Understanding the conservation potential of urban greenspaces in Sub-Saharan Africa

Solène Guenat

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The candidate confirms that the work submitted is her own, except where work which has formed part of jointly-authored publications has been included. The contribution of the candidate and the other authors to this work has been explicitly indicated below. The candidate confirms that appropriate credit has been given within the thesis where reference has been made to the work of others.

PhD in Alternative Format

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Three journal papers were written as part of this thesis and are presented as the following joint-authored publications:

- Chapter 2: **Guenat, S.**, Kunin, W.E., Dougill, A.J. and Dallimer, M. 2018. Effects of urbanisation and management practices on pollinators in tropical Africa. *Journal of Applied Ecology*. 56, pp. 214-224. DOI: 10.1111/1365-2664.13270
- Chapter 3: **Guenat, S.**, Dougill, A.J., and Dallimer M. (under review). Characterising social networks to contextualise urban conservation messages. *Landscape and Urban Planning*
- Chapter 4: **Guenat, S.**, Dougill, A.J., Kunin, W.E. and Dallimer, M. 2019. Untangling the motivations of different stakeholders for urban greenspace conservation in sub-Saharan Africa. *Ecosystem Services.* 36. DOI: 10.1016/j.ecoser.2019.100904

Contribution to those papers were as follow:

I conceived the research design, collected the data, analysed the results and wrote the manuscripts. M. Dallimer, W.E. Kunin and A.J. Dougill provided feedback and advice on the research design, contributed to the writing of the manuscripts and gave final approval for publication.

Illustrations opening the thesis chapters are the work of J. Früh.

Rationale for publication by alternative format

This thesis looks at three distinct aspects of ecosystem services in urban areas in order to gain a holistic perspective of how they can contribute to wider biodiversity conservation. Every analysis has involved different research methods and data collection, each with an independent grounding within the literature. The three empirical chapters are the three papers listed on the previous page. The multi-perspective approach with different sets of methods has been achieved more efficiently with three distinct academic publications than as a traditional monograph.

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Abstract

With more than half of the world population living in cities, land-use changes associated with urban growth are one of the main threats to biodiversity. However, it is generally accepted that urban greenspaces can mitigate this threat by providing habitat for a wide variety of species as well as improving urban liveability through ecosystem services ranging from recreation to food or shade provision.

In Africa, cities are expanding at the fastest rates globally and increasingly encroach on biodiversity hotspots. Yet we know little about their potential for maintaining biodiverse greenspaces, their ability to provide ecosystem services, the social context shaping their governance or the preferences people hold for them. This thesis begins to fill those gaps by assessing how ecosystem services are maintained, governed and valued in Sunyani and Techiman, two fast-growing cities in Ghana.

Small African cities contain greenspaces that can maintain pollinator populations of similar abundances to those found in the surrounding landscapes, albeit with variations linked to greenspace management and shifts in community structure. However, the social interactions at play in the urban landscape threaten such greenspaces. Social network analysis revealed that the stakeholders with the greatest influence on their retention have mixed attitudes towards them, contrasting with the fact that stakeholders generally value the ecosystem services provided by greenspaces. Nevertheless, perceptions of ecosystem services are diverse, highlighting the need to identify particular services around which conservation efforts and messaging can build consensus across society, while simultaneously targeting particular messages to certain influential groups. Doing so may help promote urban greenspace conservation across residents, businesses, civil society and public authorities.

By taking an inter-disciplinary approach to urban ecosystem services, this thesis provides a holistic understanding of the potential and challenges facing urban greenspace conservation in the rarely studied context of small urban areas of Sub-Saharan African.

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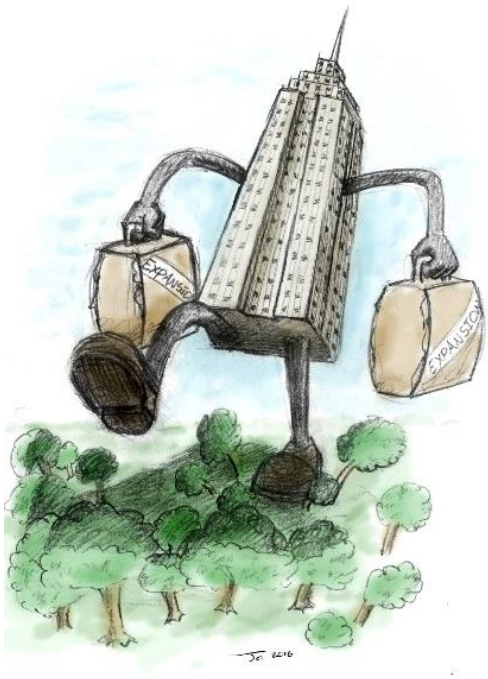

Chapter 1: Introduction

1.1 Background

1.1.1 Urbanisation

This thesis explores the potential for African urban areas*[1] to conserve greenspaces* and ecosystem services*. Urban areas currently host about 4.2 billion people, or 55% of the world population (DESA, 2018). Urban growth is not set to stop in the short term as 60% of the urban areas that will be present in 2030 will have been built since the turn of the century (DESA, 2018; Elmqvist et al., 2013). The main mechanism leading to such urbanisation is that economic growth tends to concentrate human activities to urban areas, with cities* in turn fuelling economic growth while reducing poverty (DESA, 2018). Urban areas, despite their high density of human population and of built infrastructures, can still contain greenspaces with relatively high biodiversity* and the potential to deliver many ecosystem services (Elmqvist et al., 2013).

Urbanisation is the most irreversible of all anthropogenic land-use changes, with profound impacts on surrounding environments. Such transformations include high physical disturbances to the soil, with high levels of compaction, covering by impervious surfaces and high level of pollutants, all of which affect bio-physical processes taking place in urban areas (Pickett et al., 2001; Effland and Pouyat, 1997). Additionally, the impervious infrastructure radiates overnight the heat accumulated during the day which, together with anthropogenic heat release, modify the climate of urban areas by increasing their temperatures, a

[1] Terms indicated by a * are defined in the Glossary (p. 269)

phenomenon known as urban heat effect (Rizwan et al., 2008). The environmental impact of urban areas is not limited to the cities themselves, as they are estimated to emit 78% of the world's carbon and use 60% of its water (O'Meara, 1999), despite covering only about 2.8% of the earth's land mass (The World Bank, 2018). Urban growth also threatens the biodiversity of surrounding areas. For instance, biodiversity hotspots* will experience a 200% increase in urban land-cover between 2000 and 2030 (Seto et al., 2012).

Urban growth is not geographically homogenous; the fastest rates for the next decades will be found in small- and medium-sized cities of Africa and Asia, which are typically in regions of high agricultural productivity or in biodiversity-rich landscapes (Seto et al., 2012; McDonald et al., 2008; DESA, 2015). Such geographic heterogeneity will affect the sustainability of future urban areas. Specifically, African urbanisation is mainly driven by an overall population increase (DESA, 2015) and takes place within contexts of low industrialisation, poor service delivery and weak institutional systems thus not always associated with economic growth (Turok and McGranahan, 2013; White et al., 2017). Consequently, African urban areas are thought to be at risk of a "grow dirty now, clean up later" approach (White et al., 2017, p. 3) with potential detrimental implications for urban residents as well as the environment.

On a human perspective, the lack of association between African urbanisation and economic growth might be felt strongly by the poorer inhabitants of African cities. The general understanding is that urban areas are beneficial for their residents as they provide more opportunities for education and employment (DESA, 2018). Urban areas also tend to improve health as they provide stronger social support and more accessible health care than rural landscapes (Vlahov et al., 2005). However, cities can also increase inequalities, which are already high in Sub-Saharan Africa (UN-Habitat, 2016). Additionally, bad housing conditions such as those prevalent in poorer cities, noise exposure and housing density can negatively impact urban resident's mental health, causing higher prevalence of schizophrenia, depression and anxiety in urban than in rural areas (Clark et al., 2007).

The omnipresence of urban living means that there is a great potential for urban areas to contribute to sustainable development. However, unplanned urbanisation might result in the negative impacts of cities outpacing the

positives, contributing to the deterioration of living conditions. Urban areas are therefore included in the Sustainability Development Goals (SDGs), with Goal 11 specifically aiming to “make cities and human settlements inclusive, safe, resilient and sustainable” (United Nations, 2015, p. 24). Conserving biodiverse urban greenspaces has been suggested as one of the ways to ensure such environmental and social sustainability (Elmqvist et al., 2013).

1.1.2 Urban biodiversity

Another SDG focuses on protecting terrestrial land, including by halting biodiversity losses (goal 15; United Nations, 2015). Indeed, about 25% of the earth’s flora and fauna is currently viewed as threatened (Díaz et al., 2019). Not only are many species threatened by extinction, but overall populations are decreasing, a fact observable for instance through fast declines in insect biomass (Hallmann et al., 2017). This rapid rate of species loss, caused mainly by anthropogenic changes such as land-use change and exploitation, is leading to a sixth great extinction (Steffen et al., 2007) and to a biotic homogenisation where the few species that thrive in human-altered habitats are replacing local species sensitive to human disturbances (McKinney and Lockwood, 1999).

In such a context, urban areas can be critical for providing “experimental places” where their environmental characteristics can represent wider environmental changes (Dearborn and Kark, 2010). Additionally, urban biodiversity, or at least how people perceive and understand it, can also play a role in improving the health and well-being of residents (Sandifer et al., 2015; Marselle et al., 2019) or increasing the levels of environmental awareness (Soga and Gaston, 2016). Though urban areas have long been ignored in conservation science, there is now a growing recognition that they can contribute to curtailing the current biodiversity crisis (Elmqvist et al., 2013; Tanner et al., 2014).

Contributions of urban ecosystems to biodiversity conservation are spread across most taxa (e.g. Kuehn et al., 2004 for plants; Sattler et al., 2011 for arthropods; and Magle et al., 2012 for a review of urban wildlife, mainly on birds and mammals). Such contributions mainly concern the ability of urban areas to reflect the regional species pool rather than the conservation of species specific to the urban environment (Aronson et al., 2014). Urban areas also have the

capacity to conserve threatened terrestrial species, as up to 30% of threatened species can be found in urban areas (Ives et al., 2016). However, communities found in urban areas tend to be structurally simple (Clergeau et al., 2006) and include large number of non-native* species (McKinney, 2006). Presence of non-native species can contribute to maintaining the delivery of specific ecosystem services by increasing local biodiversity (Sjöman et al., 2016), but are a threat to global diversity as local species are lost (McKinney, 2006).

Patterns of distribution of urban biodiversity are influenced by many factors acting at different scales. As in any other ecological systems, the sizes of habitat patches and the distance between such patches is critical for determining the number of species that can maintain a viable population in a specific patch (MacArthur and Wilson, 1967). In urban areas, the patches of greenspaces can be of varying sizes but, in general, tend to be smaller than in rural landscapes. Land cover management can have a strong influence on the diversity of greenspaces, with large greenspace patches usually providing more opportunities for conservation than smaller though more abundant fragments (Soga et al., 2014; Shanahan et al., 2011). Additionally, the built infrastructures surrounding those habitat patches constitute an impermeable matrix for many species and thus can further increase extinction risks (Prevedello and Vieira, 2010). Consequently, measures such as increasing connectivity between patches of greenspaces can heighten urban biodiversity.

Human factors also influence the biodiversity found in urban areas, as for instance older cities accommodating more intact vegetation than younger ones (Aronson et al., 2014). Additionally, socio-ecological factors are strong determinants of urban biodiversity and greenspace cover. Wealthier neighbourhoods tend to have both higher biodiversity and vegetation cover that neighbourhoods with lower socio-ecological status (Stow et al., 2013; Hope et al., 2003), an effect that tends to repeat itself as poorer residents are driven out by increasing rent prices after greening programs (Wolch et al., 2014).

Despite the increase of research on urban biodiversity, some contexts are still understudied, as most of the research has been carried out in the Global North* (Aronson et al., 2014; Magle et al., 2012). Consequently, very little is known on the conservation potential of urban areas with the fastest growth, in Africa and Asia. However, as African urban vegetation cover is known to be decreasing

(Yao et al., 2019), there are concerns that the fast urban expansion currently experienced by African cities is threatening urban greenspaces and biodiversity (Mensah, 2014b). This thesis aims to increase the understanding on the conservation potential of African urban areas.

1.1.3 Integrating human needs in conservation: the ecosystem services framework

As urban areas are human-dominated, integration of the motivations and values* of urban inhabitants is critical (Dearborn and Kark, 2010). The ecosystem services* framework is one prominent approach to integrate human needs within the ecosystem. First coined in late 1970s-early 1980s (Westman, 1977; Ehrlich and Ehrlich, 1981), the ecosystem service concept has been increasingly used to highlight the dependencies of human society on natural functioning (Gómez-Baggethun et al., 2010). Since then, the concept has been widely taken up in the scientific literature and is increasingly incorporated into international policies (Potschin and Haines-Young, 2011; Díaz et al., 2019) as well as in businesses (CEF and TNC, 2012).

Despite the common understanding that ecosystem services are aiming to capture the importance that nature has for people, there has been many different approaches as to how to frame human-nature relationships. The use of the “ecosystem services” term has been boosted by its central position in the Millennium Ecosystem Assessment (MEA, 2005), which framed services as being provisioning, regulating, cultural or supporting. The MEA put ecosystem services on the political scene, but the vagueness of the “ecosystem services” definition made it difficult to use in practice. The ecosystem services cascade framework has developed to tease out pathways to the delivery of ecosystem services (Figure 1.1; Haines-Young and Potschin, 2010; Potschin and Haines-Young, 2016). This framework describes ecosystem services in relation to both the ecological structure that supports them and the values and benefits that humans perceive in such services (Potschin-Young et al., 2018). As such, the cascade framework highlights the fact that ecosystem services are defined by people’s needs as opposed to being inherent characteristics of the ecosystems (Haines-Young and Potschin, 2010). By separating the ecological structure from the functions and services and allowing direct valuation of the biological

structure, this framework allows for the dual position of biodiversity as both an ecosystem service in itself and a support for ecological functions (Mace et al., 2012). The ecosystem cascade model has been used as an underpinning for the Common International Classification of Ecosystem Services (CICES; Haines-Young and Potschin, 2018), developed through a consultative process to help identify what constitutes a final ecosystem service while standardising the terminology. The CICES classification considers three main categories of final services, namely the services for provisioning, regulation and maintenance, and cultural (Haines-Young and Potschin, 2018). The ecosystem services cascade and the derived CICES classification are the frameworks adopted in this thesis.

