH' TOOLBOX OF LEVERS

Nine levers were identified that (could) help the development of a resource by small gardening actions (Figure 8.6). Also general insights were gained on how these levers could be best applied (Appendix E, Tables E.4).

In general, respondents indicated that there is no need of large-scaled instruments and subsidies. Respondents believed that a more efficient use and re-orientation of existing means and instruments could already enhance the delivery of ecosystem services by gardens.

> "Such things can be done by reassigning existing municipal resources"
>
> *Staff member of an interest group of agriculture*

The respondents mentioned both stimulating and regulating policy and instruments. The analysis indicated that the stimulating levers should form the foundation of any strategy. These levers should alert and awaken garden owners about the relevance of their garden management as well as of the common significance of their garden property. Respondents stressed the role of sensitization and referred to social instruments as a way to address the responsibility of private garden owners.

> "This works in shades, from something the citizen wants to something he or she doesn't want and you have to impose. There are different possibilities in this range. On one hand this is a matter of social and legal instruments. On the other hand we have the spatial planning instruments […] But I think that a vision is also very important"
>
> *Staff member of garden and landscape architecture education*

We identified five stimulating levers (Appendix E, Tables E.5). The first four levers have to be used in a consecutive way: first *enable*, second *engage*, third *exemplify* and fourth *encourage*. The fifth lever, *explore*, can be applied continuously and independent from the other four.

Despite a certain restraint concerning regulation, the respondents indicated that regulating levers are a necessity for specific issues. Regulating levers interfere at the operational level by constraining the decision space of private gardeners (Paavola, 2007). This need for regulation on gardening practices is also founded by Robbins et al. (2001) who proved that users of chemical products for lawn care were often fully aware of the risks, but nevertheless used such products.

This means that the presence of knowledge alone is not enough to prevent unwanted management actions. During the focus groups, private garden owners appeared to be not reluctant towards regulations on soil sealing, on the conditions that the problem setting is well-illustrated, the results are beneficial and everybody is treated equally. Their main concern was overregulation.

We identified four types of regulating levers that can be ordered according to the level of obligatory power (Appendix E, Tables E.6): standards, agreements, planning instruments and European directives.

Although respondents questioned the feasibility of the enforcement of regulating levers in domestic gardens, a set of essential success factors could be derived from the data. These are based on the experiences of some respondents with enforcement of municipal legislation on fencing, trees and solar panels in domestic gardens in the municipality of Brasschaat (Belgium).

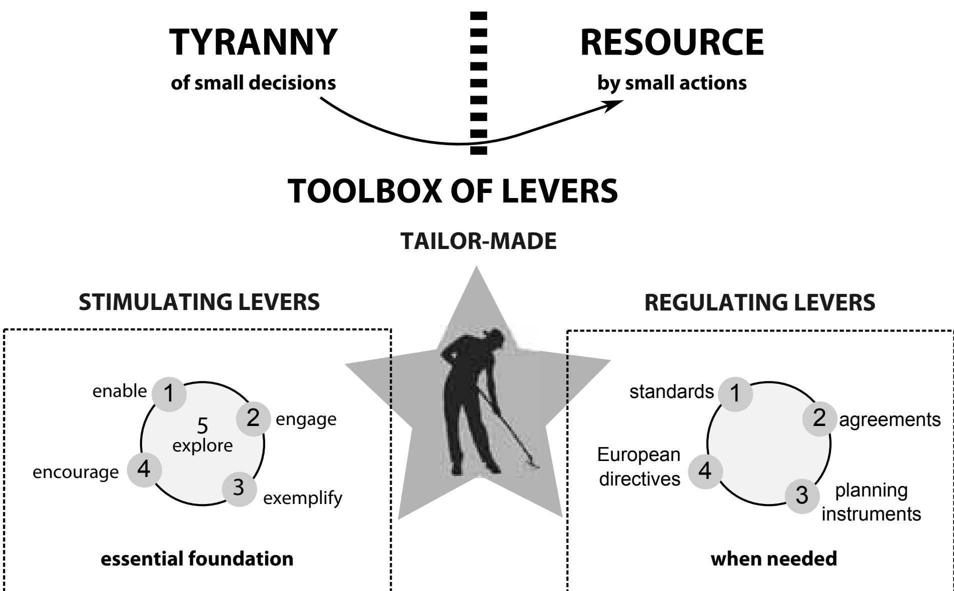

Figure 8.6 Nine levers for initiating and promoting a resource by small actions

Nine levers were identified that could help the development of a resource by small gardening actions. These include five stimulating and four regulating levers. The first four stimulating levers have to be applied consecutively (enable, engage, exemplify and encourage), while one lever can be applied continuously (explore). For the regulating levers, the degree of obligation differs: standards have no obligatory power by themselves, while agreements, planning instruments and European directives are often obligatory.

A strict policy and enforcement appeared to be the first condition. Policy opinions have to be well-communicated and clear, underpinned by information (enable lever) and backed-up by the full political base. A public servant enforces active field controls. Co-production was the second condition. There is a formal cooperation of the municipal spatial planning department with the police and public prosecutor, and between the public bodies and private actors. In the case of violations, private garden owners are first consulted to look for an arrangement.

> "The legal system has options to incorporate such regulations in the municipal plans, subdivision regulations and sales conditions, but the bottleneck is the supervision of what happens in reality. Who for example will inspect the gardens for proper plant species? You will never be able to make such things part of a binding policy. So I think the key problem is the follow-up of the good intentions."
>
> *Staff member of project realization of housing and industrial sites at intermunicipal level*

> "We also have an enforcement policy. We have clear agreements with the office of the public prosecutor of Antwerp. We enforce on garden fences for example. We are very strict on the sealing of front garden strips: only the driveway to the garage or an acknowledged parking spot can be sealed, the rest must be green […] That is also backed up by the new city council"
>
> *Head of a city spatial planning department*

The respondents stressed that any strategy should be geared to the needs of both the individual gardener and of specific sites. This 'tailor-made' aspect appeared to be crucial. Respondents underlined that there is not one kind of private garden owner. Each strategy should anticipate on the personal gain for any individual garden owner.

> "There are enough books written about wild gardens […] but I wonder if all these different things have ever been put together. In a clear website, if there is some catalogue or toolkit to inform about what you can do with your garden, just like designers sometimes use toolkits. If people could already see on one A4 paper what they could do, what they already know, and if they could tick what they'd like to do with their garden as a family"
>
> *Staff member of project realization on social housing, Flemish level*

In particular a 'toolkit' or 'box of building blocks' was mentioned by several respondents as a way to generate such gardener-specific advice. Such a toolbox should contain accessible, simple and feasible measures that focus on the individual garden experience.

> "…a box of building blocks […] a building block is a measure, material or action to stimulate a certain behavior […] bringing together a selection of these blocks, tailor-made for an individual. This makes everything feasible and acceptable for this person"
>
> *Staff member of the environmental department, province level*

Respondents also mentioned the importance to work in a non-generic way since different neighborhoods require different strategies to reach the same goal. They stressed to work at a local scale when site-specific projects are under discussion, but they also emphasized to consider each neighborhood within the wider ecological green structure and social tissue.

> "I'm not in favor of generic solutions. I prefer tangible and site-specific things, tailored to the problems and issues at stake there"
>
> *Staff member of project realization on agriculture and nature development*

Respondents expect that not one, but a plurality of strategies will be needed to shift the tyranny of small gardening decisions towards a resource by small gardening actions. They also preferred strategies that combine a set of goals and motivations, instead of adopting a single focus. Each strategy should provide a robust support of the garden owners, preferably via neutral channels and in a pragmatic way.

Elaborating further on the 'toolkit' and 'box with building blocks' ideas and the need for plural gardener and site specific strategies, a 'toolbox' for garden governance can be considered, containing the whole range of stimulating and regulating levers mentioned by the respondents. A 'mix and match' approach would then allow the selection and combination of the proper levers, based on their suitability for pursuing a specific goal, with a specific target group and in particular site (e.g. neighborhood).

3.2.1 Stimulating lever 1: Enable

First, both public and private actors should be 'enabled' to contribute to a resource by small gardening actions.

Giving information to public and private actors is the first way mentioned by respondents. They stated that policy needs to be informed on the potential value of domestic gardens to be able to overcome the barriers of non-policy and non- and undervaluation. Respondents stressed the importance of management summaries to transfer knowledge from research to policy. Informing policy makers on the current state of domestic gardens and their potential for the provisioning of ecosystem services can help them to acknowledge the relevance of garden governance.

> "The policymakers we meet always need a management summary
> to read in the car while on their way to somewhere"
>
> *Staff member of a knowledge center for cities*

Also the modest private garden owner needs simple, correct, orderly and accessible information to overcome the barriers of premature responsibility and conflicting interests. Respondents believed that information should be tailor-made for tangible gardening questions. They named a wide range of information carriers taking into account different degrees of specialization, like a practical guide, a leaflet with tips and tricks and information moments.

> "I think we have to translate this to individual gardeners […] to clarify their
> position [as individual gardener] in relation to a bigger whole"
>
> *Staff member of an interest group on ecological gardening*

> "Give me more information on what exactly is important."
>
> *Woman, housewife, retired husband*

Second, respondents cited the *education and training of skills*. The positioning of the individual domestic garden within its broader context should be (better) integrated in the existing professional schoolings of garden and landscape architecture, urbanism and spatial planning. Also the private garden owner could be educated and trained, for example by following specific courses. Finally, the education of school children is considered a valuable pathway to reach parents.

The third way is the *lowering and removal of barriers*. In particular respondents underlined the importance of support. Tailor-made garden advice like a garden audit was mentioned multiple times. Also the organization of equipment sharing and the supply of ecological products by a government were considered interesting options. Respondents stressed the need for administrative accessibility of such support measures.

> "Maybe you even should visit domestic gardens. […] I believe many people would benefit a lot from small advice on how to manage their garden […] similar to the energy help desk: citizens call and ask for building advice: how can I make my house more energy-saving? It is not a stupid idea to make a phone call and to ask 'How can I make my garden more sustainable?"
>
> *Staff member of the environmental department, province level*

3.2.2 Stimulating lever 2: Engage

Once knowledge and supporting structures are present, people need to be engaged for sustainable and pro-environmental gardening. The second lever 'engage' strives for this engagement.

The first way is to *enthuse* people by inspiring and appealing campaigns. Respondents underlined the power of small, local and playful actions. They also suggested that involving inhabitants in the management of their local public space could open the way for revising their own garden management practices. Media and opinion formers were also assigned an important role. In particular, the power of media-personalities as 'godfather' or 'godmother' of a campaign or action was mentioned.

The second pathway focuses on contact between people through *personal contacts and social networks*. Respondents considered social capital as an important strength when building a resource by small gardening actions. Enthusiasm for more environmental conscious gardening could be kindled by stimulating and supporting bottom-up initiatives and arrangements within the neighborhood. Especially initiatives transforming the ruling informal institutions were supposed to be successful. Also the exchange of knowledge between personal contacts and social networks was considered important.

> "We have neighborhood managers who organize site-specific activities. Sometimes we come together and then it becomes a bigger project. But for now such initiatives start ad-hoc, depending on the requests and enthusiasm of a particular street and neighborhood. I think it may work very well if someone makes an effort to work this out and design it properly"
>
> *Head of a city green management department of a city*

3.2.3 Stimulating lever 3: Exemplify

The third lever 'exemplify' thrives upon the power of setting examples.

First, the *mimicry-effect* was acknowledged as a possible lever.

Second, respondents indicate that policy should *set examples* within the public domain, accompanied by clear and simple information (enable lever). They gave the example of the ban on chemical pesticide use by Flemish public bodies. Municipal green managers noticed that private garden owners take over the management of their local public (green) space using exactly the forbidden products in their thrive for a 'neat and tidy' neighborhood. This illustrates the complexity of interactions between stakeholders, social institutions and issues dealt with.

Third, respondents mentioned that policy should support or stimulate the development of actual small-scale experiments and the inventory of best practices, inspiring cases and experiences. Such actual examples could work explanatory as well as enthusing.

> "I think particularly about pilot projects. That would be the most important in the beginning. Don't pick the most difficult neighborhood to start with, but focus on a neighborhood where people already experiment, so you can look into the way things work and what the consequences are. And these people could then function as ambassadors, on television or in a newspaper. People like to be inspired by other people"
>
> *Staff member of a knowledge center for cities*

Fourth, examples and best practices should be visualized by placing signs or labels by the front door. This meets the barrier of the spatial reality, in particular the invisibility of domestic behind buildings.

3.2.4 Stimulating lever 4: Encourage

The fourth lever wants to 'encourage' private garden owners to transform their management to a resource by small gardening actions.

> "There is an individual incentive to stimulate you doing it, but the system will benefit the whole society"
>
> *Staff member of a knowledge center for cities*

The first way is *showing commitment*. Respondents assign this task to policy and professional associations. They could set examples within the public domain, which refers to the previous exemplify lever.

The second way uses *financial incentives*. Respondents stated that many possibilities can arise if policy can invest money. They referred to the controversial 'green certificates' for the installation of photovoltaic panels in Flanders (see Beliën et al. (2013). Yet, the respondents were reserved towards financial support for gardening since most people like to invest in their garden. Gardening is often perceived as recreation or results in a pleasant and satisfying living environment. Respondents argue that these personal gains should not be supported by government budgets.

Despite the remarks on direct subsidies, respondents did consider the reorientation of existing means, projects and instruments feasible. They also mentioned the organization of group purchases of reliable and sustainable gardening products.

3.2.5 Stimulating lever 5: Explore

The fifth lever is to 'explore' possibilities. This lever meets a number of barriers, like the lack of knowledge, data and experience; and the difficulties of rethinking existing neighborhoods.

First, respondents referred to *academic research* to meet the lack of data and knowledge on domestic gardens. They stated that researchers could analyze similar initiatives and compare best practices to determine success factors. Also the set-up, conduction and analysis of small-scale experiments were considered a task for research.

> "If you have better scientific evidence of that value of biodiversity in gardens… increasing only the knowledge on that theme would already help sensitizing. That is another part of your concept that is important to mobilize"
>
> *Researcher on planning and housing*

Second, respondents stressed that *real life experiments* deserve space, literally and figuratively. They indicated the need for structural support to identify and alter structural barriers that prevent the development of a resource by small gardening actions. Respondents also believed in the power of real life and small-scaled experiments on themes like ownership rights, garden block renovations or temporary use. The support of innovative practices and niches, like co-gardening and community land trust initiatives, was expected to provide valuable insights.