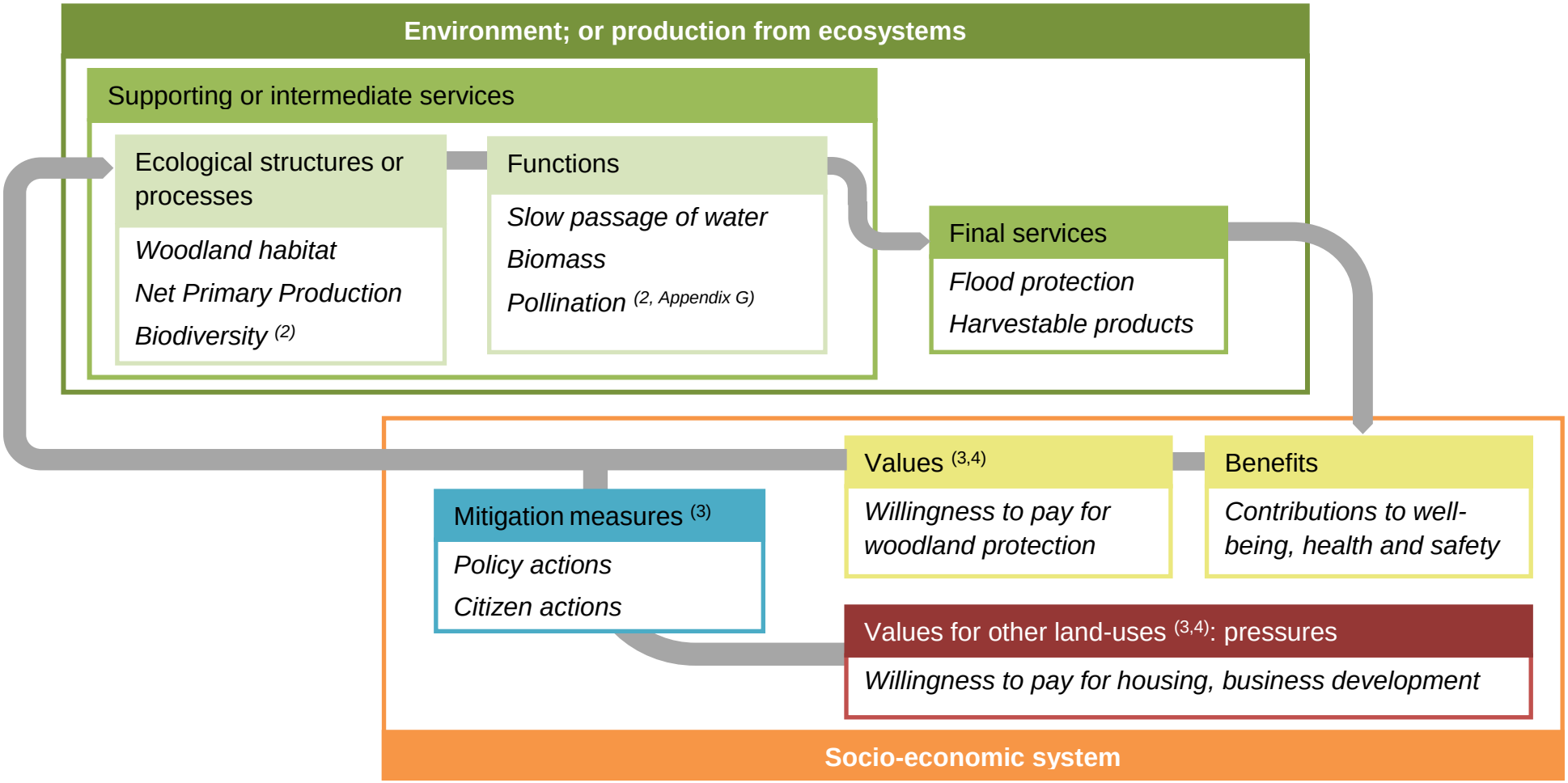

Figure 1.1. Ecosystem services cascade model, adapted from Potschin-Young et al. (2018). Examples are mentioned in italics. Aspects investigated in this thesis are indicated by superscript numbers relating to the Chapter numbering.

The ecosystem services concept, despite its strong uptake, has also faced many criticisms. It has for instance been blamed for diverting attention away from biodiversity conservation, disavowing the intrinsic value of natural entities, commodifying nature, assuming a unidirectional link between nature and humans, or promoting top-down approaches (Schröter et al., 2014; Buizer et al., 2016). Debates are still on-going, with many of those critiques having been responded to (Schröter et al., 2014) and integrated in later frameworks, for instance through acknowledging the multi-directionality of the human-nature relationships in the ecosystem services cascade (Potschin-Young et al., 2018). The risk of not implementing any conservation measures were ecosystem services not recognised is mainly deemed greater than the risks of commodification of nature through ecosystem services (Martin-Ortega et al., 2019). Especially in highly human-dominated landscape, ecosystem services are a key tool which allows the acknowledgement of multiple motivations for conserving urban biodiversity (Dearborn and Kark, 2010).

Due to the recognition of the importance to integrate the value of nature in decision-making, the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) was created in 2012 to strengthen the science-policy interface (IPBES, 2019). IPBES work focuses on publishing assessments, supporting policy implementation, building capacity and conducting outreach activities (IPBES, 2019). The IPBES considered that “ecosystem services” did not properly encompass the diversity of worldviews present in the world and thus coined the term of “nature’s contributions to people”, which builds on the concept of ecosystem services while “explicitly embracing concepts associated with other worldviews on human–nature relations and knowledge systems (e.g. ‘nature’s gifts’ in many indigenous cultures)” (Pascual et al., 2017).

In the urban context, research on ecosystem services started to be taken up in the 1990s and, despite rapid increases recently, urban ecosystems are understudied compared to rural ecosystem services (Haase et al., 2014). Urban ecosystem services research focuses mainly on understanding whether provisioning and regulation and maintenance services are maintained in urban areas (Haase et al., 2014; Luederitz et al., 2015). As for the values given to urban biodiversity and ecosystem services, they are mainly studied in specific

greenspaces such as parks or forests, addressed at the habitat scale, and rarely take into consideration cultural diversity (Botzat et al., 2016). There are also critical knowledge gaps on the synergies between different urban ecosystem services (Haase et al., 2014). A direct consequence of the focus on regulation and maintenance as well as provisioning ecosystem services is a lack of knowledge on the socio-economic aspects of urban ecosystems, with for instance very little knowledge on the governance* of urban ecosystem services (Luederitz et al., 2015). Finally, there are geographical biases, with most research being carried out in North America, China and Europe (Botzat et al., 2016; Haase et al., 2014; Luederitz et al., 2015), thus potentially ignoring the diversity of urban forms and processes taking place in the Global South*. Even within such research undertaken in Africa, most has been carried out in South Africa (du Toit et al., 2018), leaving large parts of the continent unstudied.

1.2 Research aims and objectives

The aim of this thesis is to understand the potential for urban greenspace conservation in small cities of Sub-Saharan Africa through a multi-perspective approach to ecosystem services. Specifically, the ecosystem services cascade framework (Figure 1.1) is used to examine the potential for greenspaces to maintain pollinator populations (as part of the ecological structure), the impact of social networks* and the actions of the stakeholders involved in the implementation and management of greenspaces and the perceptions that residents, local experts and influencers hold on the different ecosystem services provided by greenspaces. This aim was thus divided into several objectives, which were each further broken down into specific research goals:

(a) Environment – Ecological structure: evaluate the potential for greenspaces to maintain pollinator populations

- a.1. Evaluate the potential for urban greenspaces to maintain pollinator abundances and diversity as compared to rural landscapes
- a.2. Assess the impact of the urban landscape on pollinator diversity, including their functional traits diversity
- a.3. Determine the contribution of different types of urban greenspaces to the conservation of pollinator populations

(b) Socio-economic system - Pressures and mitigation measures: understand the influence of social networks on urban greenspaces

b.1. Describe the motivations of each stakeholder group impacting urban greenspaces

b.2. Reveal the interactions between those stakeholders and their impact on urban greenspaces

b.3. Depict how any conflicts arising from those interactions challenge urban greenspaces

(c) Socio-economic system - Values: describe and compare the viewpoints of residents, local experts and influencers on the ecosystem services and disservices* provided by urban greenspaces

c.1. Describe how the services and disservices provided by urban greenspaces are perceived

c.2. Compare and contrast viewpoints between different categories of stakeholders

c.3. Understand how those agreements and differences in viewpoints can be harnessed for urban greenspace conservation

1.3 Research design and methods

1.3.1 Thesis structure

This thesis is divided into 5 chapters. This introductory chapter discusses the background to urban conservation, sets the aims and objectives for the thesis, details the literature on the three investigated aspects of urban ecosystem services and describes the research design and study context. Three academic journal articles were written for this thesis and are presented as Chapters 2 to 4. Chapter 2, addressing objective (a), investigates the potential for urban greenspaces to maintain pollinator abundances, diversity and functional traits similar to those of rural landscapes, and assesses the contribution of different types of urban greenspaces for pollinator conservation, providing an understanding of the underlying ecological structure present in urban areas. Chapter 3, addressing objective (b), identifies the stakeholders impacting urban greenspaces, describes their attitudes towards greenspaces, and reveals how their interactions impact urban greenspace conservation. Chapter 4, addressing objective (c), describes and compares the viewpoints of different stakeholders on ecosystem services and disservices provided by greenspaces and discusses how those could be harnessed for greenspace conservation.

The thesis concludes in Chapter 5 by bringing together insights from the previous chapters, discussing the implications for the conservation of urban greenspaces in Sub-Saharan African cities, and suggesting future research directions.

1.3.2 Methodological approaches

Throughout this research, a multi-perspectives approach was used, drawing from a broad range of methods from the natural and social sciences. Chapter 2 draws on natural sciences research methods, sampling pollinators along a urbanisation gradient with pan-traps, a method commonly used in pollinator survey for its lack of collector bias (Westphal et al., 2008) and its efficiency in many habitats, including urban sites (Devigne and De Biseau, 2014). Both Chapter 3 and 4 are based on mixed social sciences methods. Chapter 3 utilises social network mapping, providing both researcher and participants with a visual representation of the network on which to base the discussions (Schiffer and Hauck, 2010). In Chapter 4, Q-methodology is used. This is a research method developed in psychology to understand subjective opinions of participants through a statement-sorting exercise (Watts and Stenner, 2012). The Q-method facilitates the disciplinary link between social and natural sciences by making qualitative data more accessible to researchers with different backgrounds via quantifying perceptions (Zabala et al., 2018) and is increasingly used in conservation science.

1.3.3 Study site

The cities examined throughout this thesis are Sunyani and Techiman, situated in the Brong Ahafo region of Ghana (Figure 1.2a). They are considered small-sized cities as, in 2010, they had populations of 162,765 and 123,973 respectively (Ghana Statistical Services, 2013). Ghana is a country located in the Gulf of Guinea, in West Africa. In 2010, it had a population of 24.6 million, of which 50.9% lived in urban areas, defined as agglomerations of more than 5000 inhabitants (Ghana Statistical Services, 2013). In the 2000s, Ghana experienced annual urban population growth of 4.2% (Ghana Statistical Services, 2013), as compared to a worldwide average of 2.05% (DESA, 2015). Reasons behind such growth include migration from rural areas, natural population increase in cities and towns, and reclassification of villages reaching

the population threshold (Ghana Statistical Services, 2013). Urbanisation is not associated with economic development, leading to inadequate living conditions as the government struggles to cope with increased urban pressure (Ghana Statistical Services, 2013). However, Ghana has a stable democracy with quinquennial elections, an efficient health and education system and thus experiences faster economic growth and development when compared to other African countries (Lenhardt and Rocha Menocal, 2015).

Ghana is spread over several ecological zones. The study sites are located in the transitional zone between the deciduous forest, considered a biodiversity hotpot (Figure 1.2b; Myers et al., 2000), and the Guinean savanna (Government of Ghana, 2015a). Overall, biodiversity in the country comprises of at least 5,429 plant, 3,413 insect, 794 bird, 377 herpetofaunal and 327 terrestrial mammal species (Hackman, 2014). However, most of what is known about biodiversity in Ghana is limited to protected areas, which cover about 15% of the country's land area (Figure 1.2b). Off-reserve biodiversity is little known (Hackman, 2014). Overall biodiversity is thus likely to be higher, especially given that the biodiversity hotspot is estimated to host up to 9,000 plant species and 1,320 vertebrate species (Myers et al., 2000). The hotspot has, however, already lost more than 90% of its primary vegetation and is increasingly threatened by urban expansion (Seto et al., 2012).

Vegetation cover in urban areas in the Gulf of Guinea, including Ghana, is decreasing faster than anywhere else in Africa (Yao et al., 2019). For instance, in 2014, urban greenspaces covered about 25.6% of the metropolitan area of Kumasi, as opposed to 58.2% in 1986 (Nero, 2017). Similarly, Accra experienced a 7.4% vegetation cover loss in the first decade of the century, a loss taking place mainly in low economic status neighbourhoods (Stow et al., 2013). The observed loss of greenspaces in Ghanaian cities is postulated to arise from a variety of factors including low prioritisation in development plans and lack of cooperation for their conservation by urban residents (Mensah, 2014a; Diko and Palazzo, 2018).

Ghanaian urban greenspaces can take many forms such as home gardens (including lawns, crops and trees), vegetation on institutional compounds, grasslands, farmland, natural forests, public parks or cemeteries (Nero, 2017). There is little known about the biodiversity that such greenspaces host and

evidence differs. Indeed, it has been suggested that West African urban greenspaces can contribute to conservation by hosting high diversity of both native flora and fauna, even though not red-listed (Deikumah and Kudom, 2011). Conversely, other studies found that two thirds of urban trees are non-native, often planted for aesthetic purposes, and could pose a threat to native biodiversity (Raoufou et al., 2011).

Despite the threats that biodiversity and greenspaces are facing, Ghana has been a pioneer in regards to environmental protection in Africa. For instance, Ghana was the first country to create an Environmental Protection Agency (Environmental Protection Council, 1988). Similarly, Ghana recently published a new spatial development framework that included the creation of a green infrastructure network (Figure 1.2.b) to link protected areas and river buffers in order to enhance biodiversity protection while providing communities with various environmental, health and lifestyle benefits (Government of Ghana, 2015b). The spatial development framework particularly emphasizes the importance of green infrastructures in and around urban areas and encourages cross-departmental collaborations for green infrastructure implementation (Government of Ghana, 2015b).

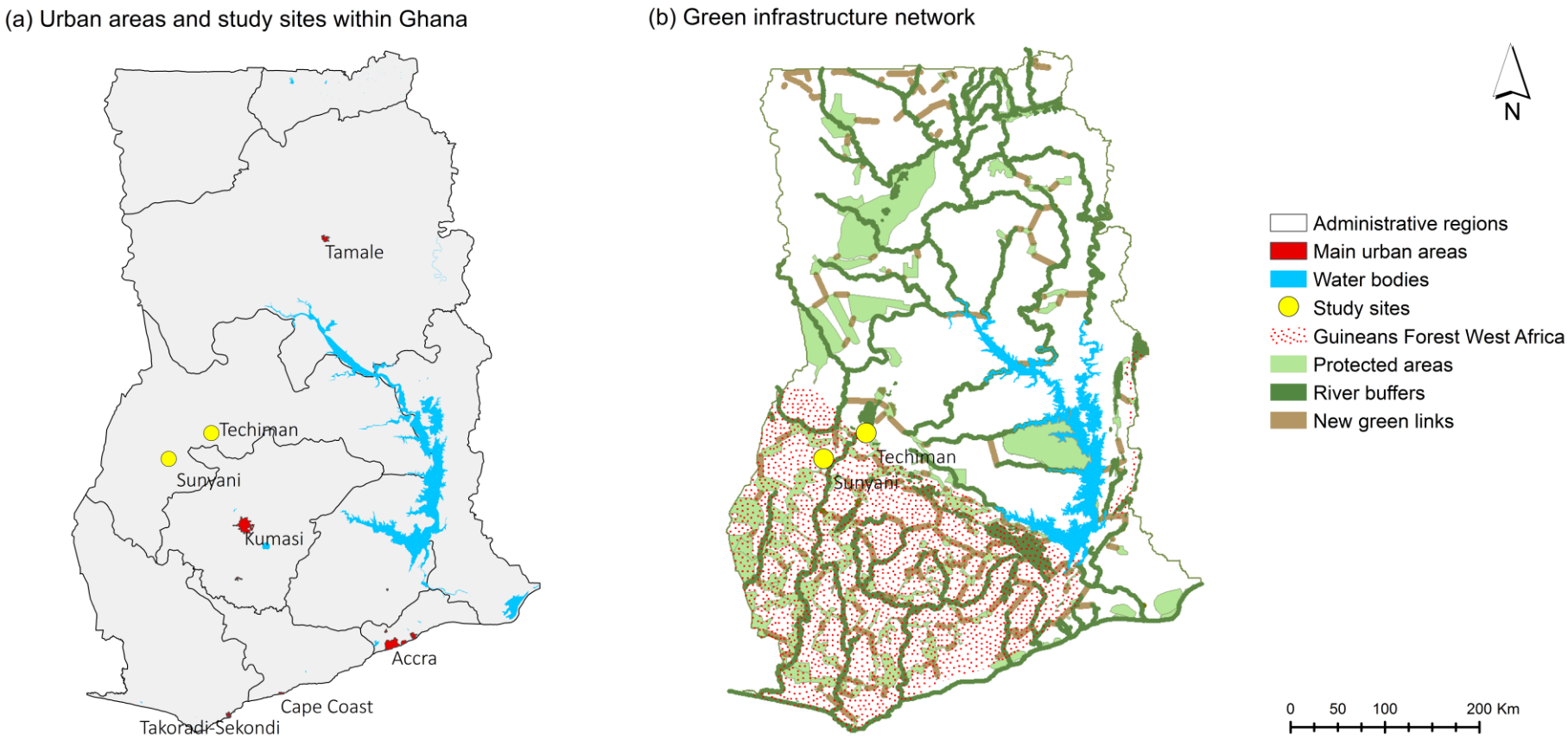

Figure 1.2. Position of the study sites within Ghana, (a) within a demographic context represented by other urban areas and the main administrative units (regions) at the time of the study, and (b) within a biodiversity context, represented by the Guinean Forests of West Africa biodiversity hotspot, Ghana's network of protected areas and river buffers, and the planned green infrastructures (adapted from the Ghana National Spatial Development Framework; Government of Ghana, 2015b).

1.3.4 Research ethics

Chapters 3 and 4 involved human participants. Research ethics were granted by the University of Leeds Research Ethics Committee, reference AREA 15-145 for the pilot interviews and AREA 16-184 for the main data collection. Participants were given information letters or verbal information on the study's aims, risks, benefits and the nature of their involvement. Full anonymity was not granted, but no names, job titles and organisation were named as source of the information in any publication. Verbal consent had to be granted.

1.4 Literature review

This section introduces the different aspects of ecosystem services that will be explored in this thesis. Consequently, this section discusses the importance of pollinators and their potential for conservation in urban areas, assessed in Chapter 2; considers the role of understanding social networks to better target greenspace conservation, assessed in Chapter 3; and explores the significance of understanding the viewpoints of different stakeholders for improving greenspace conservation. Due to the format of this thesis, where Chapters 2-4 are manuscripts published or in publication format, additional background literature is provided at the beginning of each of those chapters.

1.4.1 The ecological structure: urban pollinators

The potential of urban greenspace to conserve pollinator populations is examined in Chapter 2 of this thesis. Animal pollinators are very diverse and include bees (Hymenoptera: Apidae), responsible for 50-75% of global pollination, but also wasps and ants (Hymenoptera), flies (Diptera), butterflies and moths (Lepidotera), beetles (Coleoptera) (Rader et al., 2016), birds (Sekercioglu et al., 2004), mammals (Kunz et al., 2011; Fleming and Sosa, 1994) and reptiles (Olesen and Valido, 2003; Rader et al., 2016; Sekercioglu et al., 2004; Kunz et al., 2011; Fleming and Sosa, 1994). Pollinators might be just a sub-set of the overall biological structure of an ecosystem, but they perform a critical function, as pollination is necessary for the reproduction of 78-94% of wild plants (Ollerton et al., 2011).

Pollinators are instrumental in insuring global food security, as 39 out of the 57 main crops, accounting for a third of global food production, depend on animal pollination (Klein et al., 2007). The diversity of crops pollinated by animals not only contributes greatly to food security, but also contains many nutrients not found in other plants and whose loss would make it highly challenging to maintain nutritionally adequate diets (Eilers et al., 2011). Given that diversity is as important as quantity for conserving pollination functions (Garibaldi et al., 2016), pollinators are an ideal group to study the links between conservation of ecological structure and the service it provides.

In addition to their key role for crops and overall maintenance of biodiversity, insect pollinators have recently gained a lot of media attention (see for instance Bodkin, 2019; Briggs, 2019; Carrington, 2019). As such, they can have a role to play in increasing the connection of urban residents to nature, sensitising the population to environmental issues and developing citizen engagement activities.

However, pollinators are in decline worldwide, due to a large variety of factors including habitat loss and pollution (Potts et al., 2010; Sánchez-Bayo and Wyckhuys, 2019). Consequently, understanding a broad range of habitat and management practices with the potential to hinder their decline is crucial. Studies on the adaptation of pollinators to the urban habitat started in the late 1960s (Dathe et al., 1969; cited by Hernandez et al., 2009) and have been increasing since then (Hall et al., 2017). Generally, a trend of decreasing bee species richness with increased urbanisation has been observed, but the effect is not similar for all species (Hernandez et al., 2009; Harrison and Winfree, 2015). Urbanisation tends to decrease abundances and/or diversity of floral specialists or pollinators adapted to forested habitats (Harrison and Winfree, 2015), but increase those of bumblebees, cavity-nesting bees, kleptoparasites or pollinators adapted to open habitats (Hernandez et al., 2009; Potts et al., 2010; Banaszak-Cibicka and Zmihorski, 2012; Harrison and Winfree, 2015). The warmer conditions found in urban areas as compared to the surrounding landscape favour pollinators with a usually more southern range than the region (Banaszak-Cibicka and Zmihorski, 2012).

The impact of different types of vegetation management practices is also critical, as higher pollinator diversities can be found in urban than in agricultural

landscapes, as opposed to semi-natural ones (Verboven et al., 2014; Baldock et al., 2015). Similarly, the varying levels of floral diversity in urban areas affect pollinator distribution, leading to higher pollinator abundances in highly decorated urban centres (Hennig and Ghazoul, 2012; Lowenstein et al., 2014).

Despite the challenges of the urban habitat, pollination as a function has been seen to be successfully maintained in the urban context (e.g. Lowenstein et al., 2014; Potter and LeBuhn, 2015; Petersen et al., 2014), a success linked with floral resource density and diversity (Lowenstein et al., 2014; Harrison and Winfree, 2015; Potter and LeBuhn, 2015).

There is a particular lack of studies in sub-Saharan Africa, with the exception of a few studies in South Africa (e.g. Clark & Samways 1997; Pauw 2007; cited by Hernandez et al. 2009). African bee diversity, be it urban or rural, remains largely undescribed (Eardley et al., 2009). The few studies investigating African pollinators highlight that they might be more sensitive to habitat fragmentation than pollinators from temperate regions (Ricketts et al., 2008). It is critical to get a better understanding the patterns of pollinator abundances and diversity in under-studied areas such as Sub-Saharan Africa, where the threat of habitat destruction is high.

1.4.2 The socio-economic structure: social networks and relative value of ecosystem services

The socio-economic side of the ecosystem cascade was examined through Chapter 3 and 4 by dwelling on the identification of key stakeholders, their motivations and their interactions in Chapter 3, and on the different viewpoints on ecosystem services in Chapter 4.

Though understanding the biophysical properties of the urban ecosystem is pivotal for assessing the feasibility of different conservation measures, comprehending the socio-economic background which helps shape the environment is as crucial (Niemelä, 2014; Dearborn and Kark, 2010). Different perceptions of greenspaces and the ecosystem services they provide by stakeholders with influence on the implementation of conservation measures is likely to contribute to the development of biodiverse cities (Dearborn and Kark, 2010).

Urban landscapes are characterised by a high heterogeneity of both land-uses and social-cultural processes, including many different administrative units and influential stakeholders with a wide range of worldviews (Pickett et al., 2001; Ernstson et al., 2010). Consequently, understanding who are the stakeholders with the opportunity to act upon their worldviews, be it to help or hinder the sustainable management of greenspaces, and how they influence other stakeholders is crucial to achieve real-world conservation initiatives in a power-laden social context (Folke et al., 2005; Prell et al., 2009; Armitage et al., 2012).

Social networks are considered a useful tool for identifying key stakeholders whose involvement is to be prioritised for a more efficient implementation of natural resources management (Prell et al., 2009). They have consequently been increasingly studied in the last decade to understand both the governance and management of natural resources (Groce et al., 2019). Though such research on environmental governance is relatively well geographically spread out, it tends to focus mainly on rural areas (Groce et al., 2019) or, when in urban areas, on specific conservation projects taking place in the Global North (e.g. Ernstson et al., 2010; Farr et al., 2018). Issues of governance and lack of support from the population have been identified as one of the key challenges to greenspace conservation in Sub-Saharan Africa (du Toit et al., 2018; Mensah, 2014b). Consequently, it is critical to improve our understanding of social networks and how they impact city-wide greenspaces in fast-growing African cities.

Studies on the governance of urban greenspaces in the Global North highlight a key role for the government to lead greenspace conservation (Wilkinson et al., 2013). However government has been identified to have limited ability to efficiently implement conservation measures in regions, such as Africa, where the state is relatively weak (Wilkinson et al., 2013), has issues of coordination between its different bodies (Ernstson et al., 2010) or has access to limited context-specific knowledge (Farr et al., 2018). Additionally, a government's ability to act is limited by administrative boundaries which do not necessarily match ecologically meaningful units (Dallimer and Strange, 2015). Gaining a better understanding of the alternative stakeholders impacting greenspaces provides clues for efficiently incorporating greenspaces in urban areas (Folke et al., 2005; Bodin and Crona, 2009).

Another aspect as critical as understanding social networks surrounding urban greenspaces is identifying the value that those stakeholders hold for greenspaces and the ecosystem services they provide (CBD, 2012). The term “value” can have different significance depending on the context or the discipline. “Value” can refer to the guiding principles or worldview on which people base their decisions, a preference for a specific state of the world, the importance assigned to something, or a measure (Botzat et al., 2016; Pascual et al., 2017). In the context of this thesis, unless stated otherwise, value represents the importance assigned to greenspaces or ecosystem services by different stakeholders, though the inter-relationships between such importance and the underlying guiding principles is acknowledged (Pascual et al., 2017). Different perceptions of urban greenspaces and the benefits they provide influence how different actors value such greenspaces and their willingness engage in, or support, urban conservation initiatives. Yet again, research on the values and perceptions of greenspaces focuses mainly on the Global North (Botzat et al., 2016) or, within Africa, on South Africa (Cilliers et al., 2013). However, both cultural contexts and climate can be expected to shape the value given to urban greenspace and the management practices used in tropical Africa than in either the Global North or South Africa (Shackleton and Blair, 2013).

Such research carried out in African cities tends to focus on the perception of one group of stakeholders, mostly of some urban residents (Adekunle et al., 2013; Shackleton et al., 2015; Shackleton and Blair, 2013; Mensah, 2017; Dumenu, 2013), as the latter are identified as the main beneficiaries of greenspaces (Johnson et al., 2004). There is however no consensus on which ecosystem services are the most valued. Highly valued services include cultural services such as recreation and relaxation (Shackleton and Blair, 2013; Adekunle et al., 2013), regulation and maintenance services such as improvement of soil health (Mensah et al., 2017), windbreak or provision of shade (Shackleton et al., 2015), and provisioning services in the form of urban agriculture and fuel (Adekunle et al., 2013).

Greenspaces are not always perceived as beneficial. Several South African studies highlight the fear of residents that greenspaces serve as hideouts for criminals (Shackleton et al., 2015) or that their pollution negatively impacts

human health (Shackleton and Blair, 2013). Management of greenspace is perceived to be important, with many African urban residents being dissatisfied with the state and quantity of vegetation in their cities (Gwedla and Shackleton, 2019). Similarly, evidence from Asia shows that greenspaces can be dismissed not only because they are not valued, but because other cultural aspects of the city are deemed more important (Shamsuddin and Ujang, 2008).

Though few studies focus on the perception of experts in positions of authority, those that do highlight that the provision of urban greenspaces is mostly under-prioritised as compared to other basic services or commercial activities leading to economic growth, because it is poorly understood or perceived as "nice" rather than necessary (Schäffler and Swilling, 2013; Gwedla and Shackleton, 2015). However, this lack of prioritisation does not necessarily align with the personal worldviews of experts, but rather with what they are empowered to do as local experts or managers (Gwedla and Shackleton, 2015).

1.4.3 Thesis contributions

By taking an multi-perspectives approach on urban ecosystem services in small cities of Sub-Saharan Africa, this thesis provides a holistic understanding of the potential and challenges facing urban greenspace conservation in an under-studied research system. The ecological approach taken in Chapter 2 of this thesis explores whether and how the greenspaces found in small fast-growing African cities can maintain pollinator populations of similar abundances to those found in the surrounding rural landscapes. Chapter 2 thus provides baseline data on the conservation potential of different types of urban greenspaces for pollinator populations in the under-studied African continent. Understanding the biodiversity hosted by urban greenspaces is important as a lack of baseline data on urban biodiversity and provision of ecosystem services is impeding the creation of targets and monitoring for urban conservation initiatives (du Toit et al., 2018). The social approach taken in Chapters 3 and 4 however reveals that the specific ecological conditions of urban areas are not the only challenges facing urban conservation. The social network analysis of Chapter 3 unveils the stakeholders with the greatest influence on greenspace retention and their attitudes towards greenspaces, while Chapter 4 untangles the different viewpoints on urban ecosystem services. Those approaches, never used in

fast-growing African cities, highlight the need to identify particular services around which conservation efforts and messaging can build consensus across society, while targeting particular messages to certain influential groups. Integrating the results from this thesis will help promote urban greenspace conservation across the range of stakeholders interacting in fast-growing African urban areas.

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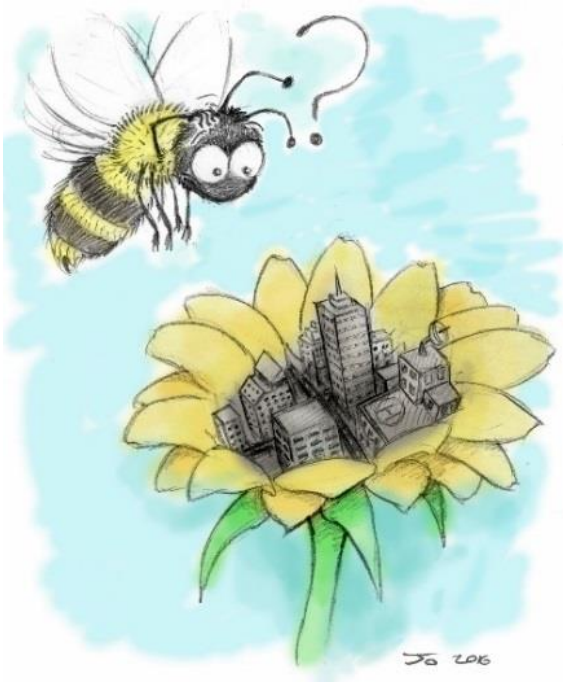
Chapter 2:
Effects of urbanisation and management practices on pollinators in tropical Africa



Solène Guenat[1]*, William E. Kunin[2], Andrew J. Dougill[1], Martin Dallimer[1]

[1]Sustainability Research Institute, School of Earth and Environment, University of Leeds, Leeds, LS2 9JT, UK

[2]School of Biology, University of Leeds, Leeds, LS2 9JT, UK

*Correspondence author. Email: eesgu@leeds.ac.uk

2.1 Abstract

1. Urban expansion is an increasing threat to biodiversity, especially in tropical Africa where biodiversity hotspots are being encroached upon by fast-growing cities. Threatened species include bees and other pollinators, which deliver important ecosystem services but are sensitive to land use changes.
2. We investigated the impact of urbanisation and vegetation management practices on pollinator abundance, bee diversity and bee functional traits. We sampled 126 locations in a stratified random design across an urbanisation gradient in two medium-sized cities in the West African Forests biodiversity hotspot, encompassing three management practices

(farmed sites; amenity lands, i.e. greenspaces managed for aesthetics; informal greenspaces), and tested their effect with generalised linear models.