Third, respondents assigned a specific role to *research-by-design* (de Jong and van der Voordt, 2002; Cross, 2006; Schreurs, 2006). They indicated the need for informal designs (i.e. that will not be realized but serve an explorative goal) as these would allow the exploration of innovative concepts. Research-by-design also allows an alternative reading of the spatial and social layers of the garden complex concept. Finally, respondents indicated that this approach nourishes the reformulation and re-conceptualization of domestic gardens.

3.2.6 Regulating lever 1: Standards

'Standards' are the first type of regulating levers. Respondents mentioned the possibility to define general Flemish quality standards concerning garden design and management. They referred to the ecosystem service approach for inspiring the definition of such standards. In particular 'green standards' were mentioned with respect to the amount and quality of private and public green space to be provided in development and allotment projects. Complying with standards is a voluntary action.

3.2.7 Regulating lever 2: Agreement

The second kind of regulating lever is the 'agreement' or 'charter', a voluntary but formal and legally binding lever. Respondents indicated that private garden owners can commit themselves to arrangements noted in an agreement or charter. This could be an agreement between private garden owners and the municipality, for example on the management of the front gardens, or between neighbors, for example on the ban of chemical garden products.

"The experiment of the very wide pavement garden: pavement gardens are normally 30 cm wide. In the inner-city, we once made pavement gardens of about 1 m wide, because the people there have no garden […] this gives them the opportunity to grow some herbs and vegetables, and it is a nice experiment. If it doesn't work, it will be paved again by the city. That is the agreement"

Staff member of the city spatial planning department

3.2.8 Regulating lever 3: Planning instruments

The third group collects levers that are part of spatial and town planning instruments (Table 8.2).

Respondents stated that the current legislations and instruments could both facilitate and hinder the development of a resource be small gardening actions. The municipal 'green plan' for example only focuses on public green. Yet, it could be broadened to include domestic green like gardens. The respondents also noticed that existing instruments are currently underused or unused from this perspective. Respondents believe that municipalities could make better use of certain permits and regulations to enforce quality standards. Also the costs-benefit principle (costs are paid but benefits are not fetched), terms and conditions of sale, and spatial implementation and zoning plans are considered to be underused.

Table 8.2 Overview of the planning instruments mentioned by the respondents
The respondents mentioned a range of planning instruments in the context of regulation. The full overview of regulating levers is given in Appendix E, Table E.6.

Planning instruments	Measures
Financial-economic	'The polluter pays' principle
	Costs-benefits principle: effective requisition of benefits
	Taxes on real estate: inclusion of the garden
Land policy	Urban land reallocation
	Land bank
	Agricultural Holdings act
Permits and regulations	All scale levels: RUP's, BPA's
	Municipal level: building permits and regulations, GAS, ...
	Site level: allotment regulations, terms and conditions of sale, building specifications
Servitudes	

> "At such a moment [permit of subdivision], the government has a lot in own hands: it can decide what is permitted and what not. This is done for the building line, angle of inclination, etc. […] while you can treat the hedges etc as you like. But conditions can be imposed: you need at least this number of trees; you need to be able to compost at least your waste, etc."
>
> *Coordinator of project realization on landscape, nature and biodiversity*

Respondents pursued two levers in greater depth. Concerning financial-economic measures, they mentioned three measures. The principle of 'the polluters pays' was cited in relation to the sealed area (see e.g. Hamelink (1998)). Also the use of a compensation instrument was suggested (see e.g. van der Veen et al. (2010)). Respondents stipulated however that this instrument has to be used as intended, so not only to settle claims but also to cash benefits.

Introducing the garden in withholding taxes on real estate was a third measure that was named. Respondents brainstormed on possibilities to tax garden size and structures (like paving), while an overall good environmental garden performance could lead to a tax reduction This performance could be evaluated on the basis of ecosystem services support. Ghaley et al. (2014) for example show how the valuation of ecosystem services allows the support of ecosystem services. A tool to evaluate the rainwater retention efficiency of domestic gardens was developed by Verbeeck et al. (2013).

> "You could levy taxes […] I have a garden and it supports several ecosystem services beneficial to society. I plant trees, meaning that I convert a certain amount of carbon dioxide into oxygen, I let rainwater infiltrate in the soil. If you would be able to account for that, monetarization so to speak, you could think of a kind of ecosystem certificate granting people to be compensated, directly by a refund or indirectly by tax reduction. […] or the other way around, if you chose to seal 90 % of your garden, you could be charged for the negative impact"
>
> *Staff member of the spatial planning department, Flemish level)*

Land policy, with a restricted use of the instruments to open space, inspired respondents to discuss the possibilities of a land reallocation instrument and a land bank specifically for (peri-) urban areas.

3.2.9 Regulating lever 4: European directives

The final group of regulating levers encompasses everything related to European directives. Respondents mentioned the translation of the CAP to regional policy and the Water directive as being relevant for domestic gardens.

> "It would also be interesting to know which guidelines and regulations exist at the European level, and which are on their way. [...] there will be strict regulations, but also statements on private green for example, that will strengthen your message"
>
> *Staff member of a knowledge center for cities*

3.3 Envision

The respondents believed that it is innovative to consider domestic gardens as part of a regional wide environmental resource (Appendix E, Table E.7). Yet, given the many barriers, they stressed the need for a convincing story and a soliciting envisioning.

> "If we all contribute, the synergy at a larger scale will result in a structural change"
>
> *Staff member of project realization of housing and industrial sites at intermunicipal level*

Respondents explored the role of the garden complex concept in such a soliciting perspective. They think that the garden complex opens up new perspectives on domestic gardens. Respondents became triggered by underused possibilities of the current stock of domestic gardens, and were curious about by opportunities for optimization. They also believed that the garden complex evokes refinement of the 'urban' label; of the advantages of private and public green; and of the missing gradations between collectivization and privatization. Finally, respondents noticed that the upscaling of individual gardens highlights common goals and allows considering domestic gardens at the landscape scale. During the interviews and the design workshop however, the principal researcher noticed that it was not always such an easy concept to grasp for the respondents.

> "I think it is a valuable thing to get to work with, especially when you consider how little the private gardener is aware about the connections and ecological possibilities"
>
> *Staff member of garden and landscape architecture education*

> “Today, we consider it [gardens] partly negatively, garden sprawl as a phenomenon. […] And by looking at the whole, you can start from ‘OK, what does this mean, landscape-ecologically, functionally’ you can look at the ecosystem services supported by that garden complex, and how they contributes to the green-blue veining of urban and rural areas”
>
> *Staff member of the spatial planning department, Flemish level*

Respondents also considered the garden complex as a useful framework for domestic gardens that is currently lacking. From the perspective of policy and practice, it was seen as a steppingstone in the reconsideration of peri-urban areas; the improvement of existing neighborhoods and the optimization of green infrastructure. From the perspective of research, respondents valued the fact that it provides a handle for studying domestic gardens and private green. Respondents also appreciated that the garden complex can be demarcated within the landscape, since this makes the concept tangible. They also assigned the concept potential to slowly infiltrate into standard planning practices.

> “Those are three issues [biodiversity, food production and the use of chemical pesticides and herbicides] of which I think that the garden complex can offer an answer, issues for which we currently have no context nor structural support”
>
> *Staff member of an interest group on ecological gardening*

Finally, the respondents of a design group thought that the garden complex builds a bridge between individual garden management and global issues like climate change. The concept not only allows the positioning of the modest domestic garden within the context of such global issues (see e.g. Throgmorton (2003), it also brings these global issues to the people in a direct and tangible way.

> “The garden complex can bring the story of climate [change] closer to the people”
>
> *Design group*

Based on these statements, we conclude that the concept of the garden complex can provide a soliciting vision that promotes the idea of a resource by small gardening actions.

4 Discussion

4.1 General insights

The obtained insights indicate that the idea of the garden complex as a 'resource by small gardening actions' is feasible. In general, respondents were open to this idea, but at the same time they indicated that it would be a long-term and difficult process. This opens up a novel way of looking at the role of modest gardens as a collective good that can actually help in building a resilient society (Moulaert and Van Dyck, 2011; Goddard et al., 2013).

It is essential that planners and designers recognize and acknowledge the numerous barriers that prevent people from adopting environmentally beneficial behaviors (Thompson, 2004). We identified eight barriers that (could) hamper the development of a resource by small gardening actions.

At the same time, the respondents mentioned a range of stimulating and regulating levers that might be used to overcome these barriers. These stimulating levers fit the outcomes of a general social marketing framework for pro-environmental behaviors developed by DEFRA (2008).

None of the respondent groups is fully in favor of regulating levers because of questions on effectiveness and cost of implementing and monitoring regulations in domestic gardens, as also stated by Balooni et al. (2014). Yet, regulations were believed to be indispensable for certain issues and enhancement appeared possible. The main goal of this chapter was to identify barriers and levers related to the garden complex and a resource by small actions idea. Future research could look for consensus on these barriers and levers.

The ideas of respondents on a 'toolkit' and a 'box with building blocks' give inspiration for a 'toolbox with levers' approach. Such a toolbox allows the selection of suitable levers (including stimulating and regulating levers) for developing tailor-made strategies at benefit of both the target groups (e.g. types of gardeners) and the site (e.g. neighborhood, city, and region) under consideration. This fits the insight of Cowling et al. (2008) that ecosystem service research should be user-inspired and user-useful. Site-specific strategies fit the planning tendency of integrated area-based development and offer room for the idea of 'territorial pacts'(Coppens et al., 2014) (page 63) and self-organization (Boonstra and Boelens, 2011).

The results and insights also illustrate that social systems for long-term environmental governance have to perform a wide range of functions such as promoting the development and sharing of frontier knowledge and the transformation of conflicting interests into effective and sustained collective action (Underdal, 2010).

4.2 Pathways towards a resource by small actions

The respondents expected that a plurality of a strategies will be needed. Three complementary pathways towards a resource by small actions were derived from the gained insights.

4.2.1 Pathway 1: mobilize neighborhood norms

Our results on the perception barrier illustrate the influence of neighbors and neighborhood norms on the gardening decisions of individuals (Zmyslony and Gagnon, 1998; Colding and Folke, 2001; Warren et al., 2008; Nassauer et al., 2009; Nassauer, 2011; Cook et al., 2012; Kurz and Baudains, 2012). We found that individuals' choices were constrained by the maintenance of collective interests of residents in visible outdoor areas. Respondents explicitly referred to the perception that a sustainable garden often looks like a neglected garden.

We see linkages with four phenomena described in literature. The first phenomenon is that a neglected garden suggests that the owners are irresponsible and probably not desirable as neighbors (Nassauer, 2011). The second phenomenon is the prestige effect (Dunnett and Qasim, 2000; Grove et al., 2006; Larson et al., 2010) that refers to the display of identity and status in front yards. Third, several studies describe spatial autocorrelation of gardening practices as an indication of a shared social garden ideal in the neighborhood, e.g. descriptive social norms (Zmyslony and Gagnon, 1998; Lapinski and Rimal, 2005; Warren et al., 2008; Cook et al., 2012). The fourth phenomenon is the 'symbolic power' of third persons, defined as the power to influence the shaping of social preferences in a community, that then become common knowledge (Ishihara and Pascual, 2009).

These phenomena indicate the potential of neighborhood norms to be used within garden governance strategies. Applying the mechanisms behind social norms can enable the diffusion of pro-environmental gardening practices within a neighborhood (Colding and Folke, 2001). Neighborhood norms are even considered a more powerful control mechanism than regulations for environmental issues related to millions of individuals (Thompson, 2004). But as Lejano and Fernandez de Castro. (2014) put it, the invisible hand of neighborhood norms requires linkages among people, places, and things, and the acknowledgment that the outcomes of these linkages are valuable for someone or something else.

Garden governance strategies could address neighborhood norms by mobilizing social capital (Adger, 2003; Underdal, 2010). Social capital is believed to be an important asset for collective action (Adger, 2003; Ishihara and Pascual, 2009; Underdal, 2010; Wolf et al., 2010), which is confirmed by our results. The *engage* and *exemplify* levers offer interesting handles to do so. Within the engage lever, personal contacts and social networks were valued highly by respondents. Stimulating and supporting bottom-up initiatives and arrangements within a neighborhood is thus a first pathway. Cooper et al. (2007) stated that the 'tyranny of small decisions' could be defeated by involving citizens in the active management of residential lands. Also Goddard et al. (2013) subscribed community-driven initiatives the role to engage, educate and empower residents in encouraging wildlife-friendly gardening.

The second pathway is social learning, understood here as a learning process that changes the understanding of individuals through social interactions, while simultaneously upscaling issues from the individual level to a more collective level and wider context (Garmendia and Stagl, 2010; Reed et al., 2010). The initiation and support of social learning processes can transform the current exchange of gardening knowledge between friends and neighbors to the establishment of sustainable normative and affective values (Garmendia and Stagl, 2010). The mobilization of the 'neighbor mimicry' phenomenon (Goddard et al., 2013) (exemplify lever) can further spread sustainable gardening practices within a neighborhood.

Yet, the state of the present knowledge is a particular point of attention. If the prevailing garden practices are not in accordance with the aimed goals, social learning systems will rather have a limiting effect (Wolf et al., 2010). Mimicry phenomena should be monitored attentively and, if necessary, adjusted. Appearance and ecological functioning are not always synonymous (e.g. the work of Nassauer (Nassauer, 1992; Nassauer, 1995; Nassauer et al., 2009; Nassauer, 2011) and calibrating people's perception with sustainable gardening is a challenge (Dallimer et al., 2012). So, as Rodela (2013) states, research on monitoring and evaluation of social learning offers valuable input.

4.2.2 Pathway 2: Dare to dream

The idea of garden governance invites to dream about a future garden complex. Such a fictive utopia can matter (Throgmorton, 2003), in particular in the visualization of the soliciting vision needed to frame garden governance strategies. Drawing on Angélil and Hehl (2013), framing the garden complex as a major collective project suggests another way of understanding contemporary collectives, recognizing the hardware, the domestic green, as an integral component of the software, the society.

One way of translating the 'garden complex' to a practical vision appealing for garden owners is 'storytelling'. Satterfield et al. (2013) recently suggested that narrative based elicitation techniques might be a suitable approach to improve the opportunities for ecosystem services support (Iniesta-Arandia et al., 2014). Future-oriented stories that are persuasive to a broad range of people help to imagine and create sustainable places (Throgmorton, 2003). It makes them familiar with possibilities and desires, inspires them to act, and makes them believe that their actions will actually make a difference (Throgmorton, 2003). This can overcome the feeling of powerlessness that many people experience when global issues like climate change are discussed. This is the perception that one has no power to affect an outcome by taking action (Stern, 2000; Aitken et al., 2011). Lejano and Fernandez de Castro (2014) refer to this as the aspect of 'recognition': someone has to perceive his or her actions as being important to someone or something else.