3. Urbanisation did not affect bee abundances or diversity but had a negative impact on both wasp and beetle abundances. There was also a management-mediated impact of urbanisation on bee abundances, which decreased with urbanisation on farmed sites but not amenity land or informal greenspaces. Management practices alone influenced bee abundances with farms harbouring fewer bees, and amenity lands fewer beetles.
4. Bee genera occurrence and dominance patterns were influenced by both urbanisation and management, with some otherwise common genera rare in urban areas.
5. Most functional traits were influenced by management, with fewer polylectic bees, cavity-nesting bees and long-tonged bees in farmed sites. Amenity lands hosted smaller bees and fewer savannah specialists. Some traits were influenced by urbanisation, with more long-tongued bees and cavity-nesting bees found in urban areas.
6. Synthesis and applications. Pollinator responses to urbanisation are complex. In our research, we demonstrate how bee, lepidopteran and non-fruit fly abundances have been maintained across an urbanisation gradient in tropical Africa, but not wasp and beetle abundances. Moreover, bee community composition and the distribution of traits shifted markedly. How greenspaces were managed was also critical. We found that farmed sites hosted the lowest bee abundances and amenity lands the fewest beetles. Retaining informal greenspaces and amenity lands in African cities, including protecting nesting sites for stingless bees, and limiting pesticide application would be important for conserving bees and the pollination service they provide to both crops and native vegetation.

2.2 Résumé (French abstract)

1. L'expansion urbaine est une menace importante pour la biodiversité, particulièrement en Afrique où les hotspots de biodiversité sont rapidement mités par les villes. Les pollinisateurs, qui fournissent des services écosystémiques importants, sont menacés du fait de leur sensibilité aux changements d'utilisation du territoire.

2. Nous avons étudié l'impact de l'urbanisation et de trois types de gestion des espaces verts (aires agricoles, lieux d'agrément, espaces verts informels) sur l'abondance des pollinisateurs et sur la diversité et les caractères fonctionnels des abeilles. Nous avons échantillonné 126 emplacements de manière aléatoire stratifiée, dans les trois types d'espaces verts, le long d'un gradient d'urbanisation dans deux villes du hotspot de biodiversité des forêts guinéennes de l'Afrique de l'Ouest, et testé leurs effets avec des modèles linéaires généralisés.

3. L'urbanisation n'affecta ni l'abondance ni la diversité des abeilles, mais diminua l'abondance des guêpes et des coléoptères. Couplée à la gestion, elle affecta également l'abondance des abeilles, qui diminua uniquement dans les aires agricoles. La gestion seule eu par ailleurs un effet : les aires agricoles abritant moins d'abeilles et les lieux d'agrément moins de coléoptères.

4. Le schéma d'occurrence et de dominance des différents genres d'abeilles fut influencé par l'urbanisation et la gestion : certains genres, autrement communs, étant rares en zones urbaines.

5. La gestion influença la plupart des caractères fonctionnels, avec moins d'abeilles polylectiques, d'abeille cavicoles et d'abeilles à langue longue dans les aires agricoles. Les lieux d'agrément abritaient des abeilles plus petites et moins de spécialistes des savanes. La proportion d'abeilles à langue longue et d'abeilles cavicoles augmenta avec l'urbanisation.

6. Synthèse et application. Les réactions des pollinisateurs face à l'urbanisation sont complexes. Nous démontrons que l'abondance des abeilles, papillons et mouches est maintenue le long d'un gradient d'urbanisation en Afrique tropicale, mais pas celle des guêpes ni des coléoptères. De plus, la composition communautaire des abeilles et la

distribution de leurs caractères fonctionnels sont clairement modifiées. La gestion des espaces verts est également cruciale : les aires agricoles abritent moins d'abeilles, les lieux d'agrément moins de coléoptères. Conserver des espaces verts informels et des lieux d'agrément dans les villes africaines, protéger les sites de nidification, et limiter l'application de pesticides sont nécessaires pour conserver les abeilles et la pollinisation qu'elles fournissent aux cultures et à la végétation indigène.

2.3 Keywords

bees, conservation, functional traits, pollinators, Ghana, Guinean Forests of West Africa, urban agriculture, urban greenspaces

2.4 Introduction

Urbanisation as a land-use change has the greatest impact on biodiversity (McDonald et al., 2008). Urban expansion, however, is not geographically homogenous, taking place mainly in developing countries (DESA, 2015), where it frequently encroaches into biodiversity hotspots (Seto et al., 2012). Urban areas also include greenspaces and their potential for biodiversity conservation is increasingly studied (Nilon et al., 2017). The majority of studies are based in the Global North, meaning that we know little about the biodiversity conservation potential of African cities (e.g. Magle et al., 2012). However, urban expansion in Africa differs from that of the Global North by being faster (Seto et al., 2012), happening mainly in smaller towns (DESA, 2015) and not always being associated with economic growth (Turok and McGranahan, 2013).

One group potentially threatened by urbanisation are insect pollinators (Jones and Leather, 2013), which are of particular concern given their importance for food security. The food system is highly reliant on their services, as animal pollination increases the production of the crops responsible for 35% of the global food production (Klein et al., 2007), needing both high abundances and diversity for optimal productivity (Garibaldi et al., 2014). With concerns growing about the loss of pollinators in surrounding rural landscapes (Potts et al., 2010), some urban areas, which can have a high floral diversity due to decorative planting and a proliferation of small vegetation patches, might provide useful habitat within an otherwise inhospitable urban matrix (Harrison and Winfree,

2015). However, if urban areas are to contribute to pollinator conservation, or serve as spillover habitat for pollinator loss in rural agricultural landscapes (Pereira-Peixoto et al., 2014), quantifying the role of different urban vegetation management practices is essential (cf. for rural landscapes Ricketts et al., 2008). The potential for urban environments to contribute to pollinator conservation has gained prominence in recent years (Hall et al., 2017) and a positive effect of urbanisation on both abundances and diversity has been observed (e.g. Baldock et al., 2015). Such effects are often trait-related, with a negative effect of urbanisation on floral specialists and ground-nesting bees but a positive one for cavity-nesting bees (Hernandez et al., 2009; Fortel et al., 2014), and are context-dependant. Despite this, few studies have been carried out in sub-Saharan Africa (Hernandez et al., 2009), which is part of the general paucity of research both on urban biodiversity (Magle et al., 2012) and pollinator conservation (Rodger et al., 2004) in the region. Those studies that have been carried out point towards a larger diversity of pollinators and steeper declines in pollinator visitor rates from natural to disturbed agricultural landscapes in tropical compared to temperate zones (Ricketts et al., 2008; Rodger et al., 2004). In a region which is extremely vulnerable to pollination deficit (Gallai et al., 2009), there is an urgent need to better understand the impact of urbanisation and management practices on the conservation of bees and pollination.

One of the many challenges in African cities is ensuring food security, something that urban agriculture can contribute to by supplementing food and incomes for an often substantial proportion of the human population (Zezza and Tasciotti, 2010). Additionally, urban agriculture can contribute to female empowerment, help reduce waste and the environmental impact of food transport, and improve urban air quality and biodiversity (Orsini et al., 2013). Crops cultivated in urban farms include staples such as maize or cassava, but also high-value vegetable and fruit crops often reliant on pollination for high yields (Ayerakwa, 2017; Klein et al., 2007). Consequently, a better understanding of the urban pollinator status in Africa is crucial for maximising the multiple benefits of urban agriculture.

Here we redress this imbalance by investigating the effect of urbanisation and management practices on pollinator abundances, bee diversity, community

structure and functional traits in medium-sized tropical African cities. By sampling bees, wasps, lepidopterans, beetles and flies to assess their abundances along an urbanisation gradient and different vegetation and management practices, we quantify the potential for pollinator conservation in cities and determine the type of greenspace management practices best suited for urban pollinator conservation.

2.5 Materials and methods

2.5.1 Study sites and sampling design

The cities of Sunyani (7°20’05’’N 2°19’40’’W) and Techiman (7°34’53’’N 1°56’09’’W), Brong Ahafo, Ghana (Figure B.1.a) are located at the fringe of the *Forests of West Guinea* biodiversity hotspot, increasingly threatened by urban expansion, despite having already lost 90% of its primary vegetation (Seto et al., 2012). The flora of the hotspot includes approximately 9000 vascular plant species and at least 482 are on the IUCN Red List (Myers et al., 2000). Data on pollination systems is lacking in the hotspot, as the little pollination research carried out in West Africa focuses on cash crops (Rodger et al., 2004). Sunyani and Techiman are medium-sized fast-growing cities, with a recent annual population growth rate of 4.8% (Ghana Statistical Services, 2013). They are embedded in an agricultural landscape with little semi-natural areas nearby. The only protected areas in the region are far from urban centres (IUCN/PACO, 2010).

We sampled 126 greenspaces which encompassed three management practices and were distributed across an urbanisation gradient based on the proportion of built infrastructure (Figure B.2). Land-cover data were extracted from Sentinel 2 aerial pictures from December 2015 (Copernicus Sentinel data 2015) within ArcMap 10.4.1 following a two-step image classification technique combining Jenks Natural Breaks classification with hierarchical clustering (Anchang et al., 2016). This map was used to extract the proportion of built infrastructure (buildings, surfaces such as roads, carparks or any area covered with impervious structures) in a 250x250m grid. Forty-two areas were randomly selected along the urbanisation gradient, ensuring an equal representation of rural (control), urban and peri-urban landscapes and a minimum distance of

1km between each (Figure B.1.b and Figure B.1.c). Rural area selection was confined to a 10km radius around the city and limited to areas accessible from paved roads and dirt paths. The pre-identified areas were walked to select three greenspaces of a minimum of 50m^2, one each of (1) amenity land, a greenspace managed for aesthetic purposes, typically lawns, trimmed hedges, or cleared vegetation; (2) farmed sites, a greenspace managed for agricultural production, including mixed-crop gardens and farms; and (3) informal greenspaces, a vegetated area receiving minimal to no management, such as fallows or abandoned sites. This resulted in a stratified sampling of 126 greenspaces nested by three management practices in 42 different areas.

Pollinators were sampled between August and November 2016, covering the shorter of the two annual rainy seasons. While little is known about the best period for sampling bees in West Africa, other tropical studies found higher abundances in the rainy season (Coulibaly et al., 2016) or similar abundances but different species composition, with smaller species and more ground-nesting bees found in the rainy season (Samnegard et al., 2015). Pan-traps were used, a method recommended for its lack of collector bias and its effectiveness in urban environments (Devigne and De Biseau, 2014). Five pan-traps, each consisting of three 300mL bowls painted in UV fluorescent yellow, white and blue (Sparvar Leuchtfarbe, Spray-Color GmbH, Merzenich, Germany), were set out in each greenspace on one occasion during the sampling period, with a maximum of five greenspaces sampled simultaneously. They were set up at the level of the ground-layer vegetation (varying from 0-0.5m), separated by 5m. These were 2/3rds filled with water and a drop of unscented detergent and left active for 24 hours to account for the full diurnal activity of pollinators. Samples were stored in 70% alcohol before being pinned for identification. All insects were identified to order in the field. Bees and wasps were pinned and differentiated with microscopy based on Goulet and Huber (1993). Bees were subsequently identified with microscopy to morpho-species following Eardley, Kuhlmann and Pauly (2010) as per training received at Oxford University Museum of Natural History.

Bee functional diversity was assessed through a selection of traits relevant for pollinators, namely habitat, pollen specialisation, nesting behaviour, body size (inter-tegula distance measured on all specimens with a caliper), tongue length

and sociality (Table B.1; Normandin et al., 2017). Functional traits were categorised at sub-genera level based on the literature (Table B.2).

Sample sites were described by their habitat structure and floral resources, flowering plant diversity (Gini-Simpson's index) and species richness. Habitat structure was defined as a visual estimation of the proportion of six habitat features in a 200m radius around the sampling site, namely unmanaged ground vegetation, regularly mown or grazed vegetation, shrub layer vegetation, tree layer vegetation, bare ground and concrete. We estimated the floral resources in a 1m circle around the pan-trap by (1) counting the flowering plant species richness, (2) estimating each species' flower head surface and (3) counting flower head abundance. In farmed sites, the presence of the different crop types was also noted.

2.5.2 Data analysis

2.5.2.1 Sample site characterisation

All analysis were carried out with R v.3.4.3 (R Core Team, 2017). To characterise the pollinator habitat, we analysed differences between the three management practices in terms of the estimated floral resources, flowering plant species richness and diversity (Gini-Simpson's index) and the six components of habitat structure (Table B.3). None were normally distributed, so we used nonparametric Kruskal-Wallis tests. Given the focus on three specific greenspace categories, findings are representative of the immediate surrounding of greenspaces, but not of the wider make-up of the cities as it excludes large areas of built infrastructure.

2.5.2.2 Abundance and diversity

We ran generalised linear mixed-effect models to test the effect of management and the proportion of built infrastructure (extracted from land-cover maps) in a 600m radius (the foraging range of most solitary bees; Gathmann and Tscharntke, 2002) around each sampling site on bee, wasp, lepidopteran, beetle and fly (excluding fruit flies) abundances and bee diversity per site (*N=126*). Due to small catches, bee diversity was calculated only when abundances were ≥2 with the Gini-Simpson index weighted by the inverse of its

variance, as this diversity estimator is unbiased with respect to catch size (Lande, 1996).

After excluding correlated explanatory variables (variance inflation factor >3) (Zuur, 2009), models included 13 variables describing weather and habitat (Table B.4), the interaction between management practices and urbanisation and a random grouping variable representing the nesting of the three management practices clustered in the sampling design. We used negative binomial error distributions to compensate for the over-dispersion observed for all abundances, except bee abundance for which we used Poisson distribution (Burnham and Anderson, 2002) and a Gaussian distribution for diversity. As bee and lepidopteran abundances had a high number of zeroes, we used zero-inflated models (Zuur, 2009), from the R statistical package glmmTMB (Magnusson et al., 2017). Models were run with all possible combinations of variables and compared according to AICc, selecting those with $\Delta AICc \leq 2$ and averaging them using Akaike weights (Burnham and Anderson, 2002), using the R statistical package MuMIN, v.1.40.4 (Barton, 2018).

2.5.2.3 Indicator species

Indicators are defined as taxa whose presence and abundance can reflect the state of the environment, highlight the impact of environmental changes or predict the distribution of other taxa (DeCaceres and Legendre, 2009). They are determined by assessing the association between species abundances and grouped sites, through their specificity (probability that, if the species is found on a site, the site belongs to a wider group of sites) and their fidelity (probability of finding the species if the site belongs to the group) (DeCaceres and Legendre, 2009). To examine whether some bee genera are indicators, we carried out indicator species analysis with sites grouped by management type and urbanisation, with the R indicspecies package, v.1.7.6 (DeCaceres and Legendre, 2009). As categorical grouping variables are a prerequisite, sites were defined as urban or rural based on the proportion of built infrastructure in 600m surrounding the sampling site (rural < 15% < urban).

2.5.2.4 Functional traits

To assess the effect of urbanisation and management practices on functional traits, we fitted generalised mixed-effect linear models of each trait

independently against the same set of explanatory variables as for the abundance and diversity analysis (Table B.4). We used a Gaussian distribution for the log-transformed ITD and binomial distributions for all other traits. We used the same model selection and averaging method as for the abundance and diversity analysis. As some traits could be inter-correlated, we quantified this with Spearman rank correlations to understand if similar relationships with urbanisation and management practices were linked to association between traits and discussed the implications of such correlations.

2.6 Results

2.6.1 Sample site characterisation

Amenity land was characterised by (i) lower coverage of ground layer vegetation (χ^2=71.71, *P*<0.001, Figure 2.1a, Table B.3), (ii) being the only management practice with mown vegetation (χ^2=49.367, *P*<0.001, Figure 2.1b), (ii) higher cover of concrete (χ^2=13.791, *P*=0.001, Figure 2.1c), (iv) lower flowering plant diversity (χ^2=16.7, *P*<0.001, Figure 2.1d), and (v) lower species richness (χ^2=26.086, *P*<0.001, Figure 2.1e) compared to other management practices. Farmed sites had a lower coverage of ground layer vegetation and flowering plant species richness than informal greenspaces but more than amenity lands. They were characterised by a higher coverage of shrub layer vegetation (χ^2=40.095, *P*<0.001, Figure 2.1f) and bare ground cover (χ^2=21.938, *P*<0.001, Figure 2.1g) compared to the other management practices. In farmed sites, we identified 30 crops with variable reliance on animal pollination, most of which were found in both urban and rural landscapes (Table B.5). Informal greenspaces had the highest cover of ground layer vegetation cover and the highest flowering plant species richness. None of the management practices differed in their floral resources (χ^2=0.171, *P*=0.918) or tree cover (χ^2=2.797, *P*=0.247). Only the proportion of concrete increased along the urbanisation gradient (rho=0.32, *P*<0.001, Figure 2.1h).

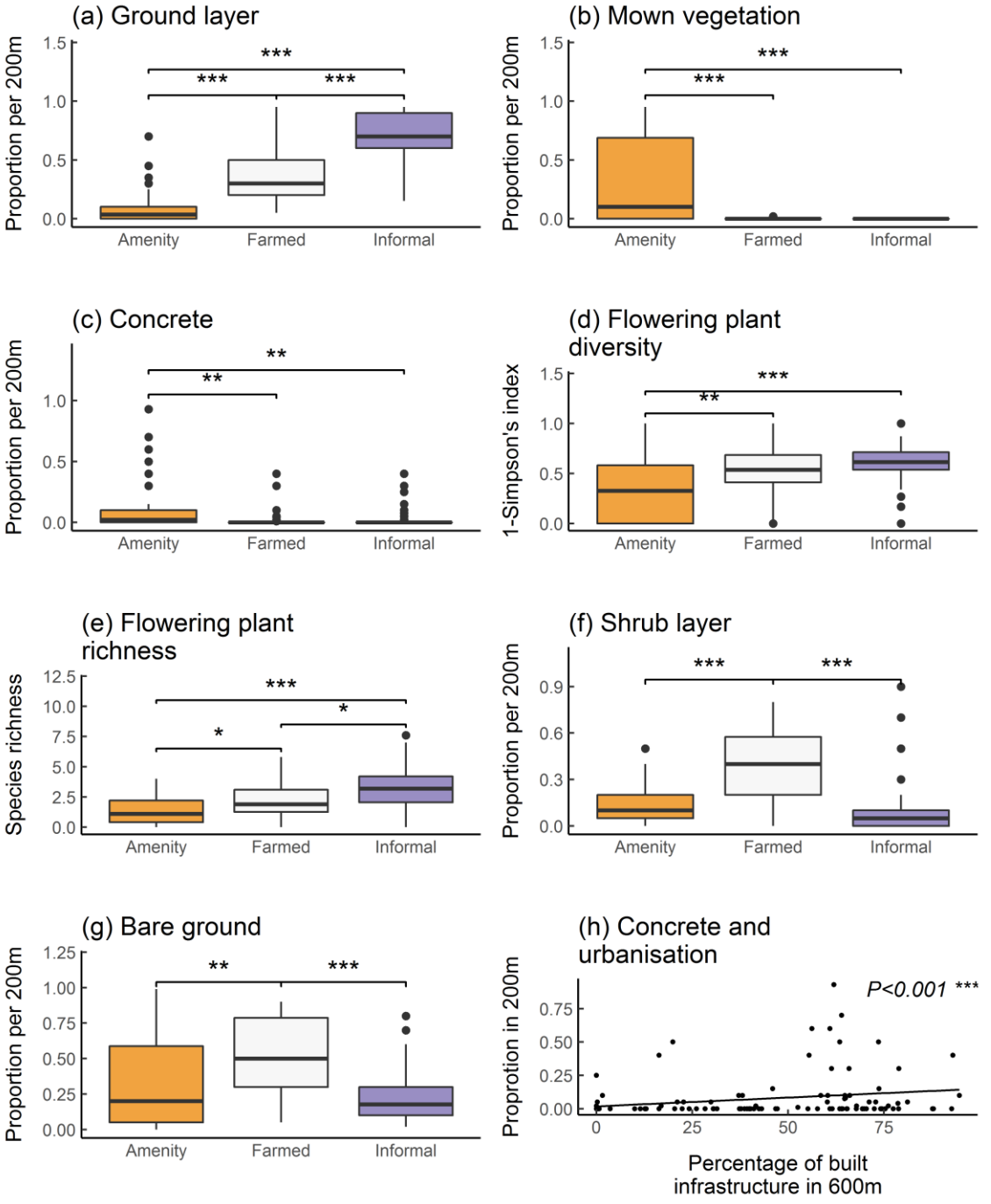


Figure 2.1. Significant relationships between vegetation structure/flowering diversity measures and management practices, and urbanisation for: (a) ground vegetation, (b) mown vegetation, (c) concrete, (d) flowering plant diversity, (e) flowering plants species richness, (f) shrubs, (g) bare ground; and (g) concrete by urbanisation. Boxes show median and interquartile ranges, with the whiskers extending to 1.5 of the interquartile range.

2.6.2 Abundances and diversity

We caught 51028 insects consisting of 167 bees (Figure B.3), 323 wasps of the Vespidae, Scoliidae, Pompilidae, Ampulicidae and Tiphicae families, 222 lepidoptera, 1090 beetles and 49226 flies. 93.7% (46123) of the flies were Drosophilidae, likely attracted by other decaying insects and therefore not relevant for pollination. We do not consider them further. The remainder were species of the Calliphoridae, Driopsidae, Tephritiddae, Asilidae, Culicidae and Muscidae. Bees belonged to 18 genera and 76 morphospecies (Table B.6).

Overall bee abundances were not affected by urbanisation but varied according to management. Abundances were lowest in farmed sites (β=-1.511, SE=0.729, P=0.040, Figure 2.2a, Table B.7). However, the interaction between management and urbanisation was significant: bee abundances in amenity land and informal greenspaces did not change with urbanisation, but they decreased in farmed sites (β=0.019, SE=0.008, *P*=0.025, Figure 2.2b). Bee abundance was negatively influenced by rainfall (β=-0.031, SE=0.013, P=0.016) and positively influenced by cloud cover (β=1.005, SE=0.470, *P*=0.034).

Bee genera and morpho-species diversity were not affected by management or urbanisation. No variables influenced morpho-species diversity. Genera diversity increased with the proportion of tree layer vegetation (β=0.296, SE=0.145, *P*=0.047).

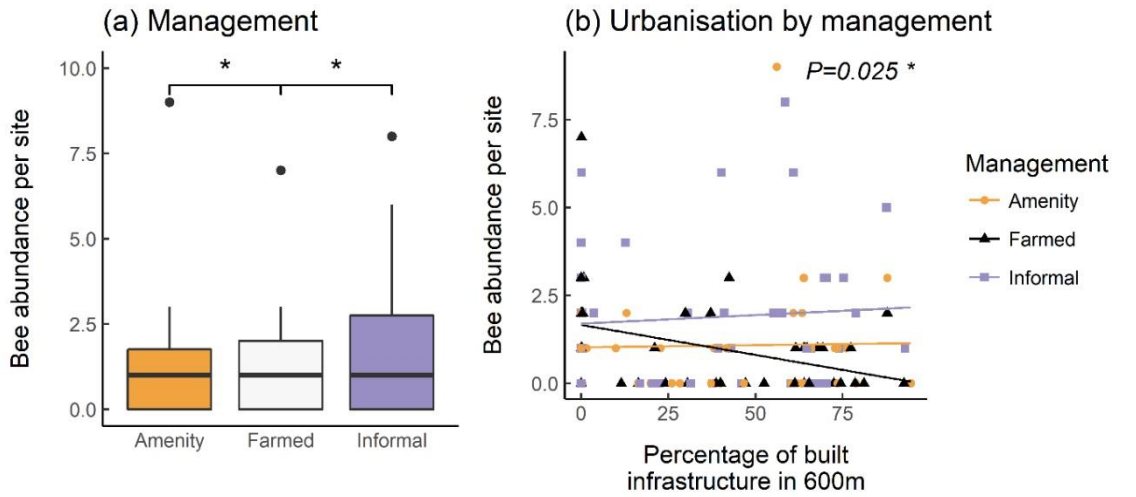


Figure 2.2. Relationship between bee abundances and (a) management practices and (b) urbanisation (built infrastructure) and its interaction with management practices. Boxes show median and interquartile ranges, with the whiskers extending to 1.5 of the interquartile range; each dot represents a sampling site (N = 126)

Wasp abundances did not change with management but decreased with urbanisation, although the data were highly variable (β=0.005, SE=0.002, *P*=0.032, Figure 2.3a). Abundances increased with cloud cover (β=1.382, SE=0.302, *P*<0.001) and floral resources (β=0.001, SE=0.000, *P*=0.015), but decreased with rainfall (β=-0.015, SE=0.007, *P*=0.038). Lepidoptera abundances were not affected by management or urbanisation, but increased with temperature (β=0.833, SE=0.261, *P*=0.002).

Beetle abundances were significantly lower in amenity land than in farmed sites (β=1.936, SE=0.392, *P*<0.001, Figure 2.3b) or informal greenspaces (β=2.101, SE=0.391, *P*<0.001), and were negatively affected by urbanisation (β=0.019, SE=0.004, *P*<0.001). This decline was greater in amenity lands than in farmed sites (β=-0.012, SE=0.005, *P*=0.013). Abundance was negatively related to rainfall (β=-0.023, SE=0.007, *P*=0.013), but increased with the proportion of mown vegetation (β=0.826, SE=0.356, *P*=0.022).

Non-fruit fly abundances were not affected by management or urbanisation. They were sensitive to weather conditions, with a negative relationship with temperature (β=-0.078, SE=0.021, *P*<0.001) and rainfall (β=-0.024, SE=0.006, *P*<0.001) and a positive relationship with cloud cover (β=0.616, SE=0.217,

P=0.005). Additionally, more were found in Techiman (β=0.368, SE=0.117, *P*=0.002).

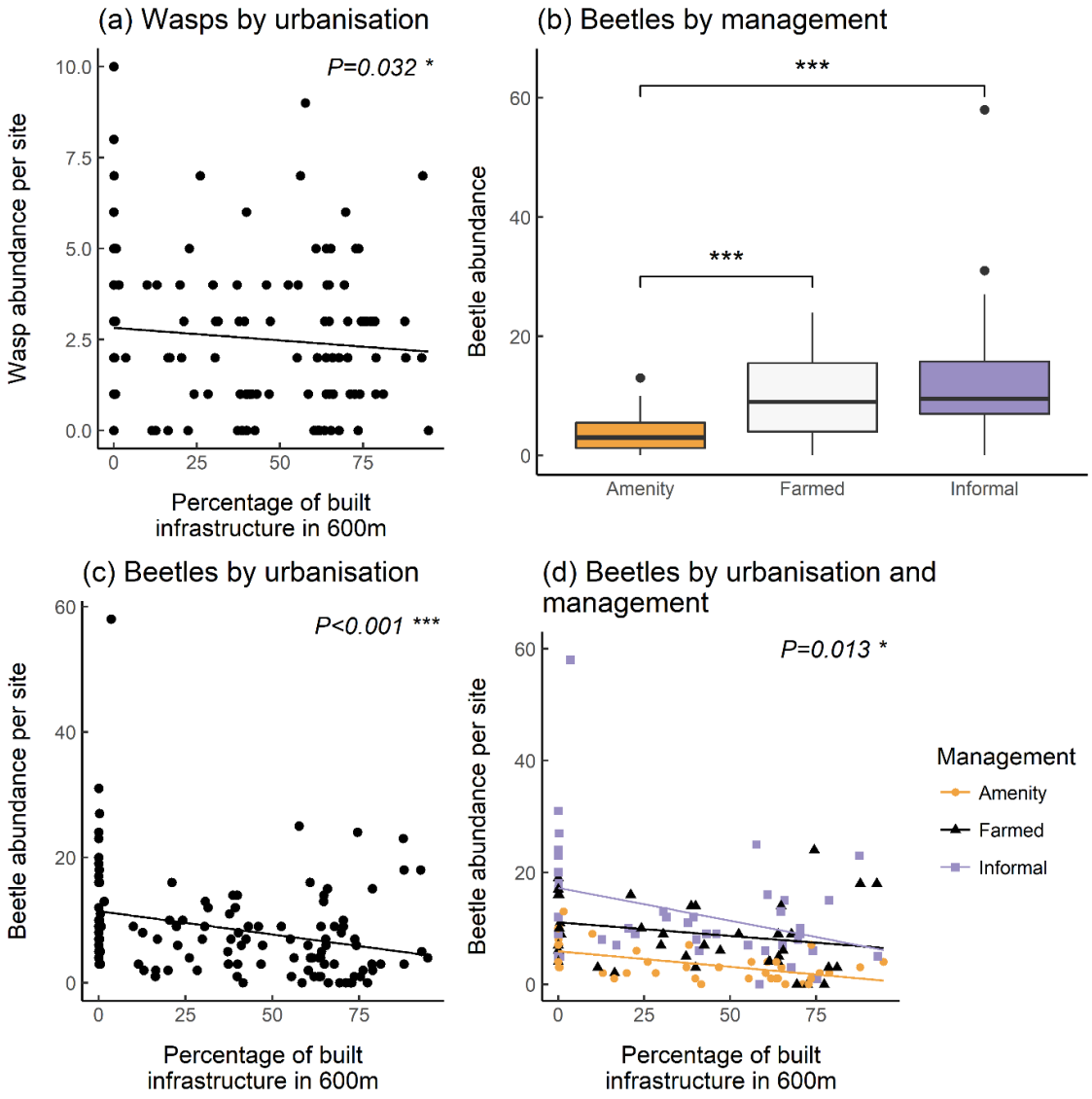


Figure 2.3. Influence of management and urbanisation on non-bee pollinator groups: (a) Wasp abundances by urbanisation; beetle abundances by (b) management, (c) urbanisation and (d) the interaction between management and urbanisation. Boxes show median and interquartile ranges, with the whiskers extending to 1.5 of the interquartile range; each dot represents a sampling site (*N*=126)

2.6.3 Indicator species

Overall fidelity scores were relatively low due to the small catch sizes, but three genera were indicators of management practices due to their high specificity. *Meliponula* sp. were indicators of amenity lands (specificity=77.3%, fidelity=23.9%, stat=0.429, *P*=0.009, Figure 2.4a, Table B.8)*, Seladonia* sp. of informal greenspaces (specificity=83.3%, fidelity=31.5%, stat=0.315, *P*=0.05) and *Braunsapis* sp. of farmed sites and informal greenspaces (i.e. “non-amenity land”, specificity=88.2%, fidelity=25%, stat=0.47, *P*=0.021). No genus was an indicator of urban areas but *Braunsapis* sp. was an indicator of rural areas (specificity=90.3%, fidelity=47.6%, stat=0.656, *P*=0.001, Figure 2.4b).

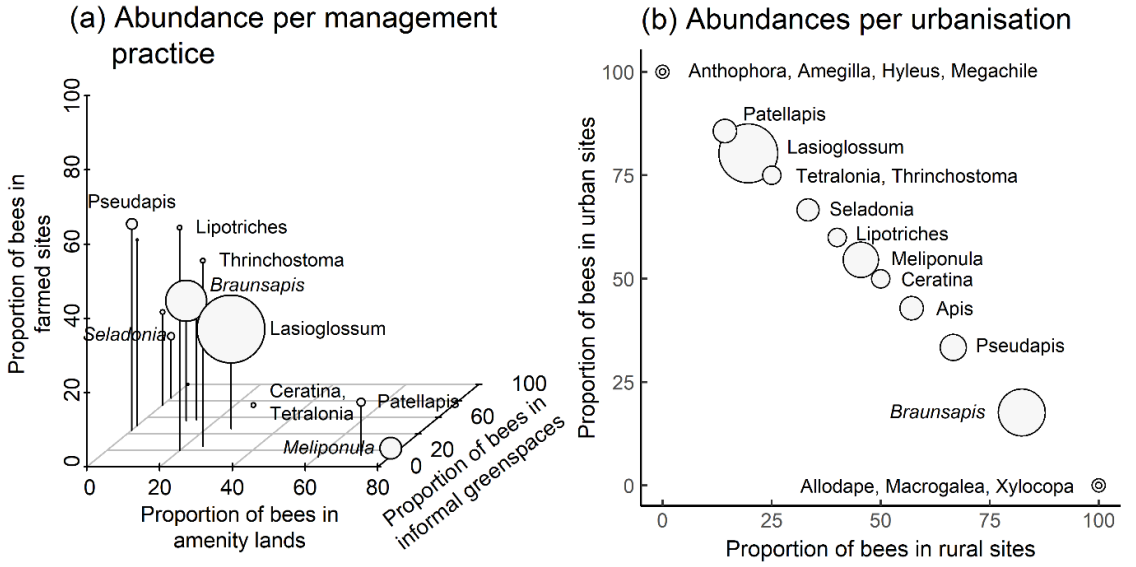


Figure 2.4. Relative abundance of the different bee genera, with indicator genera in italics. (a) Proportion of individuals sampled per genus in each management practice. Dot size is proportional to the number of individuals. For instance, *Seladonia* sp. had a low abundance but was found mainly in informal greenspaces while *Meliponula* sp., more abundant, was collected primarily in amenity lands (*N*=42 per practice), (b) Proportion of individuals sampled per genus in relation to urbanisation. Dot size is proportional to the number of individuals (*N*=84 for urban sites and *N*=42 for rural sites)

2.6.4 Functional traits

The average inter-tegument distance for bees was 1.496mm (*N*=167, SE=0.051). Most bees (64%) were habitat generalists, while the habitat specialists were split between savannah (41.6%) and woodland (58.3%) (Table B.9). Long-tongued bees constituted 52.7% of the community, ground nesters 56.2%, pollen specialists 35.9% and social or semi-social 76%. Many functional traits were correlated, with especially strong correlations between pollen specialisation, tongue length and nest location (Table B.10).