This shows that the garden complex can be used as a spatial concept to represent a desired future situation. A well-conceived spatial concept is a powerful tool for guiding, inspiring and supporting planning and landscape design (Ahern, 2005).

The task of storytelling seems mainly reserved for designers, such as planners (Throgmorton, 2003) and graphic designers (Shea et al., 2012), but we also believe that a wider group of stakeholders can play its part, including academic researchers, and developers and dealers of garden design software packages.

The insights in a multitude of tailor-made strategies suggest that we expect interactions with other measures and pathways. Private garden owners could be supported in their susceptibility of future-oriented stories on the garden complex by mobile apps, giving real-time and tailor-made gardening advice. Based on their analysis of contemporary physical activity apps, Conroy et al. (2014) found that people may need multiple mobile applications to initiate and maintain behavior change.

Although it is not possible to know in advance where the interaction of stories will lead (Throgmorton, 2003) this should not prevent us to consider domestic gardens as an environmental resource.

4.2.3 Pathway 3: Fill in knowledge gaps: explore, involve and communicate

The lack of knowledge proved to be a fundamental issue. As Lemieux et al. (2014) puts it, the importance of research, monitoring and reporting cannot be underestimated. In accordance with the *explore* lever, we identified four future research tracks.

Research track 1: The first track focuses on the generation of data about garden management practices and their impacts on the environment. Although such studies already exists (Robbins et al., 2001; Baker et al., 2007; Harlan et al., 2009; Larson et al., 2009; Livesley et al., 2010) there are still knowledge gaps present. Insights in the present gardening knowledge could improve the mobilization of neighborhood norms through social learning.

Research track 2: The second track deals with stakeholders. A stakeholder analysis could identify all relevant stakeholders. The characterization of garden owners in terms of gardening attitude and behavior for instance would be a first aspect. Here, specific attention for the cultural ecosystem services related to gardens and gardening would be interesting, as well as a further clarification of the 'lifestyle concept' (Pisman et al., 2011; Pisman, 2012) for gardening. At the same time, guidelines for cooperation between all stakeholders could be a point of attention. This brings the garden complex in the discourses of collaborative (Healey, 1998, 2007) and fuzzy planning (De Roo and Porter, 2007), and adaptive co-management (Olsson et al., 2004).

Research track 3: The third track uses research-by-design to explore garden governance strategies and to tell future-oriented stories. Research-by-design challenges the ruling principles of daily practice and makes explicit which possibilities exists beyond what is known (Janssens, 2008). As such, it can nourish the re-conceptualization and revalorization (Schreurs, 2006; Janssens, 2008) of domestic gardens. The 'urban' reallocation' instrument (regulating lever) and the framing of ecologically 'messy systems' in orderly frames (Nassauer, 1995) (*engage* and *exemplify*) are interesting topics to be explored through designing. It could also be explored if the 'ecological land use complementation' (ELC) concept of Colding (2007) can be included in garden governance strategies.

Research track 4: The final research track aims at addressing garden governance from the perspectives of a wide range of theories and concepts such as new institutionalism (Paavola, 2007), environmental governance (Underdal, 2010), collective action (Adger, 2003), private governance networks (Smith and Fischlein, 2010), public ecology (Robertson and Hull, 2003), the tragedy of the commons and the way out through privatization (Smith, 1981; Ostrom, 1990), the concept of powerlessness (Aitken et al., 2011), collaborative and fuzzy planning (Healey, 1998; De Roo and Porter, 2007; Healey, 2007) and adaptive co-management (Olsson et al., 2004; Folke et al., 2011).

One of the main challenges in acquiring data on domestic gardens and garden management remains their strictly private character (Phillips et al., 2008; Kortright and Wakefield, 2011; Van Delm and Gulinck, 2011). Involving garden owners and their lay-knowledge is a form of citizen science (Hand, 2010 ; Bonney et al., 2014). Existing insights in the organization of citizen science monitoring programs can be used (Tulloch et al., 2013; Franzoni and Sauermann, 2014). As Paavola (2007) states, most contemporary environmental policies require the users of resource to practice self-monitoring and reporting.

Although a wealth of scientific knowledge of urban landscapes is present, planning, design and management of the urban environment is seldom based on scientific knowledge (Wang et al.; Opdam and Steingröver, 2008). Knowledge on the domestic garden system has to be incorporated in any environmental governance strategy to be effective (Lemos and Agrawal, 2006). Respondents stressed the importance of the dissemination of the existing expert knowledge to the relevant stakeholders including policy (see also Cortner (2000)). As Nursey-Bray et al. (2014) state that, if we want to built scientific research outputs into policy, knowledge in strict scientific context should be broadened to other knowledge types. In his proposal for an integrated urban ecological framework, Niëmela (2014) stresses the importance of collaboration between researchers and (other) societal actors.

Expert knowledge requires translating academic insights and languages to a popular language, policy recommendations (Sterk et al., 2009) and problems relevant for private gardeners (Weichselgartner and Kasperson, 2010). Cowling et al. (2008) already clarified that researchers will need to respond to stakeholder needs from the onset and to collaborate with them in strategy development and implementation related to the support of ecosystem services.

Science must be framed so non-scientists are able to rapidly identify why an issue matters and what should be done (Nisbet and Mooney, 2007). Yet, the clear assignment of roles has to be maintained. Research is not a substitute for decision-making (Ostrom et al., 1999), but helps to inform decisions by identifying and monitoring resources.

4.3 Garden governance strategies

The pathways discussed above may all be part of garden governance strategies. Unlike traditional governance approaches, garden governance explicitly takes into account private actors. This seems a challenging task given the identified barriers of perception, private property and individualism. Moreover, public stakeholders appeared to be rather critical about interference in domestic gardens due to a lack of recent tradition and the phenomenon of 'election fever' (e.g. also Underdal (2010). We agree that the explicit role of private gardeners makes garden governance sensitive for questioning. It underlines the voluntary character of the 'resource by small gardening actions' idea, which could be considered as a weakness.

But Paavola (2007) assigns private ownership an important role in environmental policies. Moreover, innovative strategies of environmental governance need the incorporation of individuals to be efficient (Lemos and Agrawal, 2006). Nassauer (2011) and Krasny et al. (2014) described how the aesthetic experience and the meaning of one's place, like a garden, can be an entry point for taking care of something that ultimately belongs to others. Also the results indicated that individual garden management can make the mitigation of global issues like climate change and biodiversity loss more feasible and tangible. This is considered a strength since many people fail to link individual actions to larger issues of environmental quality (Steiner, 2014). Yet, as Steiner (2014) puts it, is also a challenge to realize positive changes. In addition, several authors believe in the strength of voluntary (collective) action for environmental governance (Colding and Folke, 2001; Paavola, 2007; Smith and Fischlein, 2010).

The aggregation and upscaling of individual actions to accomplish more than the individual actors intend requires heterogeneous approaches (Nassauer, 2011). Our results indeed indicate the need to develop a multitude of tailor-made strategies. This complies with Kaplan and Kaplan (1998) who stated that a 'One size fits all' approach rarely provides a very good fit. It also fits the opinion of Lehtonen (2004) that it is neither feasible nor desirable to search for a single measure or a single framework for working within an environmental–social interface.

Our grounded theory seems to combine elements from the two distinct models of environmental governance: the adaptive governance model and the collective action model (Underdal, 2010). The adaptive governance model represents response on environmental challenges as collective action through central leadership and contraction of power. Within the collective action model, societal response is conceived as the involvement of a variety of local activities undertaken by subunits of a complex and decentralized system.

Within our grounded theory, the involvement of a variety of local activities undertaken by subunits of a complex and decentralized system is fundamental. Our guideline on the mobilization of neighborhood norms explicitly addresses bottom-up initiatives. Yet, to respond to environmental challenges garden governance strategies should also include central leadership. It is important that even self-organized governance networks are not operating fully independent of the representative democracy (Hahn, 2011). For example, stakeholders at different spatial scales have different interests in ecosystem services (Hein et al., 2006). Without the development of an overall ecosystem management plan, it is likely that the not all interests will be incorporated.

This invites to consider garden governance as a 'hybrid' form of governance (Lemos and Agrawal, 2006). Such combination of elements enhances flexibility, diversity, and learning capacity while at the same time ensuring focus, energy, and sustained commitment (Underdal, 2010).

The inventory of barriers and levers for addressing the garden complex in spatial and environmental strategies presented here is considered a first essential step in the search for garden governance strategies. A next step could include an actor analysis and take these insights a step further by developing an operational model for garden governance. The operational model of Cowling et al. (2008) for safeguarding ecosystem services can give inspiration. Within the first phase of this model, opportunities and constraints are defined based on the results of social, biophysical as well as valuation assessment. In the planning phase, these opportunities are then transformed into user-friendly products to identify strategic objectives for implementation in collaboration with stakeholders. Finally, actions are undertaken and coordinated to achieve the protection of ecosystem services and to ensure the flow of these services to beneficiaries. Additional inspiration from spatial planning can be found with the communicative planning process of De Roo (De Roo, 2007).

5 Conclusion

To be able to pursue sustainable and resilient landscapes that can respond to complex future challenges, it is necessary to consider and manage the landscape as a whole (Fry, 2001; Saunders and Briggs, 2002; Haines-Young et al., 2003; Selman, 2006). Domestic gardens and their private managers are an essential part of the current peri-urban daily-life landscapes, and their sustainable governance appears to be a challenging task. Especially since *"the interaction between the 'environmental' and the 'social' still remains a largely uncharted terrain"* (Lehtonen, 2004), page 1).

The tyranny of small gardening decisions proved potential to be transformed to a resource by small garden actions. The cumulative actions of a manifold of gardeners can be considered an opportunity rather than a pitfall. However no 'silver bullet' came up: a multiplicity of actions and pathways will be needed to establish garden governance. We were able to identify barriers that could prevent a shift from tyranny to resource. To overcome these barriers, a 'mix and match' toolbox of levers emerged from the data. This toolbox allows the development of tailor-made strategies using a specific combination of stimulating and regulating levers. For a strategy to be successful, a framing vision with a matching story appeared valuable. The garden complex could be such a soliciting vision.

Placed within a broader context, this research adds up to the understanding if and how private actors and their property could be taken up in policy plans that strive for common societal goals. As such, our work meets the calls of Paavola (2007) to search pathways for the integration of traditional national policies with solutions based on voluntary cooperation, and to extend analysis from common-pool resources to other kinds of environmental resources. Our insights add to the global understanding of the strategic value of hybrid, intimate, and daily-life landscapes that exist all over the world.

> "It is not because a garden is not open to the public, that you cannot use it"
>
> *Researcher on ecosystem services, nature and forest*

REVISITING
THE GARDEN COMPLEX

"Commitment leads to action. Action brings your dream closer."

Marcia Wieder


SOFTY
Jardin Collectif

9. CONCLUSIONS

This final chapter recalls the garden complex by synthesizing the main findings. It launches four key messages that provide an agenda to go forward with the garden complex.

"I like the dreams of the future better than the history of the past."

Thomas Jefferson

1 Recalling the garden complex

This dissertation has built up original knowledge of a land use system that hitherto has been ill-documented and largely ignored in a range of territorial policies and research. Starting from the general observation of this 'garden gap', the main goal was to clarify the strategic value of the integral stock of domestic gardens in a regional context. This stock was defined as the 'garden complex'.

To structure this clarification, a framework was developed that relates the three interlocking dimensions of structures, services and strategies of the garden complex. Against the background of social-ecological systems and ecosystem services, this framework bridges the ecological and social aspects of the garden complex.

The research has launched an inceptive information base on Flemish domestic gardens. Structures and services of the garden complex were mapped and the strategic potential was envisioned. To do so, the research continuously switched between the level of individual gardens and the higher level of their collectivity. Like any study, this work gives inspiration for future research that can start from this information base.

1.1 The spatial dimension

The extent of the garden complex was studied in Chapters 4 and 5. In Chapter 4, the coverage of domestic gardens could be derived from a coarse 'garden' category of the national topographic map with support of orthophotographs and statistical techniques. The refinement revealed that domestic gardens cover more than 8 % of the Flemish territory. This is comparable to the regional coverage of forest (11 %) and sealed surface (13 %). So, the garden theme is far from marginal compared to other land use themes.

Especially this coverage figure proved to be an eye-opener for many respondents actively involved in the research (Chapter 8). We thus consider spatial data as an important entry point to put domestic gardens on the agenda. These data are also needed to assess and monitor the capacity of gardens to support a range of ecosystem services.

> "It was an eye-opener for me a few years ago to hear about the area gardens actually cover"
>
> *Staff member of nature and forest policy, Flemish level*

The tailor-made method developed in this chapter enabled to find a balance between the goal of collecting regional wide data on the spatial footprint of domestic gardens and the time constraints related to detailed empirical analysis. Future research could elaborate further on the morphological types of the garden complex, on the (bio-) physical structures of domestic gardens, and on the connections of the garden complex with the surrounding landscape.

Chapter 4 also demonstrated how the cumulative effect of new garden area is essentially at the cost of farmland. Chapter 5 further investigated the occupation of agricultural land by gardens. Existing GIS datasets (the spatial allocation plan and Land Parcel Identification System) were combined to identify parcels with an inconsistently determined use. These parcels were further inventoried using Google Streetview images. Domestic gardens turned out to cover about 6 % of the statutory farmland in six municipalities. So next to planned and legal conversions, also the cumulative effect of unplanned conversions to garden puts farmland under pressure. Future research can extend this analysis to include parcels with a mixed allocation like the category 'housing area with rural character'.

1.2 The functional dimension

The functional dimension of the garden complex was analyzed in Chapters 6 and 7. These chapters explicitly studied the link between the physical garden and garden management, i.e. the link between the ecological system and the social system. The study focused on the ecosystem function of nutrient cycling and the ecosystem service of providing cultivated crops.

In Chapter 6 a regional internet survey was combined with garden soil analyses. The data indicated an excessive use of fertilizers. Also pH, carbon and phosphorus levels appeared to be well over the agronomical growth optimum. But the results equally well illustrated that the garden complex has potential as a carbon sink. A mixed methodology combining a regional wide internet survey with detailed soil analyses proved valuable in unlocking rather inaccessible data on garden management.