Both social and solitary bees were evenly spread across the urbanisation gradient and management practices, and their presence was not affected by the other variables (Table B.11). Similarly, the proportion of habitat generalists was constant across the urbanisation gradient and management practices, though within the habitat specialists, there was a lower proportion of savannah specialists in amenity lands than in informal greenspaces (β=-1.605, SE= 0.762, *P*=0.041) or farmed sites (β=-2.629, SE=0.877, *P*=0.004, Figure 2.5a). Body size differed between management practices and so did feeding and nesting habits; bees in amenity lands had smaller bodies than those in informal greenspaces (β=0.340, SE=0.080, *P*<0.001) or farmed sites (β=0.299, SE=0.064, *P*<0.001, Figure 2.5b). Farmed sites hosted lower proportion of long-tongued bees (β=-1.539, SE=0.705, *P*=0.031, Figure 2.5c) and polylectic bees (β=-1.807, SE=0.675, *P*=0.009, Figure 2.5d). Cavity-nesting bees were more common in amenity land than farmed sites (β=-1.539, SE=0.705, *P*=0.031, Figure 2.5e). The proportion of long-tongued bees (β=0.340, SE=0.080, *P*<0.001, Figure 2.6a) and cavity-nesters (β=0.025, SE=0.009, *P*=0.008, Figure 2.6b) decreased with urbanisation.

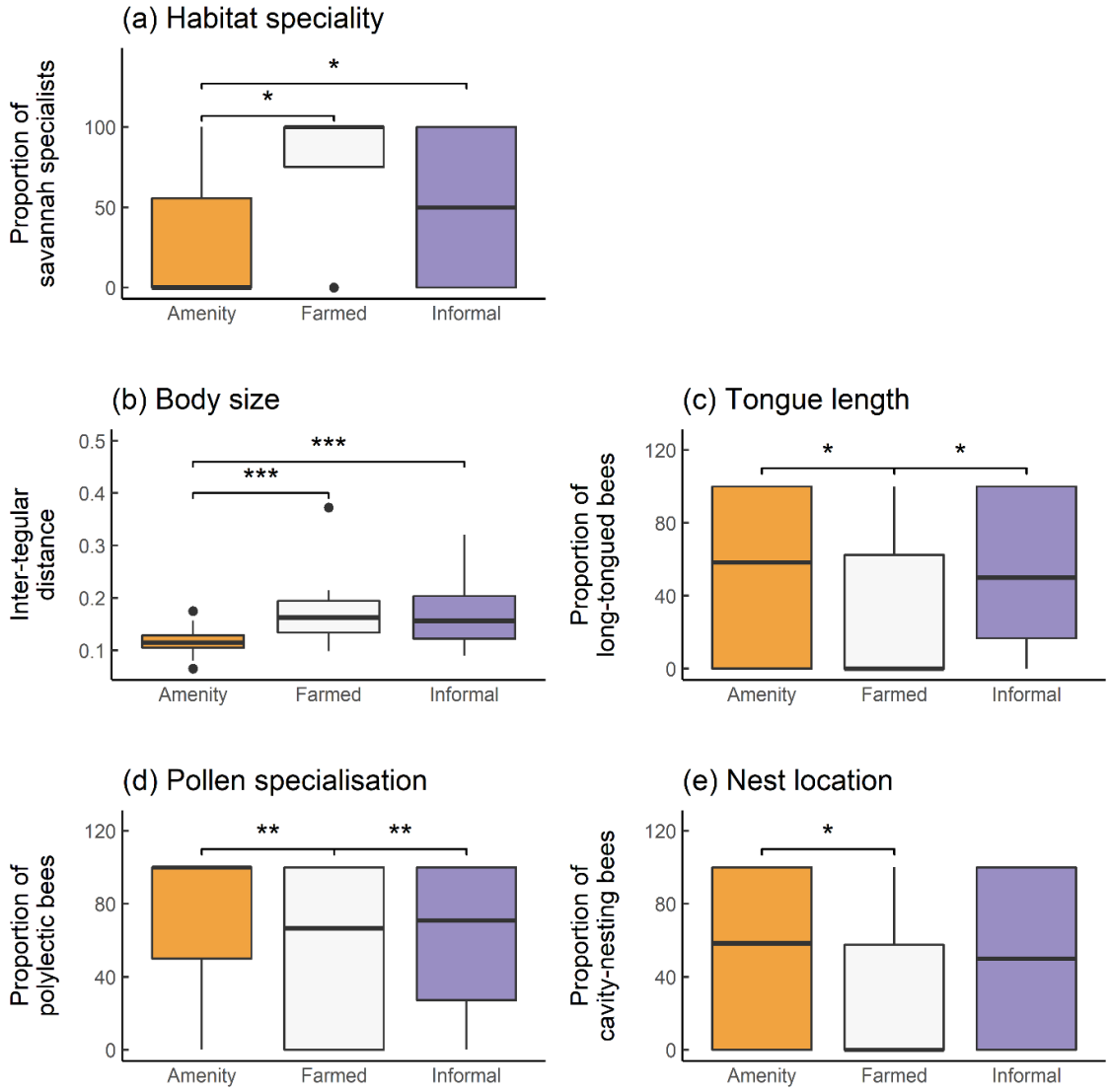


Figure 2.5. Functional traits significantly influenced by management practices. (a) Habitat speciality amongst the habitat specialist bees (*N*=60), (b) body site, (c) tongue length, (d) pollen specialisation, (e) nest location. Boxes show median and interquartile ranges, with the whiskers extending to 1.5 of the interquartile range

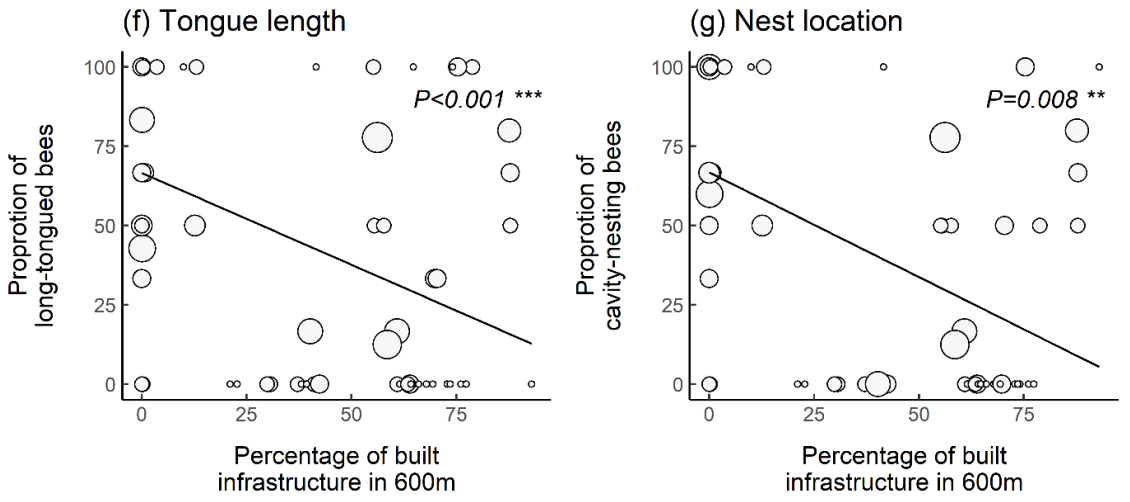


Figure 2.6. Functional traits significantly influenced by urbanisation. (a) Tongue length and (b) nest location. Dots are proportional of catch sizes per site (N=76)

2.7 Discussion

In tropical Africa, vegetation management affected bee abundances and functional traits, with fewer bees in farmed sites. Although there was no direct effect of urbanisation on abundances, an interaction between management and urbanisation meant that the more urban a farmed site was, the fewer bees it hosted. Similarly, abundances of other pollinators such as wasps and beetles decreased as the landscape became more urban. Urbanisation influenced bee community composition and their functional traits, favouring short-tongued bees and ground-nesting bees.

2.7.1 Urbanisation

Although urban greenspaces in temperate regions are a potential refuge for pollinators (Hall et al., 2017), evidence remains mixed (Baldock et al., 2015; Ramírez-Restrepo and MacGregor-Fors, 2017). In a rarely studied tropical African context, we found no direct effect of urbanisation on overall abundance of bees, lepidoptera or non-fruit flies. Increased urban cover did, however, negatively impact wasp and beetle abundances.

Some functional traits were affected by urbanisation; fewer long-tongued bees and cavity-nesting bees were found in urban than in rural areas. This change in nesting habits contrasts with the one observed in temperate regions, where

ground-nesters are less present in cities, a decrease thought to be due to the increased cover of impervious surfaces offering little access to ground nesting sites (Cane et al., 2006). In contrast, African cities often have less coverage by impervious surfaces than cities of the Global North (Lall et al., 2017), therefore offering a greater extent of open ground for bees to nest in. Similarly, we found a low overall coverage of concrete, supporting the proposition that ground-nesting bees are affected by increased impervious surface cover and highlighting the need to retain bare ground in urban areas.

Despite the urban landscape likely being more fragmented than rural landscapes, the abundance of bees was maintained in our study sites, perhaps due to the variety of different-sized greenspaces providing usable habitat in an otherwise inhospitable urban matrix (Harrison and Winfree, 2015). However, bee communities differed between urban and rural sites. For instance, *Braunsapis* sp. was virtually absent in urban areas despite being the most abundant genus in rural areas and a common genus in tropical Africa (Eardley *et al.* 2010). The only other urban pollination study on the continent focused on a specific bee, *Rediviva peringueyi*, and found it to be absent from urban sites (Pauw, 2007). Conversely, other genera such as *Lasioglossum* bees were common in urban samples, but rare or absent in rural environments. Our results highlight the fact that changes in resource availability and environmental conditions brought about by urbanisation induce a modification in bee community composition which would require further investigation.

The cities are surrounded by agricultural landscapes, within a biodiversity hotspot and without nearby protected areas (IUCN/PACO, 2010). The similarity in bee abundances across the urbanisation gradient might therefore reflect a generally depleted regional species pool, something that is likely the norm rather than the exception in urbanisation studies. The negative effect of rural farmed landscapes on bee abundances in comparison to semi-natural rural areas has already been documented (Coulibaly et al., 2016; Combey and Kwapong, 2016). Further research on pollinator distribution in different West African rural landscapes could improve the understanding of the impact of urban landscapes on pollinator abundances and community composition. Nevertheless, our study demonstrates that urban areas can play a role in maintaining bee abundances and diversity in some ways equivalent to those in

surrounding rural landscapes, despite changes in community structures. However, maintaining abundant and diverse bee populations in the long term, despite high development pressures and consequent disappearance of African urban greenspaces (Mensah, 2014), might prove challenging. Insects are not recognised by policy makers as worthwhile of conservation (Ministry of Environment and Science, 2002), even though they provide important ecosystem functions. Proactive planning is crucial to maintain urban greenspaces and ecosystem services while cities are expanding, rather than attempting to retrofit greenspaces once cities have densified.

2.7.2 Management

By highlighting the effect of management on bee abundances, our results raise concerns regarding the retention of insect pollination within an urbanising Afro-tropical landscape. Indeed, regardless of the level of urbanisation, farmed sites hosted lower bee abundances than any other management practices. Findings from other parts of Africa show a similar decrease in bee abundances in agricultural areas, regardless of their management or the heterogeneity of the landscape (e.g. Kehinde and Samways, 2011). Moreover, pollen generalist bees are known to be more resilient to land-use and climate change than specialists (IPBES, 2016), yet we found a higher proportion of specialists in farms, potentially decreasing the long-term resilience of their pollination.

Amenity lands also differed from other management practices by hosting bees of smaller sizes, a lower proportion of ground-nesting bees and savannah specialists. This was due to the association with stingless bees (*Meliponula* spp.), which are small-sized, cavity-nesting woodland specialists, and show the importance of providing nesting sites. Indeed, amenity lands had highly disturbed soils, with higher proportion of concrete and mown vegetation than the other management practices, and so provide little opportunities for ground-nesters. Additionally, as body size is often linked with dispersal ability (Gathmann and Tscharntke, 2002), promoting only amenity lands as a source of dispersion for urban farms will not be optimal.

Other pollinators groups were not as affected by management practices. Only beetle abundances were lower in amenity lands, a pattern similar to trends observed elsewhere in Africa, where beetles are highly sensitive to habitat

disturbances (Clark and Samways, 1997). Those results highlight the importance of structurally diverse habitat and low-intensity management practices for maintaining pollinator abundances and diversity. Conserving such informal greenspaces while they are often perceived as derelict and vacant (Ruelle et al., 2013), will require concerted efforts from urban planners.

2.7.3 Urban farming

An interaction between urbanisation and management also influenced bee abundances, with abundance staying stable with urbanisation in informal greenspaces and amenity lands but decreasing with urbanisation in farmed sites. Similarly, other pollinator groups such as beetles and flies decreased with urbanisation (although not all beetles and flies were necessarily pollinators). This highlights the importance of using context-specific information when promoting urban farming practices. Bumble bee studies in European cities suggest that bee abundances and species richness did not vary according to whether the site was farmed or cultivated for flowers (Foster et al., 2017). One explanation given as to why urban greenspaces have more bees than rural areas is that agricultural pesticides with negative impacts on pollinators (Goulson et al., 2015), are less prevalent. However, the opposite might be true in tropical Africa, as their cost and accessibility is a barrier to pesticides' widespread use in rural farms (Williamson et al., 2008). Urban farmers are typically better-off (Sahn and Stifel, 2003) and have access to a wider range of agricultural products (Linard et al., 2012) despite farming smaller plots (Asomani-Boateng, 2002). Chemical pesticides are also used by municipalities to reduce mosquito abundances to control vector borne diseases (S. Mensah, personal communication, 2016) and could affect pollinator populations. While the local Environmental Protection Agency is aware of the environmental impact of such chemicals (Atta-Agyem, 2016), pollinators are not considered when decisions on chemical use are made, reflecting the lack of insect conservation initiatives within national policy (Ministry of Environment and Science, 2002). Given that urban farms tend to focus on high value insect-pollinated crops, reduced or more targeted municipal pesticide use could benefit both insect conservation and food productivity.