But more detailed and specific environmental studies are needed to better understand garden management behavior and its feedback to the environment, and consequently to a wide range of ecosystem services. For instance, the application of home compost can be the subject of future research. The practice is currently widespread and strongly promoted: about 70 % of the people applying compost use home-made compost. But there is almost no information on the carbon and nitrogen contents of applied home-compost, or on the actual applied quantities. Consequently, there is insufficient insight in the impact of compost application on water quality, e.g. the leaching of nitrate to the groundwater. A similar request for better clarification of use and environmental impact can be made for the much used horticultural peat (Holmes, 2010; Cameron et al., 2012).

Agricultural optimal growth standards were used to evaluate the current soil fertility states. These were developed for optimizing food production in an agronomic context. The development of fine-tuned soil fertility classes for a range of specific ecosystem services supported by gardens (Appendix A) is a key task.

Chapter 7 further unraveled the gardening decisions taken by households. The focus was on the allocation of space and time to the provisioning ecosystem function of crop cultivation, e.g. food production. Original quantitative and qualitative data on the home production of vegetables and fruit were collected using a regional wide internet survey, garden visits, expert interviews and focus groups.

The data revealed amongst other things the magnitude and actual market value of current home garden produce. These insights inspired the development of an economic utility model. Against a background of future challenges within the food system, the potential of domestic garden area for food provision appeared to be far from marginal. These insights illustrate the potential contribution of domestic gardens to the adaptive capacity of food systems. Especially the effect of the share of lawns and sealed surfaces and of gardening knowledge on the adaptive capacity asks for further research.

Hardly any information is present on Flemish garden management practices. The support of ecosystem services delivered by gardens is mainly determined by household preferences. These influence both the design and management of the garden. The economic model developed in Chapter 7 can be further uploaded and validated with data from choice experiments, from qualitative research on the value and benefits households assign to gardening, and from more profound and long-term surveys. The model itself can be further developed by integrating other ecosystem services like pollination, carbon and nitrogen storage and maintaining habitats Insights in garden management, that can be generated by utility modeling, should be incorporated in any garden governance strategy to be effective (e.g. Lemos and Agrawal (2006)).

The lack of baseline data limited the number of studied ecosystem functions and services studied to two. But the insights in the potential of domestic gardens to support both strengthens the call to study in-depth the wide range of ecosystem functions, services and benefits related to gardens. Especially in gardens, cultural services are strongly interwoven with the provisioning and the regulating services. Based on the insights from Chapter 6 and 7, these cultural services may be a major drivers in the support of ecosystem services and benefits delivered by gardens (e.g. Krasny et al. (2014)). Future research could elaborate further on this, including the social, ecological and economic valuation of garden services and benefits.

Also the link between structures and services deserves further exploration. The design workshop incorporated in the qualitative research clarified that research-by-design is an interesting approach to explore possibilities for mobilizing the garden complex. The morphologies of garden units discussed in Chapter 2 could be studied in design exercises with a specific focus on the support of ecosystem services. Several studies already indicated links between garden unit morphologies and ecosystem services like the regulation of temperature or the provisioning of habitat for bird species (Andersson and Colding, 2014; Lehmann et al., 2014). Residential development and certainly ribbon development have a negative connotation in current planning philosophies. Refocusing on the strategic value of the associated gardens may create new perspectives in the locked-in situation of peri-urban areas as places without value.

Also the social learning capacity of design workshops could be explored further. As suggested by Rodela (2013), it is interesting to study how, when and under what conditions such workshops foster learning and which learning outcomes can result from them. This could be done by surveying participants about their mindsets before and after the workshop, or by action research where designers are followed on a trajectory of consecutive design workshops and their professional activities in the meantime and afterwards.

In the long run, the insights from studies on garden structures, functions and services might strengthen practicing garden and landscape architects in shaping their individual design assignments and management plans in such a way that they contribute to the support of ecosystem services.

1.3 The societal dimension

Chapter 3 gave an historical review of the rise and disappearance of a 'garden program' in Belgian (and Flemish) territorial policies. This review offered interesting references about the mobilization of private households in the development of the territory and the persuasion of common goals set by policy.

The search for a contemporary approach of mobilizing the garden complex, for example in relation to climate change and biodiversity loss, was discussed in Chapter 8. A detrimental cumulative effect of individual garden fertilization decisions on soil fertility was illustrated in Chapter 6. Such a phenomenon is called 'the tyranny of small decisions' in literature. Yet, the results in Chapter 6 also indicated that the garden complex has potential as a carbon sink. So, we hypothesized in Chapter 8 that a 'tyranny of small gardening decisions' has potential to become a 'resource by small gardening actions'. To verify this, qualitative data were analyzed adopting the grounded theory approach. Eight barriers and nine levers were identified, that can respectively hamper or stimulate the transformation from a tyranny to a resource.

It became clear that a multitude of complementary actions and pathways will be needed to establish this transformation. Three of such complementary pathways were discussed, addressing neighborhood norms, the spirit to dream, and the need for research and cooperation. These pathways were positioned within 'garden governance'. These results clarified possibilities and limitations of addressing the garden complex in spatial and environmental strategies. These insights will give stakeholders like policy makers and NGO's a handle on how they should proceed if they want to develop the garden complex as a resource by small actions.

Further understanding is needed of which stakeholders should be involved, how this should be done and in which way their cooperation should be organized. Garden governance strategies require insights in site-specific success factors. Why does one approach work in a certain neighborhood and not in another? Also a characterization of garden owners is needed in terms of behavior and attitude, as well as information about the present gardening knowledge and its exchange amongst family, friends and neighbors. Such insights would especially contribute to the understanding of how private stakeholders should be involved in policy development processes, which goes far beyond the garden theme.

Further elaboration on the strategies dimension would allow the garden complex to infiltrate in the fields of landscape architecture, spatial planning, urbanism and landscape urbanism, and the reconsideration of the garden complex as a land use theme in its own right.

1.4 The strategic value of the garden complex

Bringing the above findings together allows us to conclude that domestic gardens indeed have significant strategic value. This strategic value is not only present in their spatial, temporal and functional characteristics, but also in terms of governance strategies (Figure 9.1).

Recalling the insights on a 'garden agenda' in past territorial policies we can state that this is not new. Combining these historical insights with a renewed valuation of domestic gardens in terms of structures, services and garden governance strategies gives inspiration for future pathways towards a garden complex that is a valued resource by small gardening actions.

There is room for a new strategic valuation of domestic gardens.

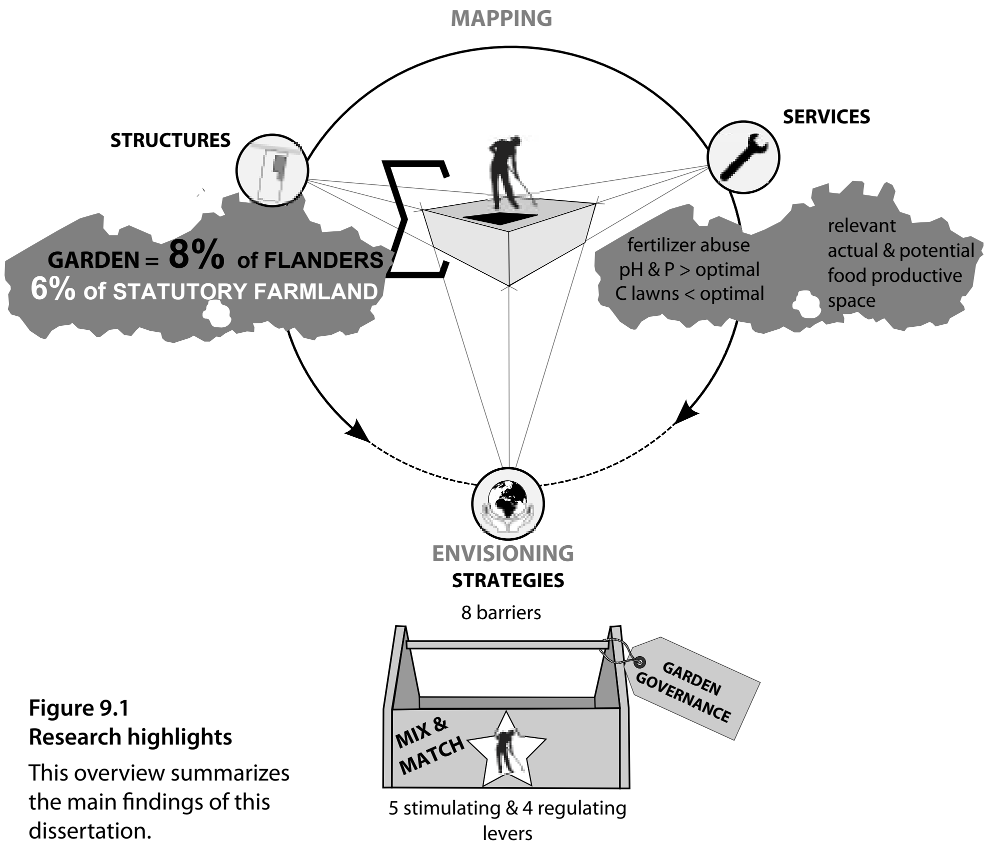

Figure 9.1
Research highlights
This overview summarizes the main findings of this dissertation.

1.5 General methodological reflections

One of the merits of this dissertation, besides revealing the strategic value of the garden complex, is the development of methods to collect data about an important part of the territory. Throughout the Chapters 4 to 8, a range of methods was developed for the case Flanders by originally combining existing methods and approaches.

For the mapping objective, existing information like a topographical land use map or Land Parcel Identification System dataset was combined with data from aerial and streetview photograph analysis and surveys. The detailed character of the empirical analyses has proven its strength in generating spatial knowledge on gardens, but a trade-off remains with time investments. The Google Streetview photographs proved to be an interesting surrogate for terrain inventories.

The lack of baseline data on gardens and garden owners hampered the characterization of the whole populations of gardens and garden owners. This made it challenging to design a representative and accurate sampling. Nevertheless, several techniques were used with the survey to gain minimum insights in representativeness. These included the use of strata, the estimation of minimum sample sizes based on infinitely large populations, and scorings on Likert-theses to gain insights in possible overrepresentation of certain types of gardeners (e.g. passionate or ecological gardeners).

Within the qualitative research used for the envisioning objective, data from open interviews, focus groups and research-by-design practiced during a design workshop was triangulated. Future research should focus on the surplus value of triangulating these methods, for example by analyzing each of three data sources separately as well as joined.

The case study approach focusing on Flanders was necessary to break through the vicious circle of non-attention. It allowed the necessary detail (e.g. the collection of empirical data) without making abstraction of the time-demanding character of the analyses. Exactly these data has proven potential to break through the vicious circle. Also, Belgian territorial policies have shaped a mixed landscape that can be considered informative for peri-urban regions all over the globe. Within such landscapes, case studies are needed as experimental or exemplary cases (see also Chapter 8 explore lever) (Bomans, 2011). The insights gained for the case of Flanders offer inspiration for research on domestic gardens elsewhere, but each region or country will need to tailor the presented approaches to the datasets that are at their disposal.

2 Forward with the garden complex

The insights gained throughout the dissertation can fuel discussion on several issues. The main issues are summarized in the following four key messages.

2.1 Key message 1. Ontology of the garden complex

The reflection of domestic gardens as idiosyncratic objects was considered to hamper a new strategic valuation of domestic gardens. To leap this 'garden fence', we introduced the concept of the garden complex as the aggregation of individual domestic gardens within a certain region (Chapter 2).

This preliminary definition can now be evaluated based on the results.

What is the garden complex? First of all, the concept proved to be a powerful spatial concept that allowed the aggregation of all kinds of data on individual domestic gardens to multiple scales. This upscaling contributes to the acknowledgment of the importance of the accumulation of small garden spaces and gardening actions: *'Many a little makes a mickle'*. As such, the garden complex allows land use and environmental policies to look at gardens from a different angle. This opens the way to, as Selman puts it, *"address the complete mesh of inter-locking units rather than elite selections"* (Selman (2006), p. 25).

The garden complex proved to be more than just an assembly of spatial modules. The 'complex' in 'garden complex' has a deeper meaning related to the complexity of social-ecological relations within and across domestic gardens. It is a space of actions and decisions that are influenced by cultural norms, identity and institutions. It is a social space as well as it is an ecosystem. And this space is continuously evolving.

Especially the social-ecological character allows the concept to bridge the gaps between environmental and spatial planning, landscape scales, and individual households and global environmental issues. Many people fail to link their individual actions to global issues of sustainability and environmental quality (Steiner, 2014). The garden complex offer opportunities for people to actually become stewards of ecosystem services, as demonstrated in Chapter 8, and in the work by Nassauer (2011).

During the research the concept of the garden complex evoked an 'a-ha erlebnis' with stakeholders. Despite this soliciting success and appreciation by stakeholders, the 'garden complex' also appeared to be a difficult term to understand in certain situations and for certain stakeholders. This could be due to the feeling of 'complexity' evoked by the term 'garden complex'. An alternative term can be 'gardenscape' in analogy with landscape, townscape, energyscape (Howard et al., 2013) or waterscape (Grau and Dreiseitl, 2005). The Swahili language would allow the neology 'ubustani' that might represent something similar. 'Bustani' means garden, while 'u' is a preposition that represents abstraction and collectivity.

We believe that a permanent monitoring of the further development of the garden complex is not only interesting but also advantageous. Future research can focus on demographic and societal characteristics of garden owners and their effect on the garden design and management. The influence of ethnicity, age and level of education are examples. It can also be interesting to map garden evolutions in some kind of 'garden career', maybe analogous to the 'housing pathways' of individual households (Clapham, 2005; Meeus et al., 2013). The triangle plot presented in Chapter 7 appeared an interesting tool to analyze and visualize such garden careers and the changes in design and 'nature' of domestic gardens, e.g. amount of sealed surfaces, vegetation structure etc.

Gardens are part of a bigger family of green components related to urban features. With the extended garden complex, we propose to include rooftop gardens, allotment gardens, village and industrial greens, temporary waiting spaces, road verges, places of community gardening and urban agriculture, etc. (Figure 9.2).

The extended garden complex can be a concept that unites the fragmented knowledge on these greens. It can also highlight the overall significance of green by showing territorial policies the cumulative importance. This is similar to what the garden complex has done for domestic gardens throughout this dissertation. This once more stresses the information gap about an important share of green categories discussed in Chapter 2.

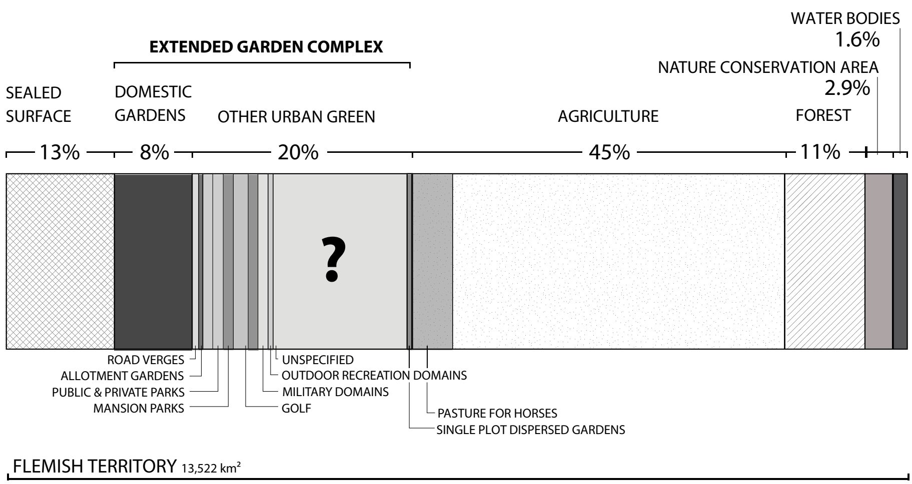

Figure 9.2 The extended garden complex revised.

The results of this dissertation refined and documented the share of domestic gardens in Flanders. But still an important share of the green categories remains insufficiently documented, indicated by the question mark.

Source See Figure 2.7

2.2 Key message 2. The challenge of surveying and monitoring

The fundamental methodological questions that remain are how to collect data on issues like ecosystem structures, functions and services not dealt with in this work, and how to monitor gardens and garden management. Based on the experiences and results from this dissertation, we suggest future research projects and monitoring programs focusing on gardens to continue combing different quantitative and qualitative research methods. The mixed methodology approach is particularly promising. Joining both quantitative empirical and in situ field data and qualitative data with remote sensing techniques, environmental analyses, economic modeling approaches and governance theories, will only raise the understanding of feedback and trade-offs in the complex social-ecological garden system.

The private nature of domestic gardens may hinder the establishment of scientifically sound survey and monitoring programs. The main challenge is defining the proper sampling unit to survey and monitor key characteristics of gardens and garden owners. Gardens are social-ecological systems. This makes accuracy for both the spatial and biophysical presence of gardens, and the socio-economic characterizations of gardening households especially challenging.

A focus on the social aspects like garden management decisions, utility and cultural ecosystem services requires the household as a sampling unit. Research on biophysical structures, the presence of sealing and the support of regulating services should design a sampling based on the spatial unit of a garden. The use of stratification and ordination techniques would allow control over representativeness. The collection of baseline data on key characteristics of both is crucial in the development of future research.

Regardless of the sampling unit, households are important key holders and participants. I see great potential in actively involving garden owners through 'citizen science' monitoring programs (Hand, 2010 ; Tulloch et al., 2013; Bonney et al., 2014; Franzoni and Sauermann, 2014). The use of gardening logbooks or diaries that are kept in a (semi-) autonomous way for data on garden management and food production (Algert et al., 2014) could be promising. The widespread use of mobile applications (apps) also offers interesting perspectives.

The application of remote sensing techniques is promising for making spatial explicit characterizations of functional and structural properties of garden vegetation. Here, citizen science can be involved for example for allowing drones for image capturing (UNEP GEAS, 2013) and for collecting field data for calibration and validation. Submitting different monitoring protocols to a trial run can give valuable insights in how a national 'citizen science' monitoring system can be best organized. The development of the Land Use Parcel Identification System across the EU member states can offer inspiration (Inan et al., 2010).

2.3 Key message 3. Strategic reflections for planning

The results of this dissertation may give an opening to return domestic gardens in the planning picture as the garden complex.

2.3.1 About garden fences and collective projects

Because of its complexity and strategic potential, the garden complex is an interesting space for experimenting on collaborative (Healey, 2007) and fuzzy planning (De Roo and Porter, 2007), adaptive co-management (Olsson et al., 2004), self-organization (Boonstra and Boelens, 2011) and territorial pacts and strategic alliances (Coppens et al., 2014).

The fact that domestic gardens are private properties remains a major hurdle for addressing gardens in territorial policies. This hurdle still has to be leaped when the mobilization of the strategic value of the garden complex comes to mind. The three complementary pathways for garden governance discussed in Chapter 8 are a first step in the development of different scenarios for the development of the collective side of the garden complex.

The private ownership of gardens seems to limit a collective reflection. Surprisingly enough, this dogma of 'private property' is not a barrier when it comes to legislations about agricultural practices, forest exploitations and low-energy housing construction, although these legislations also address private properties. For example, while agricultural practices are extensively regulated and monitored, garden management is not. This leaves 8 % of the Flemish territory without environmental control. This raises the issue whether or not regulation on this private garden space (e.g. the relating levers of the toolbox) is acceptable. This is fuel for further research.

The 'private property' hurdle seems contradictory to the historical Belgian territorial policies. Belgian (and later on also Flemish) policy mainly mobilized private household as the elementary developer of the territory (Chapter 3). Domestic gardens were deliberately promoted as an important component of the national food security policy. A wide range of organizations made sure that these gardens would fulfill this common goal as they educated thousands of garden owners on how to grow their own vegetables. Even today, millions of households in developing countries depend on their garden for their food provisioning (Marsh, 1998; Landon-Lane, 2004; Batello et al., 2010; FAO, 2012). An estimated 700.000 urban residents of Malawi rely on their home garden to meet their food needs (FAO, 2012). It is the same subsistence logic that historically paved the way for the current Flemish garden complex.

The neo-liberal turn in planning at the end of the 20th century may explain the contemporary almost unassailable position of the domestic garden. But planning policy and practitioners should not be afraid to re-envision the mobilization of private properties. I believe that the adaptive capacity of the garden complex is enclosed exactly in the private ownership, fragmented state and small-scale character of its gardens (Gunderson and Holling, 2002; Fraser et al., 2005; Fraser, 2006) (Chapter 7). These characteristics allow short feedback loops, actions at short notice and the simultaneous mobilization of thousands of people and their gardening budgets.

Thinking in terms of strictly private and public goods appears to be an outmoded view, especially its connotation with the (non-) possibilities to contribute to common goals. I plea for breaking open the way we think and feel about privately owned domestic gardens.

The participatory NIMBY-ism, where the sharing of our back or front-yard for the common good stops at the level of garden parties (Moulaert and Van Dyck, 2011), can be lifted to the actual participation in a collective project. The toolbox for garden governance developed in Chapter 8 has demonstrated how such mobilization of private households could be translated into a contemporary approach. This toolbox could be taken a step further by exploring consensus on its levers and by mapping out a wide range of pathways for garden governance.

Recognizing urban structures as agents that determine how we can live together can frame collectivity as a cross-disciplinary project (Hehl, 2013). This dissertation proved that the garden complex has potential as such an agent. As a spatial concept it can represent a desired future situation. This can be a powerful tool for guiding, inspiring and supporting planning and landscape design (Throgmorton, 2003; Ahern, 2005). Finally, the direct relation between gardens and global environmental issues brings these issues closer to our bed. This can defeat the feeling of powerlessness (Stern, 2000; Aitken et al., 2011) experienced by millions of individuals worldwide.

This 'reinvention of the commons' is a contemporary way of looking at the role of gardens in building a resilient society (Moulaert and Van Dyck, 2011; Foré et al., 2012a; Foré et al., 2012b). It underpins the conviction that domestic gardens should be on the agenda in spatial, environmental, agricultural, urban and conservation policies. Studies and policy development in these domains would benefit greatly if the focus on the analysis of collective's would shift from ideological connotations to operational modes and productive forces (Hehl, 2013). This point of view is already embodied in the call for developing strategic alliances and territorial pacts when it comes to a sustainable development and management of the Flemish territory (Coppens et al., 2014).

2.3.2 About the houses outside the garden complex and the garden complex within urbanization

The garden complex was defined with exclusivity of houses, except for house-like constructions in the garden such as garden sheds or carports. Of course, the garden complex is intimately linked with housing. The garden complex should be taken up as equivalent parts of spatial and urban development, in spatial planning and planning policy. It offers a handle for integrated designs that actively consider the strategic potential of private green spaces.

But the 'garden complex' should not be seen nor used as an excuse for ongoing urbanization. This dissertation is not meant as a promotion for urban and garden sprawl. Instead of spreading the urbanization-as-usual models everywhere, we should take it a step further and search for scenarios that develop further the already existing territorial structures and their qualities in an integrated way. To do so, the garden complex should be considered as a land use theme in its own right, interwoven with urban features. Its mobilization should be part of the search for strategies to cope with the various challenges of our society, now and in the future.

2.4 Key message 4. Transdisciplinary projects as the way forward

This dissertation has proven the strength of interdisciplinary (cross-disciplinary) work, combining land use monitoring, geography, governance, utility economics, spatial planning and design. A mere geospatial approach of the garden complex would have fallen short in capturing the interrelations between the physical system and society (Talen, 2011; Dewaelheyns et al., 2014). Land use valuations should be based on both social research and the assessment of physical landscape features (Ives and Kendal, 2013) and their functioning.

As Hell (2013) puts it, connecting social studies, political economies and technological science with urban planning is the essence of framing collectivity as a cross-disciplinary project. Such cross-disciplinary approach for studying a land use system can be considered a case of 'land system science': an interdisciplinary effort that joins the human, environmental, and geographical information sciences (Turner et al., 2007). So, research and policies related to gardens should break through the traditional divide lines between disciplines, policies and sectors of society and land use.

The social-ecological character of the garden complex and the quest for garden governance highlights the need for collaboration and stakeholder involvement. So, a further way forward is the involvement of non-academic stakeholders such as policy makers, interest groups and private gardeners, on top of the cross-disciplinary collaboration between academic researchers from different unrelated disciplines. This would ultimately result in what Tress et al. (2005) call transdisciplinary projects, aiming at the creation of new knowledge on a common question. This implies that both lay knowledge (like practical experience and professional knowledge) and scientific insights have to be elaborated on in the scientific system.

The need for transdisciplinary projects positions the garden complex within the current discourse on inclusivity and integration in landscape research (Swanwick, 2009; Vouligny et al., 2009; Scott, 2011) (Figure 9.3). The domestic garden is neither wild nor awesome. It is just a nearby everyday space that is often unspectacular (Kaplan et al., 1998). But the garden complex brings the opportunities of this triviality on the fore in planning issues like densification, land use categorization, and the adaptive capacity embedded in private spaces.

Transdisciplinary projects require the dissemination of knowledge through both scientific and non-academic channels (Tress et al., 2005). This is also at stake if we want policy makers to take up scientific research outputs in their policies (Nursey-Bray et al., 2014). Management summaries (see also Cortner (2000)) and popular science articles are crucial in reaching policy and society in general. This assigns researchers the roles of critical participants and knowledge brokers (Sterk et al., 2009). At the same time, gardeners are key providers of reliable information and must be convinced to participate in citizen science programs.

The interplay between research, policy and practice makes this dissertation a work at the hearts of the science-policy interface and what Bacon called 'the pursuit of science for the common good' (Sargent, 2012).

By introducing the dissertational work in the informal JooR network, this dissertation contributed to what Bacon suggested: "*the need for a brotherhood of scientists whereby the labors of many would be conjoined and an exchange of information would take place among all of the scholars of Europe*" (Sargent, 2012). Strongly believing in the societal role of researchers in general, the final outcomes of this work illustrate the validity of that conviction. By bridging the divide between research and policy, this dissertation may have helped to put domestic gardens on the agendas of research and policy (Figure 9.4).

I believe that research on domestic gardens should continue to inform and inspire policy and society about the strategic value of their gardens.

JooR is the acronym of 'Jonge onderzoekers open Ruime" ('Young researchers on open space'), an informal and voluntary platform where researchers from different Flemish and Brussels' institutions meet to discuss their results and methodologies, to join their analyses for gaining additional results and to inform policy about their gained insights.

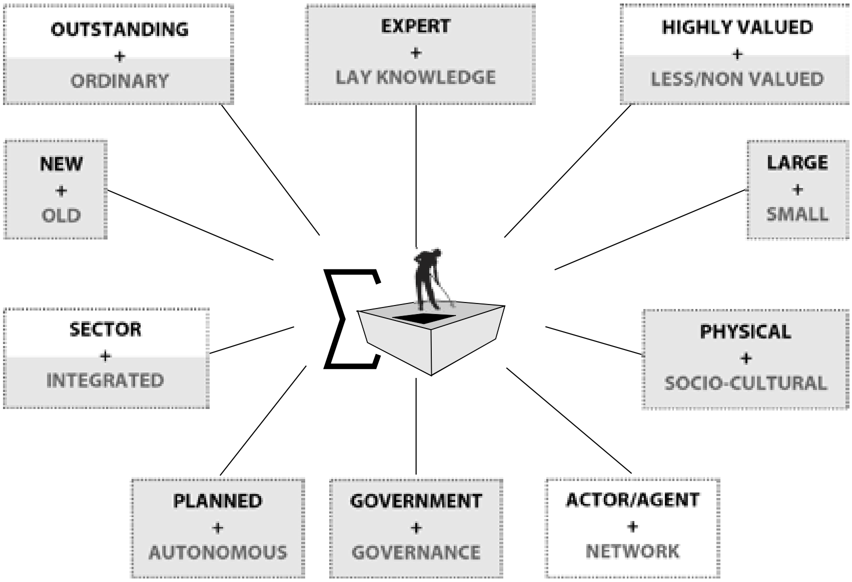

Figure 9.3 The garden complex within the inclusivity discourse

Domestic gardens can be positioned in the inclusivity discourse. Within each couple of aspects, the above mentioned term already receives attention within general landscape research. The below mentioned term should also be included according to the inclusivity discourse. The gray blocks indicate which aspects are studied in this dissertation.