2.7.4 Other ecosystem (dis)services

We identified non-bee pollinators to order level, yet this taxonomic resolution does not allow for the identification of the diversity of ecosystem functions they could provide and can hide some potential pests or biocontrol agents. For instance, wasps and flies included members of families some of which are natural predators of crop pests (Goulet and Huber, 1993). However, wasp abundance decreased with urbanisation, meaning that the pest control service they provide to urban agriculture is likely to be below its full potential. Flies also included some families with negative impacts on human health and agriculture, such as crop pests, bee predators, or human and livestock disease vectors (Picker et al., 2002). Indeed, an increase in malaria-carrying mosquitoes is often raised as a concern in irrigated urban agriculture (Afrane et al., 2004), highlighting both the importance of understanding locally relevant trade-offs if greenspaces are to be managed for insect conservation and ecosystem service provision and the need for further research on the comparison of ecosystem service and disservice providers in tropical urban landscapes.

Honey production is also an important service provided by bees, and often more valued by urban residents than pollination (Eardley et al., 2009). Although the honey bee (*Apis mellifera*) is usually the main producer, there is a growing market for stingless bee honey in Africa (Kwapong et al., 2010). We found that stingless bees (*Meliponula* sp.) are present in high abundances within amenity lands, and they are already known to have different patterns of adaptation to disturbances than other bee genera (Combey and Kwapong, 2016). Moreover, traditional beekeeping contributes to bee conservation by reducing destructive honey hunting practices (Dietemann et al., 2009). The association between stingless bees and amenity lands could provide an opportunity to include hives in some greenspaces and offer an additional ecosystem service in locations that are not optimal for many bee species.

2.8 Conclusion

Pollinator responses to urbanisation and management practices were diverse, with lepidoptera not being affected at all, wasps being affected mainly by urbanisation and beetles by both. Bees were affected by management practices, but their responses were not homogeneous and varied across taxa.

This demonstrates the importance of considering each pollinator group separately for maintaining their ecosystem services in urbanising landscapes.

Although urban farms had lower bee abundances compared to rural areas, both amenity land and informal greenspaces kept stable abundances along the urbanisation gradient. This illustrates that urban areas retain similar bee abundances to rural landscapes despite their inhospitable matrix and so can contribute to bee conservation in tropical Africa. Urban bee conservation might not directly contribute to decreasing food insecurity through improved urban agriculture, but can benefit regional biodiversity and help maintain crop pollination in the surrounding rural landscape.

In sum, urban pollinator conservation is possible, but will require a radical change in direction by urban planners to ensure a mix of informal and formal greenspaces in tropical African cities as they continue to expand.

2.9 Author contributions

S.G., M.D., W.E.K. and A.J.D. conceived the ideas and designed the methodology; S.G. collected the data; S.G. analysed the data; all the authors contributed to the writing of the manuscript and gave final approval for publication.

2.10 Acknowledgments

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2.11 Data accessibility

Data available via the NERC Environmental Information Centre, Centre for Ecology and Hydrology https://doi.org/10.5285/2e245944-ee5b-4612-b866-cafa3a129270 (Guenat et al., 2018).

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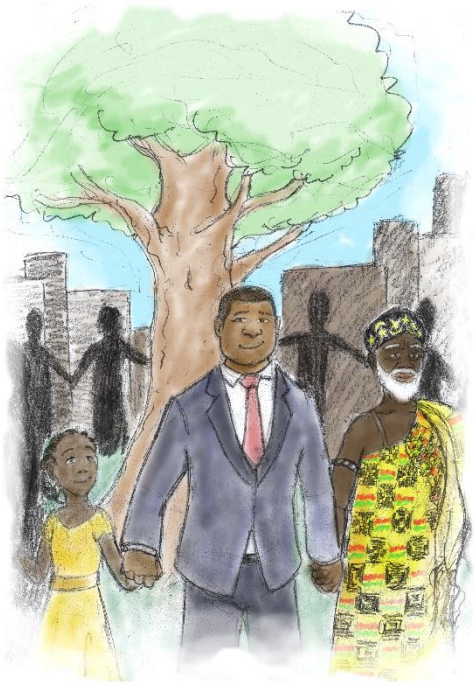
Chapter 3: Characterising social networks to contextualise urban conservation messages



Solène Guenat[1]*, Andrew J. Dougill[1], Martin Dallimer[1]

[1] Sustainability Research Institute, School of Earth and Environment, University of Leeds, LS2 9JT Leeds, UK

*Corresponding author: S.Guenat@leeds.ac.uk

3.1 Abstract

An understanding of social networks is crucial for efficient implementation of conservation measures as they inform how stakeholders interact and influence one another. Social networks are rarely studied in urban conservation contexts despite the growing evidence that suggests retaining urban greenspaces is essential for biodiversity conservation and ecosystem services provision. In regions where cities are expanding most rapidly, such as in sub-Saharan Africa, greenspace retention and conservation is key to ensuring cities remain liveable and resilient.

Here we explore the role of social networks in affecting urban greenspace conservation in sub-Saharan Africa. We quantify networks in two fast-growing Ghanaian cities through the Netmap method, mixing visual networks with qualitative interviews. We carried out 23 interviews with 28 government workers, chiefs, members of non-governmental organizations and land

developers. A centrality analysis on the aggregated network was conducted and complemented by a qualitative analysis of interview transcripts.

Ten stakeholder groups were identified. None were characterised as actively protecting greenspaces while also having sufficient influence to change the behaviour of others. Local government, chiefs and central government have the strongest impact on greenspaces due to the role their legal basis and customary position gives them in urban land-use management. However, they were typically described as having a negative or mixed impact on greenspace conservation and as being highly influenced by economic pressures from industries. Any potential for the conservation of greenspaces is jeopardised by development pressures, conflicting governing institutions, insufficient funding and lack of accountability.

Understanding social networks enables the identification of locally relevant stakeholders who are able to act in order to retain urban greenspaces, reveals their motivations and provides insights on the best ways to harness their relationships for greenspace conservation gains. In African cities, our analysis suggests that social networks hinder the conservation of greenspaces, as chiefs are key stakeholders yet thus far largely not engaged with greenspace conservation. Recognising the full value of urban greenspaces for societies is critical for gaining chiefs' endorsement and achieving greenspace conservation despite the pressure from expanding cities.

3.2 Keywords

Social networks, urban greenspaces, Ghana, governance, traditional institutions, Netmap, biodiversity conservation

3.3 Introduction

Humans play a dominant role in shaping ecosystems and driving the current biodiversity crisis (Díaz et al., 2019). Understanding which stakeholders are responsible for the loss of natural habitats, who is best placed to initiate conservation measures, and how stakeholders interact is crucial (Folke et al., 2005). A key approach is the study of social networks, defined as the set of relationships enabling the movement of information or influencing the beliefs and behaviours of individual stakeholders (Groce et al., 2019). How networks

are constituted can either help or hinder the sustainable management of natural resources (Groce et al., 2019).

Urbanisation is one of the main threats to biodiversity and ecosystem service provision (Díaz et al., 2019). Urban greenspaces, defined as all vegetated areas within the urban environment (Taylor and Hochuli, 2017), mitigate the negative environmental impact of cities through the conservation of specific species (Guenat et al., 2019; Ives et al., 2016) and the provision of ecosystem services (Gómez-Baggethun et al., 2013). Greenspace conservation has a key role to play in improving the wellbeing of residents (Dean et al., 2011) and the resilience of cities to climate change and extreme weather events (Demuzere et al., 2014). Some of the fastest urban growth is taking place in Africa, threatening biodiversity rich regions (Seto et al., 2012). African urban greenspaces face challenges including insufficiently coordinated and collaborative systems of formal government and lack of holistic planning (du Toit et al., 2018). Consequently, understanding how different stakeholders and their associated social networks impact greenspaces is key to improving the conservation of urban greenspaces in Africa.

Research on the governance of urban biodiversity and ecosystem services highlights that stakeholders leading greenspace conservation are generally drawn from the planning and environmental management division of the government (Wilkinson et al., 2013). However, the ability of the government to manage urban greenspaces is limited by a lack of knowledge of ecosystem functioning (Farr et al., 2018), a mismatch between administrative borders and ecologically meaningful units (Dallimer and Strange, 2015), the weakness of the state in some countries (Wilkinson et al., 2013), lack of coordination between different government bodies, and the dismissal of locally relevant practitioner knowledge (Ernstson et al., 2010). To counteract such issues, good governance should encourage integration, adaptability, and involvement of non-state stakeholders (Bodin and Crona, 2009). Examples of stakeholders in urban greenspace conservation include members of civil society, and research organizations (Folke et al., 2005).

Globally, research on social networks for conservation is limited yet provides critical contributions to the implementation of context-specific conservation strategies (Mills et al., 2014). The few studies on how social networks impact

urban greenspaces focus on specific projects (e.g. Ernstson et al., 2010; Farr et al., 2018), meaning their findings are less likely to be generalizable. Thus far, we know nothing of how social networks might impact the conservation, retention or rehabilitation of city-wide networks of greenspaces in Africa.

Here, we use a social network approach to investigate how stakeholders impact the conservation and management of greenspaces in two cities in Sub-Saharan Africa. We describe the stakeholders, examine how they impact greenspaces and how they interact with one another. Further, we explore the conflicts arising from differing motivations for greenspace management and the resulting challenges for greenspace conservation.

3.4 Methods

3.4.1 Study setting

African cities are expanding rapidly and thus encroaching on biodiversity hotspots (Seto et al., 2012). Ghana has a higher proportion of urban residents than most African countries (DESA, 2015) and is often praised as an example of stable development (Lenhardt and Rocha Menocal, 2015). Understanding how to improve greenspace conservation through stakeholders' interactions in Ghana could serve as an example of good practice for other African countries.

Since 1993, Ghana has undergone a period of decentralization to improve public participation (Government of Ghana, 1992). This has resulted in the creation of Assemblies, the highest level of local government authority in a district, and is overseen by a Regional Coordinating Council (Government of Ghana, 1993). Local governments are divided into two elements: appointed technocrats, spilt into different departments, and elected assembly members, who approve and budget for decisions made by technocrats. Ghana also has an officially recognised system of traditional leadership in the form of chieftaincies (Government of Ghana, 1992). Their roles include upholding customary law, organizing traditional ceremonies, protecting customary land and improving the socio-economic situation of their communities (Ubink, 2007). Chiefs have an advisory role in government, and 9% of the seats in Assemblies are reserved for them (Commonwealth Local Government Forum, 2018).

This study was carried out in Sunyani and Techiman (Figure 3.1), two small-sized cities located in the Brong Ahafo region of Ghana. Sunyani, the regional capital, is often described as an example of a well-planned city (Adu-Gyamerah, 2016). Techiman has been developing fast due to its prominent market. Both cities are split across two administrative districts (Ghana Statistical Services, 2013).

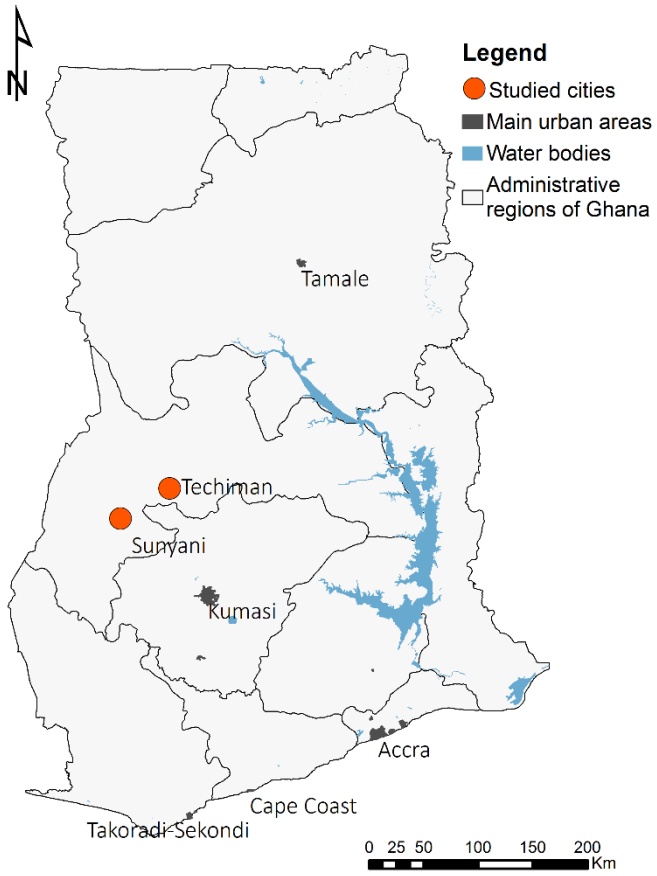


Figure 3.1. Studied cities within Ghana, including state administrative divisions at the time of the study. Those divisions were modified in 2019, at which point Techiman was designated the capital of the newly created Bono region.

3.4.2 Mapping social networks

We carried out stakeholder mapping using Netmap, a visual method for social network mapping that mixes qualitative and quantitative data (Schiffer and Hauck, 2010). Firstly, different stakeholders are identified and, secondly, their relationships are described and their relative levels of influence ascertained (Schiffer and Hauck, 2010). The method has been designed to minimise the

impact of cultural and language differences (Schiffer and Hauck, 2010) and has been used to understand governance of natural resources throughout Africa (e.g. Hauck et al., 2015). Visual network mapping methods provide participants and researchers with a representation of the network on which to base discussion (Hogan et al., 2007) and allow for the description of several types of relationships (Schiffer and Hauck, 2010).

3.4.3 Participant selection

We interviewed 28 participants, either individually (18) or in groups of two (five interviews). We identified participants through snowball sampling. The first participants were recruited through government offices whose official aims were related to greenspaces and/or urban planning. Further participants were identified in the stakeholder mapping exercise. Stakeholders from all groups mentioned regularly or given high importance were contacted, resulting in interviews with workers from various government departments or institutions (hereafter designated GW, n=12, Table D.1), chiefs (CH, n=5), members of non-governmental organizations (NGOs, n=4) and land developers (LD, n=3).

3.4.4 Data collection

Interviews took place in participants' offices or in public spaces familiar to them in October and November 2017. They were carried out in English (n=19) or in Twi (n=4) according to the participants' preference. Participants were asked to identify as many stakeholders, or groups of people, they thought had an impact on urban greenspace conservation and/or management and to describe what this impact was. They were then asked to draw relationships between stakeholders, illustrating the type of relationship (here divided into information sharing, formal authority over, informal influence over, funding, and conflicts) with different coloured lines. Finally, participants were asked to pile up as many tokens as they liked to represent the how strongly each stakeholder impact on greenspaces (Figure D.1). All interviews were recorded and later transcribed for analysis.

3.4.5 Data analysis

We grouped stakeholders according to their roles as given by the participants (Table 3.1). We qualitatively extracted from interview transcripts the role of each

stakeholder both in society and in impacting greenspace conservation. We quantified the strength and recognition of their impact by normalizing the height of the pile of tokens representing the relative impact on greenspaces from zero to one and by recording the number of interviews in which they were mentioned. Relationships between the stakeholders were analysed by a centrality analysis with Visone 2.17 (Brandes and Wagner, 2004), in which we calculated, for all the stakeholders and all types of relationships in each network, the degree centrality (number of direct ties a stakeholder possesses) and the betweenness centrality (number of times a stakeholder rests between two otherwise disconnected stakeholders). For all relationship types except conflicts, which were described in a unidirectional way, indegree (incoming ties) and outdegree (outgoing ties) centrality was computed separately. For each stakeholder, means across the interviews were calculated.

3.5 Results

3.5.1 Stakeholders and their impact on greenspaces

Sixty stakeholders were identified as having an impact on greenspace conservation. Impacts were positive, negative and could be direct or indirect. Stakeholders were placed into 10 groups (hereafter stakeholders; Table 3.1). Some stakeholders were mentioned in all 23 interviews, while others got as few as three mentions (Figure 3.2a, Table D.2). The five most frequently acknowledged stakeholders were Local and Central Government, Residents, Chiefs and Industries (including land developers; Figure 3.2.a). Industries were less frequently mentioned by Government Workers; and Land Developers did not mention Chiefs or members of NGOs as often as other groups (Figure 3.2.b). The strength of the impact of each stakeholder on greenspace conservation also varied. Local Government, Central Government and Chiefs had the strongest impact (Figure 2.3.b).

Table 3.1. Stakeholders identified by the participants as having an influence on urban greenspaces, grouped according to societal organizations, and the number of times they were mentioned out of the 23 interviews (where n>1).