Source Author, based on Swanwick (2009); Vouligny et al. (2009); Scott (2011)

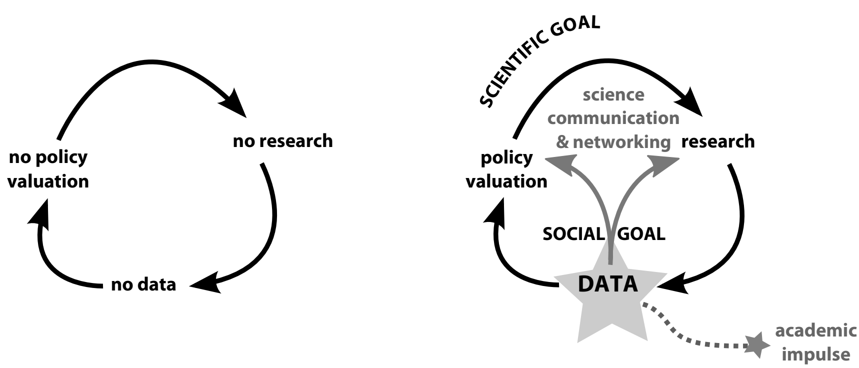

Figure 9.4 Opening of the vicious circle of non-attention through a social goal

The work presented in this dissertation is situated at the hearts of the science-policy interface. The societal motivation for breaking through the vicious circle between the lack of data and the lack of valuation is elaborated on through science communication and networking.

3 Conclusion

The outcomes of this dissertation have strengthened the conviction that the qualities enclosed within the historical structures of a territory should be tracked down. The need for new perspectives on domestic gardens is illustrative for the need to start exploring opportunities embedded in the spatial reality rather than reclaiming such established spaces. The conclusions of this work underline the call raised by Dehaene (2013) for the continued development of existing patterns of urbanization to a better reality, and to continue gardening, though carefully, in the existing urban field.

The garden theme is here to stay. As stated in our book 'The powerful garden', the 19th century Belgian strategists had a point: through gardens, households are active participants in the territorial development. Taking off the old paternalistic principles and emphasizing many more strategic concerns including environment, climate, health and well-being, the garden complex can attain a new mature position in strategies for enhanced sustainability (Dewaelheyns et al., 2011). To conclude with the words of Moulaert and Van Dyck ((2011), page 7), I hope that this dissertation provides a large dose of inspiration on "*how modest gardens as a collective good hold the power to contribute to a more resilient society – in Flanders and beyond*".

"Knowledge is like a garden: if it is not cultivated, it cannot be harvested."

African proverb

APPENDIX A

Ecosystem services supported by domestic gardens

The following tables give an overview of ecosystem services supported by domestic gardens and related green (including green infrastructure). The classification of these services is based on the Common International Classification of Ecosystem Services version 4.3. (CICES) (Haines-Young and Potschin, 2013). They are supplemented with and in exhaustive list of references.

Table A.1 Provisioning services supported by domestic gardens

Provisioning services			**References** (in exhaustive list)
Nutrition	Biomass	*Cultivated crops*	**Food crops:** (Niñez, 1987; Marsh, 1998; Seeth et al., 1998; WinklerPrins, 2002; Pandey et al., 2007; Alayon-Gamboa and Gurri-Garcia, 2008; Alber and Kohler, 2008; Buchmann, 2009; Gray, 2011; Kortright and Wakefield, 2011; Siviero et al., 2011; Calvet-Mir et al., 2012; FAO, 2012; Ghosh, 2012; Reyes-García et al., 2012; Schupp and Sharp, 2012; Taylor and Lovell, 2012; Barthel and Isendahl, 2013; Jehlicka et al., 2013; Smith and Jehlička, 2013; Ernwein, 2014; Taylor and Lovell, 2014) **Horticultural plants:** (Daniels and Kirkpatrick, 2006b, a; Baker and Harris, 2007; Kirkpatrick et al., 2007; Loram et al., 2007; Tratalos et al., 2007; Sims et al., 2008; Goddard et al., 2010b; Cameron et al., 2012; Kurz and Baudains, 2012; Goddard et al., 2013) (Zipperer et al., 1997; Maki and Galatowitsch, 2004; Phillips, 2005; Phillips et al., 2008; Kendal et al., 2012; Politi Bertoncini et al., 2012; Zhang and Jim, 2014)
		Reared animals and their outputs	**Home-produced eggs:** (Van Overmeire et al., 2009a; Van Overmeire et al., 2009b; Waegeneers et al., 2009a; Waegeneers et al., 2009b; Windal et al., 2009)
		Wild plants, algae and their outputs	(Helfand et al., 2006; Doody et al., 2014) **Medicinal resources:** (Pirker et al., 2012; Masondo et al., 2013)
		Wild animals and their outputs	(Beebee, 1979; Owen, 1991; Thompson et al., 1993; Chamberlain et al., 2004; Gaston et al., 2005; Daniels and Kirkpatrick, 2006b; Sims et al., 2008; Davies et al., 2009; Evans et al., 2009; Owen, 2010; Paker et al., 2014)
Materials	Biomass, Fibre	*Fibres and other materials from plants, algae and animals for direct use or processing*	**Genetic materials from all biota:** (Trinh et al., 2003; Vogl and Vogl-Lukasser, 2003; Vogl-Lukasser and Vogl, 2004; Van der Veken et al., 2008; Batello et al., 2010; Gladis and Pistrick, 2011; Norfolk et al., 2013; Bossu et al., 2014; Doody et al., 2014)
		Water (non-drinking purposes)	(Pauleit and Duhme, 2000; Pauleit et al., 2005; Verbeeck et al., 2011a; Verbeeck et al., 2011b; Barthel and Isendahl, 2013)
Energy	Biomass-based energy sources	*Plant-based resources*	(Parikesit et al., 2001; Yu et al., 2002; Kannan et al., 2005; Mulyoutami et al., 2009; Kaoma and Shackleton, 2014)

Table A.2 Regulating and maintenance services supported by domestic gardens

Regulating & maintenance services			**References** (in exhaustive list)
Mediation of waste, toxics and other nuisances	Mediation by biota	*Filtration/ sequestration/ storage/ accumulation by micro-organisms, algae, plants, and animals*	**Sequestration in vegetation:** (Nowak, 1993; Nowak and Crane, 2002; Tratalos et al., 2007; Favoino and Hogg, 2008; Marco et al., 2008; Niinemets and Peñuelas, 2008; Davies et al., 2011; Visscher et al., 2014) Air pollutant removal: (Jim and Chen, 2008)
	Mediation by ecosystems	*Filtration/ sequestration/ storage/ accumulation by ecosystems*	**Compost:** {Favoino and Hogg, 2008} (Barr et al., 2013; Dewaelheyns et al., 2013) **Sequestration in soils:** (Groffman et al., 2004; Davies et al., 2011; Zirkle et al., 2011)
Mediation of flows	Liquid flows	*Hydrological cycle and water flow maintenance*	(Syme et al., 2004; Tratalos et al., 2007; Niinemets and Peñuelas, 2008; Aitken et al., 2011; Breyer et al., 2012; Verbeeck et al., 2013; Warhurst et al., 2014)
		Flood protection	(Linnekamp et al., 2011; Autixier et al., 2014)
	Gaseous / air flows	*Ventilation and transpiration*	(Akbari et al., 2001; Norton et al., 2015)
Maintenance of physical, chemical, biological conditions	Lifecycle maintenance, habitat and gene pool protection	*Pollination and seed dispersal*	(COMBA et al., 1999; Matteson et al., 2008; Osborne et al., 2008a; Osborne et al., 2008b; Cussans et al., 2010; Verboven et al., 2014)
		Maintaining nursery populations and habitats	(Beebee, 1979; Owen, 1991; Thompson et al., 1993; Chamberlain et al., 2004; Gaston et al., 2005; Daniels and Kirkpatrick, 2006b; Smith et al., 2006a; Smith et al., 2006b; Baker and Harris, 2007; Niinemets and Peñuelas, 2008; Sims et al., 2008; Van der Veken et al., 2008; Warren et al., 2008; Davies et al., 2009; Evans et al., 2009; Walther et al., 2009; Goddard et al., 2010a; Goddard et al., 2010b; Owen, 2010; Dallimer et al., 2012; Lindemann-Matthies and Marty, 2013; Andersson and Colding, 2014; Doody et al., 2014; Paker et al., 2014)
	Pest and disease control	*Pest control*	(Niinemets and Peñuelas, 2008; Moloney et al., 2009)
	Atmospheric composition and climate regulation	*Global climate regulation by reduction of greenhouse gas concentrations*	**Greenhouse gas emissions:** (Howarth et al., 2002; Kaye et al., 2004; Kaye et al., 2006; Bijoor et al., 2008; Lorenz and Lal, 2009; Livesley et al., 2010; Trudgill et al., 2010)
		Micro and regional climate regulation	**Air quality:** (McPherson et al., 1998; Setälä et al., 2013; Vos et al., 2013) **Climate:** (Tsilini et al.; Tratalos et al., 2007; Oliveira et al., 2011; Qiu et al., 2013; Demuzere et al., 2014; Lehmann et al., 2014; Skelhorn et al., 2014)

Table A.3 Cultural services supported by domestic gardens

CULTURAL SERVICES			**References** (inexhaustive list)
Physical and intellectual interactions with biota, ecosystems, and land-/seascapes [environmental settings]	Physical and experiential interactions	*Experiential use of plants, animals and land-/seascapes in different environmental settings*	(Kaplan, 1973; Aben and de Wit, 1998; Ousset et al., 1998; Connell, 2004; Milligan et al., 2004; Connell, 2005; Gross and Lane, 2007; Matsuoka and Kaplan, 2008; Crouch et al., 2009; Kiesling and Manning, 2010; van den Berg et al., 2010; Bateman et al., 2011; Roe and Ward Thompson, 2011; Dallimer et al., 2012; Freeman et al., 2012; Laaksoharju et al., 2012; Adevi and Mårtensson, 2013; Lipovská, 2013; Jiang, 2014)
		Physical use of land-/seascapes in different environmental settings	(Milligan et al., 2004; Pudup, 2008; Swanwick, 2009)
	Intellectual and representative interactions	*Educational*	(Pothukuchi and Kaufman, 1999; Yiridoe and Anchirinah, 2005; Barthel et al., 2010; Kortright and Wakefield, 2011; Calvet-Mir et al., 2012; Ghosh, 2012)
		Heritage, cultural	(Airriess and Clawson, 1994) (Vogl and Vogl-Lukasser, 2003; Head et al., 2004; Vogl-Lukasser and Vogl, 2004; Phillips, 2005; Graham and Connell, 2006; Domene and Saurí, 2007; Phillips et al., 2008; van den Berg and van Winsum-Westra, 2010; Gladis and Pistrick, 2011; Pirker et al., 2012; Phillips, 2014)
		Aesthetic	(Francis and Hester, 1990; Turner, 2005; Crouch et al., 2009; van den Berg and van Winsum-Westra, 2010; Kurz and Baudains, 2012; Lindemann-Matthies and Marty, 2013)
Spiritual, symbolic and other interactions with biota, ecosystems, and land-/seascapes [environmental settings]	Spiritual and/ or emblematic	*Symbolic*	(Aben and de Wit, 1998; Christie, 2004a, b; Adams and Hardman, 2014) **Gardening identity:** (Gross and Lane, 2007; Kiesling and Manning, 2010) **Bonds to a rural past or traditions from the home country:** (Airriess and Clawson, 1994; Head et al., 2004; Domene and Saurí, 2007; Pirker et al., 2012) **Status symbol & social norms:** (Nassauer, 1995; Saugeres, 2000; Colding and Folke, 2001; Martin et al., 2004; Kirkpatrick et al., 2007; Tratalos et al., 2007; Warren et al., 2008; Nassauer et al., 2009; Kurz and Baudains, 2012; Goddard et al., 2013; Doody et al., 2014)
		Sacred and/or religious	(Mazumdar and Mazumdar, 2004, 2009, 2012)

APPENDIX B

Evaluation of pH, carbon and phosphorus in domestic gardens in Flanders

The following tables give an overview of the evolution of Ph, C and P in domestic gardens in Flanders. They are discussed in Chapter 6.

When interpreting these tables, attention should be paid to the facts that (i) a different assessment framework is used for the three types (a) gardens under construction, vegetable gardens and ornamentals gardens, (b) garden lawns and (c) greenhouses, and that (ii) the assessment classes differ per soil type (Tables A1–A7).

Table B.1 Evaluation of pH-KCl in gardens under construction, vegetable gardens and ornamentals gardens

evaluation	pH-KCl sand	pH-KCl sandy loam	pH-KCl loam	pH-KCl clay
very low	<4.0	<4.5	<5.0	<5.5
low	40.-4.5	4.5-5.5	5.0-6.0	5.6-6.4
rather low	4.6-5.1	5.6-6.1	6.1-6.6	6.5-7.1
optimal	5.2-5.6	6.2-6.6	6.7-7.3	7.2-7.7
rather high	5.7-6.2	6.7-6.9	7.4-7.7	7.8-7.9
high	6.3-6.8	7.0-7.4	7.8-8.0	8.0-8.1
very high	>6.8	>7.4	>8.0	>8.1

Table B.2 Evaluation of pH-KCl in lawns

evaluation	pH-KCl sand	pH-KCl sandy loam - loam	pH-KCl clay
very low	<4.4	<4.6	<4.9
low	4.4-4.7	4.6-5.1	4.9-5.3
rather low	4.8-5.0	5.2-5.6	5.4-5.6
optimal	5.1-5.6	5.7-6.2	5.7-6.4
rather high	5.7-5.9	6.3-6.5	6.5-6.8
high	6.0-6.4	6.6-7.0	6.9-7.2
very high	>6.4	>7.0	>7.2

Table B.3 Evaluation of pH-KCl in greenhouses

evaluation	pH-KCl sand	pH-KCl sandy loam	pH-KCl loam	pH-KCl clay
very low	<4.2	<4.7	<5.2	<5.7
low	4.2-4.7	4.7-5.7	5.2-6.2	5.7-6.6
rather low	4.8-5.3	5.8-6.3	6.3-6.8	6.7-7.3
optimal	5.4-5.8	6.4-6.8	6.9-7.5	7.4-7.9
rather high	5.9-6.4	6.9-7.1	7.6-7.9	8.0-8.1
high	6.5-6.9	7.2-7.6	8.0-8.2	8.2-8.3
very high	>6.9	>7.6	>8.2	>8.3

Table B.4 Evaluation of carbon content (C %) in gardens under construction, vegetable gardens and ornamentals gardens

evaluation	C% sand	C% sandy loam - loam	C% clay
very low	<1.2	<0.8	<1.0
low	1.2-1.4	0.8-0.9	1.0-1.2
rather low	1.5-1.7	1.0-1.1	1.3-1.5
optimal	1.8-2.8	1.2-1.6	1.6-2.6
rather high	2.9-4.5	1.7-3.0	2.7-4.5
high	4.6-10.0	3.1-7.0	4.6-10.0
very high	>10.0	>7.0	>10.0

Table B.5 Evaluation of carbon content (C %) in lawns

evaluation	C% all soil textures except loam	C% loam
very low	<2.0	<1.5
low	2.0-2.9	1.5-2.0
rather low	3.0-3.5	2.1-2.5
optimal	3.6-5.5	2.6-4.2
rather high	5.6-7.0	4.3-6.5
high	7.1-10.0	6.6-9.0
very high	>10.0	>9.0

Table B.6 Evaluation of carbon content (C %) in greenhouses

evaluation	C% sand	C% all soil textures except sand
very low	<1.3	<1.3
low	1.3-1.6	1.3-1.4
rather low	1.7-2.4	1.5-1.9
optimal	2.5-3.9	2.0-3.5
rather high	4.0-5.0	3.6-5.0
high	5.1-10.0	5.1-8.0
very high	>10.0	>8.0

Table B.7 Evaluation of phosphorus content (in mg P/100 g dried soil, measured in ammonium lactate extract)

evaluation	P gardens under construction, vegetable and ornamental gardens	P lawns	P greenhouses
very low	<5	<8	<12
low	5-8	8-13	12-20
rather low	9-11	14-18	21-34
optimal	12-18	19-25	35-50
rather high	19-30	26-40	51-60
high	31-50	41-60	61-80
very high	>50	>60	>80

APPENDIX C

Socio-demograpic profile of the survey and garden visits respondents

The following tables gives an overview of the socio-demographic characteristics of the respondents from the internet survey (Flanders; N=1.138) and garden visits (Herent, N=25). The average monthly gross income of the respondents is estimated to be a bit higher than the average income for inhabitants of Herent and higher than the Flemish average.

Table C.1 Socio-demographic characteristics of the respondents from the internet survey (Flanders; N=1.138)

Respondent characteristics	Flanders
Number of respondents	1,138
Respondents working in the garden themselves	51%
Largest age group*	Around 50 years
Male / female ratio*	1.7
Share retired (%)*	13
Share active (%)*	76
Share higher education (post secondary) (%)*	/

* Respondents working in the garden themselves

Table C.2 Socio-demographic characteristics of the respondents from the garden visits (Herent; N=25)

Respondent characteristics	Herent
Number of respondents	25
Number of family members represented by respondents	64
Average age	55 years
Male / female ratio	1.5
Share retired (%)	36
Share active (%)	44
Share higher education (post secondary) (%)	80

APPENDIX D

Qualitative data sampling

Semi-structured questionnaire used with the expert interviews

1. Short introduction: Who are you? What do you do? How do you get in contact with gardens professionally?

I will briefly clarify what we understand by the term 'garden complex'.
'Because of their private character, gardens are often regarded as individual objects. As a consequence, the totality of domestic gardens is often not considered. With the concept 'garden complex' we define the whole of domestic gardens within a certain region (that can be a neighborhood, village, city, rural area,…). In fact, we zoom out to look at the whole, and we consider this as a landscape component. This way, domestic gardens can be considered from a different perspective. We consider this concept as a starting point to think differently, and especially in a broader way, about domestic gardens. Such a garden complex exists out of gardens that are spatially related, but this is not necessary. The garden complex is also an abstract concept that refers to the whole of domestic gardens, without the need for spatial connectivity.'

2. Have you heard about this idea before?

3. What do you think about this concept? What is your first reaction? Do you see something in it?

4. Do you see possibilities to use the garden complex in practice? What are benefits and disadvantages? * It is expected that several themes will be mentioned, take up on this to elaborate further on themes

5. How could the garden complex be put into practice? Which instruments would be needed? Can we use the current instruments, or do we need new instruments? How should that look like? What is crucial?

6. Which steps should be taken to use the concept in practice?

7. Who do you think are crucial actors? And how can these actors become involved?

8. To what extent are you willing to consider the garden complex idea in your professional activities? How would you do that?

I will now briefly explain another concept called 'common good in action'

'The concept 'commons' comprises the collective management of chared resources. These resources can be anything, from natural resources like water, air and land, to software, internet and knowledge. Both in the historical and the current interpretation of the commons, focus lies on the collective property and collective management. Given the highly fragmented state of the garden complex, it is maybe interesting to introduce a new type of commons, in which the management according to a collective mental legacy is central and not the collectivity of management and property. If hundreds of individual garden owners would make small changes in their garden management or design, this could help to partly realize societal needs and goals. We called this idea 'common good in action'. It is about the contribution to common societal goals through individual actions.'

9. What do you think about this concept? What is your first reaction? What are themes that it could be interesting to think about a common good in action?

10. Do you think that people will be prepared to do things for a collective goal? Are there certain groups that will be willing, or not willing?

11. How could we stimulate this you think?

12. From your professional activities, do you see other possible applications for this idea?

13. To what extent are you willing to promote this idea in your professional context? How would you do that?

14. Would you like to add something that has not been addressed yet?

15. Do you know people that could be interested in cooperating with these interviews?

Discussion guide used in the focus group discussions

Warm-up exercise (10 minutes)

- Explanation of the study
- Let every respondent present him- or herself briefly

Attitude towards the garden (20 minutes, flipchart)

- Emotional relation with a garden?
  - Association exercise
  - Personification exercise
  - Why do they think/feel these associations?
- Rational relation with a garden?
  - What does a garden mean to them?
  - What is its significance for them?
  - Why do they have a garden?

Segmentation exercise gardens

(20 minutes, photo's of model gardens and the respondents' gardens)

- Let each respondent present their garden using pictures or a plan
  - How do they describe their garden?
  - Why did they choose for this garden design
  - What would they change?
- Segmentation of different gardens
  - Which garden categories could we make?
  - Does everybody agree with these categories? Why (not)?

Customer journey gardening (30 minutes, flipchart)

For the group in the (re-)designing phase

- Spark
  - Why did they start to (re-)design their garden?
    - When/What was the moment of this decision?
    - Was certain media of overriding importance?
  - Collection of information
    - What kind of information?
    - Via which channels?
      - Order of priority
      - Significance of persons and certain organizations/associations?

- Evaluation of information and decision
  - Which decision was made? Why?
    - How difficult was it to make this decision?
    - Which garden was chosen? Why?
  - What were criteria for making decisions?
- Realization and adjustments
  - Did-it-yourself or by someone else? Why?
  - Which adjustments were made compared to the initial plan/idea? Why?
- Management and evaluation
  - How is the management done?
  - Who does the management?
  - How important was this in decision making?
- What would you do differently next time in decision making?

For the group in the management phase

- Design
  - Why did they design their garden in a certain way?
  - How important was management in the decision making?
  - Which garden was chosen then? Why?
- Collecting information
  - What kind of information?
  - Via which channels?
    - Order of priority
    - Significance of persons and certain organizations/associations?
- Management
  - Who does the management?
  - How is the management done?
  - Why do you do it like that?
  - Garden waste
    - What do you do with garden waste? Why?
  - Adjustments passed year
    - Which small adjustments have you made to the garden? Why?
    - Customer journey of this adjustment (information, decision, realization, evaluation)
  - What would you change? Which adjustments would you like to do?

Discussion on policy actions (30 minutes, action sheets)

- Glance through the different actions, while making links with their own gardening to understand barriers and triggers
    - Past actions: Koesterburen (Neighbors to cherish), Kringlooptuinieren (cycle gardening), group purchases of hedge plants
    - Possible future actions: regulation on maximum area of sealed surface, tailor-made garden advice/garden doctor, regulation that fences could only be natural (like hedges), specific advice for young families with children lawn design, stimulation of co-use of gardening equipment, group purchase of soil analysis to stimulate adjusted plants, information campaign on the use of chemical herbicides and pesticides
    - Co-creation for new actions that could be initiated by the province Vlaams-Brabant?

Outro (10 minutes)

- Glance through the most important aspects
- Wrap-up and thanks

APPENDIX E

Categories and concepts resulting from the coding process

The following tables give an overview of the categories and concepts resulting from the coding process. They are discussed in Chapter 8.

Table E.1 Categories and concepts for the barriers related to private actors

Categories	Concepts	
PERCEPTION	Fixation on 'neat and tidy'	The garden has to be neat
		A sustainable garden looks like a neglected garden
		No weeds, moss,.. between the stones and in the lawn
		Especially important for what is in sight
		Education
		Norms
	Image problem	Open sandals and woolly socks type
		It comes from the Green
	Ecological gardening	More expensive
		Asks more time
	There is not much possible in small gardens	
	Having time for gardening is all about priorities	
	Ease and cheap versus sustainable	
INDIVIDUALISM	Private intimacy of the household	My garden, my paradise, my freedom
		Garden as a fenced-off space; more social control and less tall hedges and gates bygone
	Individual reflex	Self-interest
		Ease and cheap
		The character of the Flemish people
		Restraint towards more collective ideas
		Coming home in peace and quiet
	Lack of confidence	In the fellow man
		In the government
	Voluntary base	Difficult to convince people
		Elderly people will be less susceptible

Table E.2 Categories and concepts for the barriers related to public actors

Categories	Concepts	
(NON-)POLICY	No priority in policy	Not (yet, anymore) on the policy agenda
		Available time and means are restrictive
		No administration
		No policy frame and vision
	No recent tradition in interfering with the private garden	
	No need of a central regulation	
	Election fever	
	No garden sector	No sector allows more easy functioning
		No sector is less intimidating and threatening
		Private interests
	No construction of knowledge and experience	Lack of knowledge transfer to policy and practice
		No precedents or best practices
	Rules and instructions	Limited when it concerns domestic gardens
		No enforcement
		No norms
		Ad-hoc priorities of permit granters
		Juristic bottlenecks
		Often at the municipal level
		Fragmentation of legislation and jurisdictions
		Liberal spatial policy
NON- & UNDER VALUATION	Zoning plans put a monetary value on each m², determined by the allocated use (e.g. housing is valued more than agricultural land)	
	Dominance of the built over the green	In financial terms
		In land use classification and categories
	Lack of a proper valuation	
	Perception 'green costs money'	
	People do not make an economic valorization of gardens	
	Remains under the radar due a lack of knowledge	

Table E.3 Categories and concepts for general barriers

Categories	Concepts	
PRIVATE PROPERTY	Historical foundation	Catholic policy in reaction to the socialist movement
		No tradition in collectivity
	Organisation of property and ownership	Sensitive to questioning
		Structuring of the financial sector, like mortgage loans
		Right of use versus right of ownership
		Housing and infrastructure policy
		Small-scaled character
	Private versus collective	No gradations between private and collective use and ownership in Flanders
	Voluntary base	Difficult to oblige something within the garden
PREMATURE RESPONSIBILITY	Lack of data and knowledge	With policy
		With organizations
	Lack of knowledge and experience	With individual garden owners
	Too much individual responsibility without sufficient knowledge and interests	
	Unknown	
	Practical limitations	
	Not (yet) possible to monitor	
SPATIAL REALITY	Not easy to rethink existing neighborhoods	
	Heterogeneity and spatial fragmentation of existing gardens blocks a more comprehensive view	
	Invisible: gardens are hidden behind buildings	
	Spatial preconditions	
	Time and evolution are not considered	
	Anchored within the economic functioning	
CONFLICTING INTERESTS	Commercial interests	Lack of supply of sustainable products
		Lack of well-founded advice combined with a too large supply
		Profit maximizing of project developers
		Temporariness and limited life span of products
	Private garden owners	Trade-off between creativity and preconditions
		No cooperation of garden owners at a crucial location
	Differing ideas between garden architect and town planner	Collectivize versus privatize
		Ideological versus emotional
		Garden versus landscape
	Differing ideas between policy levels	Use of native species: ideological versus practical considerations

Table E.4 Categories and concepts for general insights on levers

Categories	Concepts	
INSTRUMENTS AND MEANS	No need of large scaled instruments or subsidies	Accessible, low profile, simple and feasible measures
	Efficient use of existing means and instruments	Underused existing instruments
		Current limited instruments specifically for gardens
	Stimulating and regulating policy and instruments needed	
	Sensitization	Alerting and awakening
		Responsabilization: 'you can really make a difference as an individual'
		Communication by social marketing: convincing story, theme, campaign
		Combined package instead of a single focus
		Use the garden aspect as a way to deal with garden governance
TAILOR-MADE	Plurality of strategies needed	Robust support
		Pragmatic approach
		Neutral channels
		Combination of motivations and goals
	Target groups	In terms of persuasion: people that will never be convinced, people that need a boost and people that are already convinced
		In terms of gardening pleasure: people for whom gardening is a hobby and people for whom gardening is a burden
	For the private gardener	Target group specific goals and strategies
		Concretization of the goals
		Clear definition: who is a gardener?
		Willingness differs between target groups
		Difference between people from cities and rural areas
	For the considered site	Local scale
		Landscape context
		Non-generic: different neighborhoods require different strategies
PERSONAL GAINS AND RIGHTS	Personal interests, beliefs, values	
	Personal gain	Pleasant living environment
		Services
		Monetary profits
		Product
		Acquire new knowledge, experience new things
		Being part of a bigger community
	No personal loss	No loss of income
		Possible to reconsider and stop a more collective commitment
	Concerns	Health, children....
	Common profit	

Table E.5 Categories and concepts for stimulating levers

Categories	Concepts	
1. ENABLE	Give information	Tailor-made
		Simple, correct, orderly, accessible
		Translation needed: to the daily-life practice of the garden owner; to a management summary for policy makers
		Different forms: quality hand book, practical guide, guidelines, tips, information moments, articles in the municipal magazine, toolkit, box with building blocks
		Platform for knowledge exchange between policy, research and practice
	Educate and train skills	Integration in existing professional schoolings: garden en landscape architecture, spatial planning, urbanism, landscape development
		Training and education of the private garden owner
		Education of schoolchildren; reaches the parents
	Lower and remove barriers	Support by services: garden audit, tailor-made garden advice
		Support by products: supply of ecological products, organization of equipment sharing,...
		Administrative accessibility of support
2. ENGAGE	Enthuse	Inspiring and appealing campaign
		Create a wish
		Take advantage of pleasure of gardening
		Activities: small, local and playful actions, walks,...
		Involvement in management of public space
		Media campaigns, opinion formers
	Personal contacts and social networks	Personal contacts and enthusiasts
		Social capital and knowledge exchange: parents, friends, neighbors,...
		Informal institutions: mimicry effect
		Neighborhood initiatives and arrangements
		Local social base
		Bottom-up initiatives
3. EXEMPLIFY	Mimicry-effect	
	Exemplary role of policy	Take exemplifying actions in the public space
	Actual examples	Small-scale experiments
		Inventory of best practices, inspiring cases and experiences
	Visualize	Visualize by signs or labels, for example by the front door
		Make investments of tax money visible

Continuation table E.5

Categories	Concepts	
4. ENCOURAGE	Show commitment	From policy, like the municipality
		From professional associations
	Financial incentives	You can realize a lot with money
		No financial support in gardens: people like to invest in their garden
		Already existing subsidies applicable in domestic gardens
		Broadening of existing means, projects and instruments
		Organisation of group purchases of reliable products
5. EXPLORE	Academic research	Collection of data
		Analysis of similar initiatives
		Small-scale experiments
	Room for real-life experiments	Structural support
		Possible themes: ownership rights, garden block renovations, temporary use, ...
		Identification and changing of structural barriers
		Support of innovative practices and niches: CSA, community land trust, co-gardening,...
	Research-by-design	Alternative reading
		Focusing the goals of the garden complex
		Exploring thinking exercise: fictive examples
		Need of informal designs
		Search for innovative concepts
		Search for the needed handles and instruments
		Development of several versions

Table E.6 Categories and concepts for regulating levers

Categories	Concepts		
WHEN NEEDED	Theme specific generic regulations		
	No overregulation		
INSTRUMENTS	Standards	Flemish quality standards	
		Green standards	
	Agreements, charter		
	Planning instruments	The current legislations and instruments are both facilitating and hindering	
		Financial-economic	'The polluter pays' principle
			Costs-benefits principle: effective requisition of benefits
			Taxes on real estate: inclusion of the garden
		Land policy	Urban land reallocation
			Land bank
			Agricultural Holdings act
		Permits and regulations	All scale levels: RUP's, BPA's
			Municipal level: building permits and regulations, GAS, ...
			Site level: allotment regulations, terms and conditions of sale, regulations of design, building specifications
		Servitudes	
	European directives		
ENFORCEMENT	Feasibility is questioned		
	Organisation in practice: municipal level	Cooperation between different municipal organizations and with private actors	Participation of inhabitants: neighborhood talk, in the case of spatial interventions
			Cooperation with the police and the public prosecutor
			Consultation of the private garden owner by violation
		Strict and clear policy and enforcement	Clear opinions and communication
			Political social base
			Active control on the field by a public enforcement servant

Table E.7 Categories and concepts related to the need for a framing vision such as the garden complex when developing garden governance strategies

Categories	Concepts
INNOVATIVE	Mobilizing private land
OFFERS CONTEXT	A framework on domestic gardens that is currently lacking
	A handle for studying domestic gardens
	Potential to slowly infiltrate into regular planning practices
	Steppingstone in the reconsideration of peri-urban areas, the improvement of existing neighborhoods and the optimization of green infrastructure
OPENS UP NEW PERSPECTIVES	Reconsideration of the gradations between collectivization and privatization
	Refinement of the labels 'urbanization' and 'urbanized'
	Refinement of the advantages of both private and public green
	Insights in the underused possibilities of the current stock of domestic gardens and opportunities of optimizing this
	Upscaling of the individual garden, consideration at the landscape scale
	It allows to highlight common goals

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Dewaelheyns, V., Bomans, K., Verhoeve, A., Tempels, B. (2012). Van tuinen en paarden. *Ruimte, 14*, 24-30.

Verhoeve, A., Vanempten, E., Dewaelheyns, V., Bomans, K. (2012). Vele kleintjes maken een groot. *Ruimte, 4* (14), 16-17.

Book editor

Dewaelheyns, V., Bomans, K., Gulinck, H. (Eds.) (2011). *The Powerful Garden. Emerging views on the garden complex.* Antwerp: Garant Publishers.

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Book Chapters

Allaert G., Bouwer L., De Sutter R., Gulinck H., Meire P., Van Damme S., Van den Broeck P., Van Eetvelde V. (Eds.), *Klimaat in Vlaanderen als ruimtelijke uitdaging*. Gent, Academia Press.

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Conference Proceedings

Gulinck, H., Marcheggiani, E., Lerouge, F., Dewaelheyns, V. (2013). The Landscape of Interfaces: Painting Outside the Lines. In Newman, C. (Ed.), Nussaume, Y. (Ed.), Pedroli, B. (Ed.), . UNISCAPE international conference. Paris, 2-3-4 May (pp. 71-76). Pontedera: Bandecchi & Vivaldi.

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Dewaelheyns, V., Bomans, K., Gulinck, H. (2008). *Verspreiding, ruimtelijke associaties en morfologie van het tuincomplex in Vlaanderen*, 163 pp. Heverlee: Steunpunt Ruimte en Wonen.

Dewaelheyns, V., Gulinck, H. (2008). *Inputs en outputs in privétuinen*, 174 pp. Mechelen: Vlaamse Miliemaatschappij, MIRA.

Bomans, K., Dewaelheyns, V., Goffings, M., Gulinck, H., Govers, G., Heremans, S., Lambié, B., Meeus, S., Notebaert, B., Poesen, J., Ruysschaert, G., Stalpaert, L., Van den Bulck, S., Vandendriessche, H., Van Rompaey, A., Verstraeten, G. (2007). *Achtergronddocument 2007, Thema Bodem - Milieurapport Vlaanderen, MIRA (2006)*, 165 pp.

Van den Bulck, S., Van Dyck, E., De Naeyer, F., Maebe, P., Gregoir, T., Goffings, M., Lambié, B., Vandendriessche, H., Gulinck, H., Heremans, S., Dewaelheyns, V., Meeus, S., Bomans, K., Stalpaert, L. (2007). Bodem Verontreiniging en afdichting bedreigen de bodem. In: Van Steertegem M. (Eds.), *Milieurapport Vlaanderen. MIRA-T 2007 Focusrapport*, Chapt. 9. Leuven: Lannoo Campus, 217-237.

Oral and poster presentations at (inter)national conferences

Session chair 'Strategic gardening: Mobilizing cultural aspects of gardening in sustainable development'. Culture(s) in Sustainable Futures: theories, policies, practices. Helsinki, Finland, May 6-8, 2015

Dewaelheyns, V., Rogge, E. (2014). Bringing private actors into action. The garden complex in Flanders. PECSRL2014. Gothenburg and Mariestad, 8–12 September 2014. *Oral presentation.*

Dewaelheyns, V., Gulinck, H. (2012). Linking the garden interface to its urban and rural contexts. i-SUP. Bruges, 7-9 May 2012. *Oral presentation.*

Dewaelheyns, V., Gulinck, H. (2012). The garden complex and its food production potential. *Agriculture in an Urbanizing Society*. Agriculture in an Urbanizing Society. Wageningen, 1-4 april 2012 (pp. 1-18). *Oral presentation.*

Dewaelheyns, V., Bomans, K., Gulinck, H. (2011). Lost in the rural-urban interface: the garden complex. *Mind the Gap*. EFLA2011, Mind the Gap. Tallin, 2-4- November 2011 (pp. 1-17). *Oral and poster presentation.*

Dewaelheyns, V., Bomans, K., Gulinck, H. (2011). How natural is our nearest nature?. In Berney, R. (Ed.), Harris, B. (Ed.), *How natural is our nearest nature?*. CELA. Los Angeles, 30 March - 2 April 2011 (art.nr. 3). Los Angeles: Figueroa Press. *Oral presentation.*

Dewaelheyns, V., Verhofstede, B., Bomans, K., Allaert, G., Gulinck, H. (2011). Exploring opportunities of domestic green for climate change adaptation. In Berney, R. (Ed.). CELA. Los Angeles, 30 March - 2 April 2011 (art.nr. 12). Los Angeles: Figueroa Press. *Poster presentation.*

Dewaelheyns, V., Gulinck, H. (2008). Private gardens: single small but multiple big at regional level and in environmental perspective. In Dilly, O. (Ed.), Helming, K. (Ed.). Impact Assessment of Land Use Changes. Berlin, 6-9 April 2008. *Poster presentation.*

Dewaelheyns, V., Gulinck, H. (2008). Domestic gardens in Flanders. In Dewaelheyns, V. (Ed.), Gulinck, H. (Ed.). Rurality near the city. Leuven, 7-8 February 2008. *Poster presentation.*

Presentations for a general public

'De kracht van tuinen'. Stand at the event 'Leuven: city of ideas'. Collaboration with the province Vlaams-Brabant within the frame of the government order 'Sustainable gardening'. Leuven (Belgium), May 17th 2014.

Lunch causerie 'Open ruimte'. The JooR collective as invited speaker at Bond Beter Leefmilieu, Brussels (Belgium). June 18th 2013

'De kracht van tuinen: een herwonnen rol voor voedselproductie?' Invited speaker 'STUK Ongehoord: Stedelijke voedselstrategieën.', Leuven (Belgium), November 5th 2012

‘Ondertussen ergens op den buiten…’. The JooR collective as invited speaker at Winvorm, Bruges (Belgium). October 9th 2012

‘The Powerful Garden’. Invited speaker at Kubiekeruimte lectures at Floriade2012. Venlo (Netherlands). June 19th, 2012.

‘The Powerful Garden’. Invited speaker at Het Groene Boek 2012. Antwerp (Belgium). May 6th, 2012.

‘Het tuincomplex’. Invited speaker at ‘Werking van vijf jaar Steunpunt Ruimte en Wonen: Team Ruimte’, Ferrarisgebouw, Brussel (Belgium). February 17th 2012

Book presentation at Garant Uitgevers NV ‘Inleiding tot het tuincomplex in Vlaanderen.’ Antwerp (Belgium). December 13th 2011

Collaborations and joined efforts

JooR - active role in the inter-institutional collective of young researchers working on open space

Kubiekeruimte vzw - active participation in Kubiekeruimte vzw, an association of ‘outdoor’ designers

Member of the PWO knowledge centre on ‘(semi-) private garden and urban landscapes’ since August 25th 2014

Government order ‘Sustainable gardening’, province Vlaams-Brabant, Sep 2013 Dec 2014

Research track Landscape and garden architecture, Erasmus University College Brussels, April 2013 - …

Strategy workshop ‘Sustainable gardening’, Province Vlaams-Brabant, Dec 16th 2013, Leuven (Belgium)

VRP Think tank ‘Green-blue networks’, August 8th 2012, part of Groenboek Ruimte, Brussels (Belgium)

VOLANTE international workshop ‘Visions on future land use. Nature and recreation’ June 18-19th 2012, Berlin (Germany)

Awards

Bouwmeesterlabel III (2014) with Temp.o.r. (Aurelie De Smet, Bart Tritsmans, Serena Vanbutsele & Valerie Dewaelheyns). ‘De kracht van tijdelijke open(bare) ruimte.’

CURRICULUM VITAE

Valerie Dewaelheyns is a Bioscience engineer in land and forest management (KU Leuven), and a garden and landscape architect (EhB). She has an interdisciplinary interest in landscape design and spatial planning, land use and spatial transformations, urban green; and in governance strategies that try to address private actors for the realization of common societal goals. Her main research topic is the garden complex. As a researcher she has worked at KU Leuven (Forest, Nature and Landscape) on policy supporting research projects and at ILVO (Social Sciences Unit) on a doctoral grant. Her interdisciplinary interest is also reflected in her collaborations with fellow researchers beyond institutional and disciplinary boundaries. She highly values the societal role of research. Accordingly she positions her work within the heart of the science-policy interface by actively communicating her research with policy and practice.

EDUCATION

2010 - 2014
Doctoral training in Bioscience engineering
KU Leuven, Faculty of Bioscience engineering

'The garden complex in strategic perspective. The case of Flanders'

Supervisors: Prof. Hubert Gulinck, KU Leuven
Prof. Dr. Elke Rogge, ILVO

2008 - 2012
Bachelor of Landscape & Garden architecture
Erasmushogeschool Brussel

2002 - 2007
Master of Bioscience engineering Land and Forest management
KU Leuven

PROFESSIONAL EXPERIENCE

SCIENTIFIC RESEARCHER

Sep 2010 - Dec 2014

PhD project
'The garden complex in strategic perspective.
The case of Flanders'

KU Leuven, Department Earth and Environmental Sciences
Institute for Agricultural and Fisheries Research (ILVO),
Social Sciences

Jan 2013 - Jul 2014

VLIR-UOS project
'Sharing environmental information to stimulate creativity for rural development.
Case Lushoto District, NE-Tanzania'

KU Leuven, Department Earth and Environmental sciences
in collaboration with EhB, SUA & SeKoMU

Jul 2010 - Dec 2012

'CcASPAR - Climate change and adaptation in spatial planning in Flanders research project'

KU Leuven, Department Earth and Environmental sciences
in collaboration with UGent, UA & OMGEVING BVBA

- Policy supporting research funded by IWT-SBO
- Researcher WP5: development of spatial planning concepts for the Campine area using research-by-design

May 2008 - Nov 2008

'Distribution, spatial associations and morphology of the garden complex in Flanders'

KU Leuven, Department Earth and Environmental sciences

- Ad Hoc 2008 for the Policy Research Centre on Space and Housing
- Principal researcher

Sep 2007 - May 2008

'Inputs and outputs inprivate gardens'

KU Leuven, Department Earth and Environmental sciences

- Policy supporting research as part of environmental reporting MIRA of the Flemish Environmental Agency
- Principal researcher

STAFF MEMBER

Nov 2008 - Jun 2010

'Walking network Zuid-Dijleland'

Regionaal Landschap Zuid-Dijleland vzw in collaboration
with VLM Vlaams-Brabant &Toerisme Vlaams-Brabant vzw

EPILOGUE

'Er is géén voertuig dat je een eerlijkere indruk geeft van het land, dan de trein. Aanschouw dus onze tuintjes, onze duiventillen en koterijen. Zie onze onderbroeken drogen aan de draad. Aanschouw onze tuinkabouters, onze selder en onze prei. Onze veranda's en onze gemetselde barbecues. Kijk hoe de koeien langs het traject gestaag baan ruimen voor onze bakstenen gedrochten, die smakeloos met de goedkeuring van de bank in dat [..] landschap hebben neergepoot.'

Dimitri Verhulst in De Helaasheid Der Dingen

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'It is about the reading and design of the implicit, of possibilities that are latently present but have not yet come to the foreground of reality.'
Janssens, 2008