Stakeholders	Number of mentions
Local government (Assembly)	23
Assembly as a whole	20
Assembly members	3
Parks and Gardens Department	14
Physical Planning Department	16
Roads Department	5
Works Department	7
Chiefs	19
Central government and state agencies	22
Central Government as a whole	5
Electricity companies	5
Environmental Protection Agency	13
Forestry Commission	14
Land Commission	12
Ministry of Food and Agriculture	3
National Disaster Management Organization	2
Ghana Highway Authority	2
Ghana National Fire and Rescue Service (GNFRS)	2
Politicians	2
Water-related governmental institutions	6
Residents	21
Urban crop farmers	6
Livestock farmers	4
Landowners	8
Students and young people	6
Drivers	2
Residents	16
Industries	19
Land developers	12

Timber industry	7
Hospitals	3
Hotels and restaurants	2
Mining companies	3
Food processing factories	2
Media	9
Religious bodies	5
NGOs	15
Environmental NGOs	5
Community-based organizations	3
Farmer associations	2
Non-governmental organizations	8
Educational institutions	13
Research institutions	5
Schools	10
Regional government	3
Regional Coordinating Council	3

3.5.1.1 Local government

Local Government was mentioned by all participants and was the stakeholder that was considered to have the most impact on greenspace conservation (Figure 3.2). This impact was frequently described as negative. The Physical Planning Department was seen to impact greenspace conservation through the drafting of plans to *"ensure sustainable city development"* (GW08). They were said to create some greenspaces, but also not to *"give [greenspace conservation] the first priority"* (CH01). The Works Department was understood to be responsible for enforcing planning, but was perceived to "*just sit in their office, […] sign and the person starts building"* (GW03). Additionally, any planning decision was said to require the approval of Assembly Members, who did "*not appreciate the fact that these greenspaces must be developed in the built environment."* (GW02).

The Parks and Gardens Department was identified as aiming to implement and maintain greenspaces throughout the city, and were seen to "*nurse these flowers and other species of plants that make the city beautiful naturally"* (GW08). Recent restructuring of the Assemblies was mentioned, including the

merger of the Parks and Gardens Department with Physical Planning, and subsequent uncertainty as to its future roles and responsibilities.

3.5.1.2 Chiefs

The impact of the Chiefs on greenspace conservation was acknowledged and described as important (Figure 3.2). This was mainly due to their position as "*custodians of the land"* (NGO04; GW02; GW04), which was seen to give them the final say on any planning activity. Chief's vetoes were described as leading to situations of "*development […] at all cost"* (NGO02) at the expense of greenspace conservation. However, some chiefs were heavily involved in greening activities, spearheading environmental NGOs. Most participants mentioned that all chiefs, as spiritual leaders, had a strong desire to conserve sacred sites such as traditional cemeteries.

3.5.1.3 Central government

Three Central Government institutions were specifically acknowledged to impact greenspace conservation: the Land Commission, the Forestry Commission and the Environmental Protection Agency (EPA). The Land Commission was frequently described as critical as they allocate and value land. However, the Commission are sometimes seen to *"add monetary value [to the greenspace] and then protect it"* (GW05) and sometimes to *"collude and […] lease portions of such lands to developers"* (NGO04). The Forestry Commission was said to aim to "*to leave [forests] for future communities […] that are better managed and better valued than we have inherited"* (GW06), by granting permission to fell trees, source seedlings, and initiate education programs. Their role was seen as generally beneficial for greenspace conservation, but they were criticised for *"watch[ing] people do some indiscriminate felling"* (NGO04). The EPA described their mandate as ensuring that any non-residential project developed in the country is *"environmentally sensitive"* (GW02), a task carried out through impact assessments, allocation of building permits, environmental monitoring and education. They were seen to *"make sure that, if you are putting up a building, [you] have to replant to recover the vegetative cover"* (GW08). The Central Government was described as critical for creating the legal basis for greenspace conservation. Although this was viewed as a positive role, the

actual implementation of legislation relies on political will, which was perceived to largely be absent.

3.5.1.4 Residents

Residents were thought to perceive greenspaces negatively, due to safety concerns linked to poisonous animals and disease vectors, and because greenspace was often thought of as being unused land. Residents were also reported to extract resources such as firewood or build without respecting zoning. Conversely, there was a consensus among participants that many residents included greenspaces on their property and that negative perceptions of greenspaces were changing due to improvements in education. Survey participants acknowledged that residents' engagement was needed to successfully conserve greenspaces as *"environmental protection is […] a shared responsibility"* (GW05), and that some residents are critical in championing greenspaces.

Urban farmers were highlighted as a specific subset of urban residents impacting greenspaces differently. Farmers were thought to change vegetation structure towards economically valuable species, occasionally enhancing the levels of greenspace provision, or conversely farmers could damage protected greenspaces. Cattle farming in particular was seen negatively, as *"[cattle] eat the grass and the leaves and the crops"* (CH02), with an associated negative influence on the behaviour of other residents who *"do not feel very encouraged to have such backyard gardens"* (NGO04).

3.5.1.5 Industries

The negative impact of industries, of which land developers were the main subcategory, on greenspace conservation was considered to be important (Figure 3.2). Land developers included building companies and private individuals who *"develop [their] house by [them]selves"* (LD01). *E*ncroachment and bribes for rezoning by developers were seen as a common occurrence, and re-greening as not culturally ingrained. Other industries such as timber extraction and utilities were reported to destroy urban greenspaces to install infrastructure, often without prior consultation.

3.5.1.6 Media

The role of the Media was described as important (Figure 3.2.c) because of its ability to transmit information to a wide audience. NGOs reported that media provided free airtime for promoting their work. The Media was described as *"the voice of the voiceless"* (GW02), a way for urban residents with little other opportunities of communicating with government workers.

3.5.1.7 Religious bodies

Religious bodies were less frequently mentioned as important stakeholders in regards to greenspaces (Figure 3.2.a). Their roles were perceived as developers of public lands, on which they often implemented parks and tree planting activities, and as having a strong advocacy power by *"preach[ing] about conservation of nature"* (LD03), sometimes strong enough to *"indirectly […] even influence the chiefs"* (CH02).

3.5.1.8 NGOs

NGOs were seen to work on aspects that were *"dear to their hearts"* (GW11), such as active tree planting around rivers, seedling production, or education programs. Their work was seen to have a positive impact on urban greenspaces. However, the impact of NGOs on greenspaces was not acknowledged by land developers (Figure 3.2.b). Although NGOs were mentioned by government workers, specific organizations were often not known and activities were dismissed as *"just some volunteerism"* (GW08).

3.5.1.9 Educational institutions

Schools were seen to have some impact on greenspaces as teachers were a trusted source of knowledge and because schools provided public spaces where active greenspace conservation could be combined with educational activities. Similarly, Universities were seen to influence policies and mind-sets through their research.

3.5.1.10 Regional government

The regional government was not mentioned frequently (Figure 3.2. a), but when mentioned, it was perceived to have a strong impact on greenspaces

(Figure 3.2.c), because it serves as coordinator of local planning. Its attitude towards greenspaces was unclear to participants.

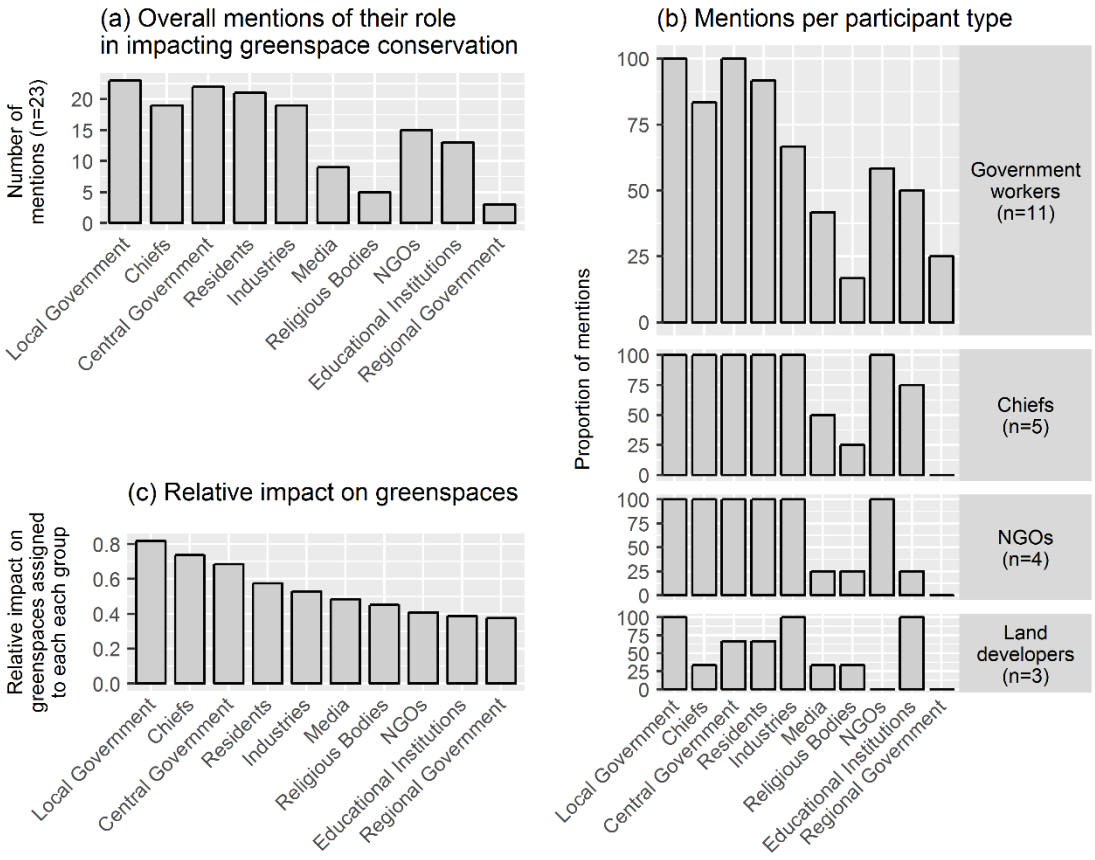


Figure 3.2. Importance given to the identified stakeholders: (a) number of mentions of their role in impacting greenspace conservation out of 23 interviews; (b) mentions by type of participant; and (c) the relative importance of their perceived impact on greenspace conservation.

3.5.2 Interactions between different stakeholder groups

3.5.2.1 Formal authority

Participants highlighted that the formal authority of the Central Government was mainly exerted in regional capitals or in specific sectors such as in forests and schools, leaving other stakeholders such as the Chiefs or Industries free reign elsewhere. In contrast, the formal authority of Local Government was exerted on their municipalities only, therefore lacking in overall planning as urban areas often span several municipalities. Representatives of Local Governments reported that, despite the fact that their formal authority has been granted by

legislation, they struggled to enforce planning. Most participants also recognised the formal authority of the Chiefs (Figure 3.4. a) and their leadership role in land development.

3.5.2.2 Informal influence

Chiefs had a high relative outdegree of informal influence (Figure 3.4. b). They self-described as having a higher authority than that of the Governments because of historical precedence, a view acknowledged by government workers. Their role in informal influence was mainly directed towards the Local Government (Figure 3.3.b), but also in supporting NGOs. For example, most environmental NGOs in Techiman were led by Chiefs. Chiefs had a high betweenness (Figure 3.4.b), playing a key role in linking Residents or Industries with Local Governments (Figure 3.3.b).

Residents also had a high outdegree of informal influence (Figure 3.4.b), which they exerted on a wide range of stakeholders (Figure 3.3.b) through behaviours such as complaints, voting decisions or violence. Both Chiefs and government workers mentioned the need to keep community members satisfied, as they fear that *"[residents] will not even vote for you because you are destroying [their] place of abode"* (GW08).

3.5.2.3 Funding

Many participants perceived funding to be crucial as *"economic power would outweigh"* (NGO04) any other influences. Industries, including land developers and utility companies, were the main source of funds, followed by Central and Local Governments (Figure 3.4.c). Central government was described as the main provider of funds for government-led spatial planning. Local Government were perceived to be easily influenced by Central Government, Industries or Chiefs.

Two stakeholders understood to receive funds, from multiple sources including Industries, Governments and Residents, were Chiefs and NGOs (Figure 3.3.c and 3.4.c). How dependent Chiefs are on external funding was likely to affect their approach to greenspace conservation, as they are seen to *"not agree to [greenspace conservation] because they want their money faster"* (NGO03). NGOs' dependence on donors influences their activities, with potential negative

impacts on greenspace conservation when NGOs find themselves promoting an industry-led project, even though it is at "*the wrong side of any environmental government advice" (NGO04)*.

3.5.2.4 Information transfer

NGOs, Central and Local Government were perceived as important sources of information, whereas the Chiefs, Industries, Residents and Regional Government were largely receiving information (Figure 3.4.d). Specialist knowledge was not always well received as it was perceived to come from outsiders: "*some of the public servants are not residents of the area, when they give advice [the residents] don't pick it."* (NGO03).

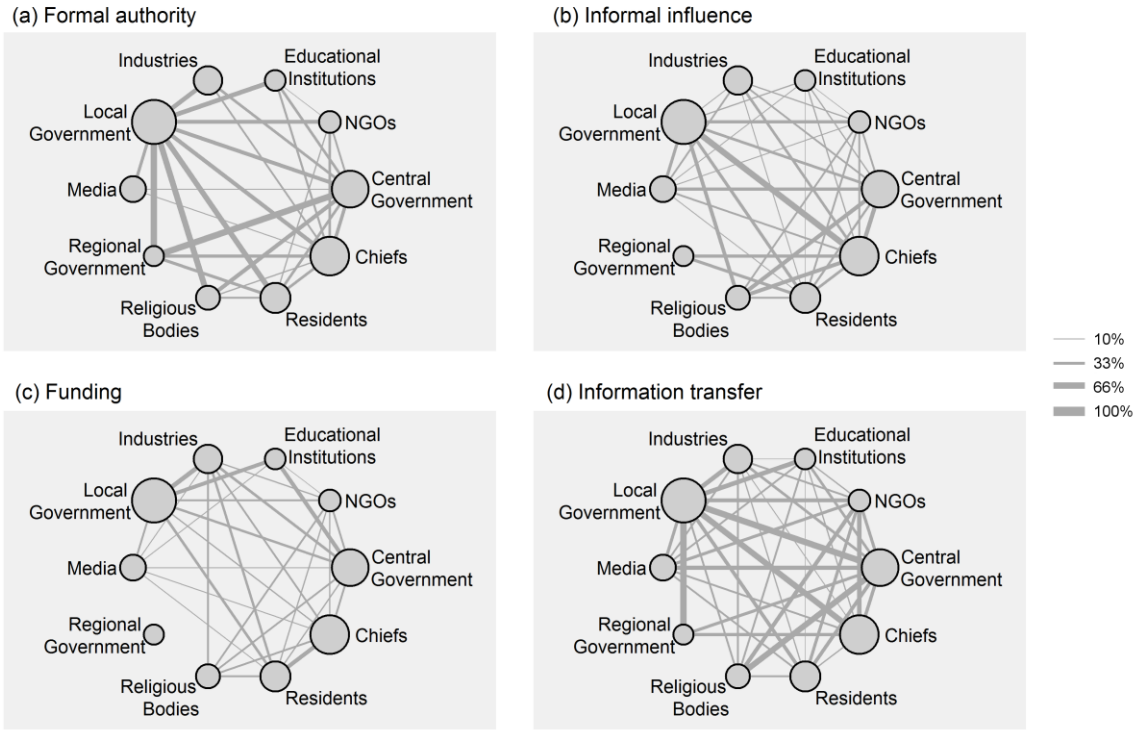


Figure 3.3. Different types of interactions between the stakeholders: (a) formal authority, (b) informal influence, (c) funding, (d) information. Lines represent the presence of an interaction, with line width weighted by the proportion of respondents mentioning this link. Circle sizes represent the perceived impact on greenspaces, quantified in Figure 3.2.c.

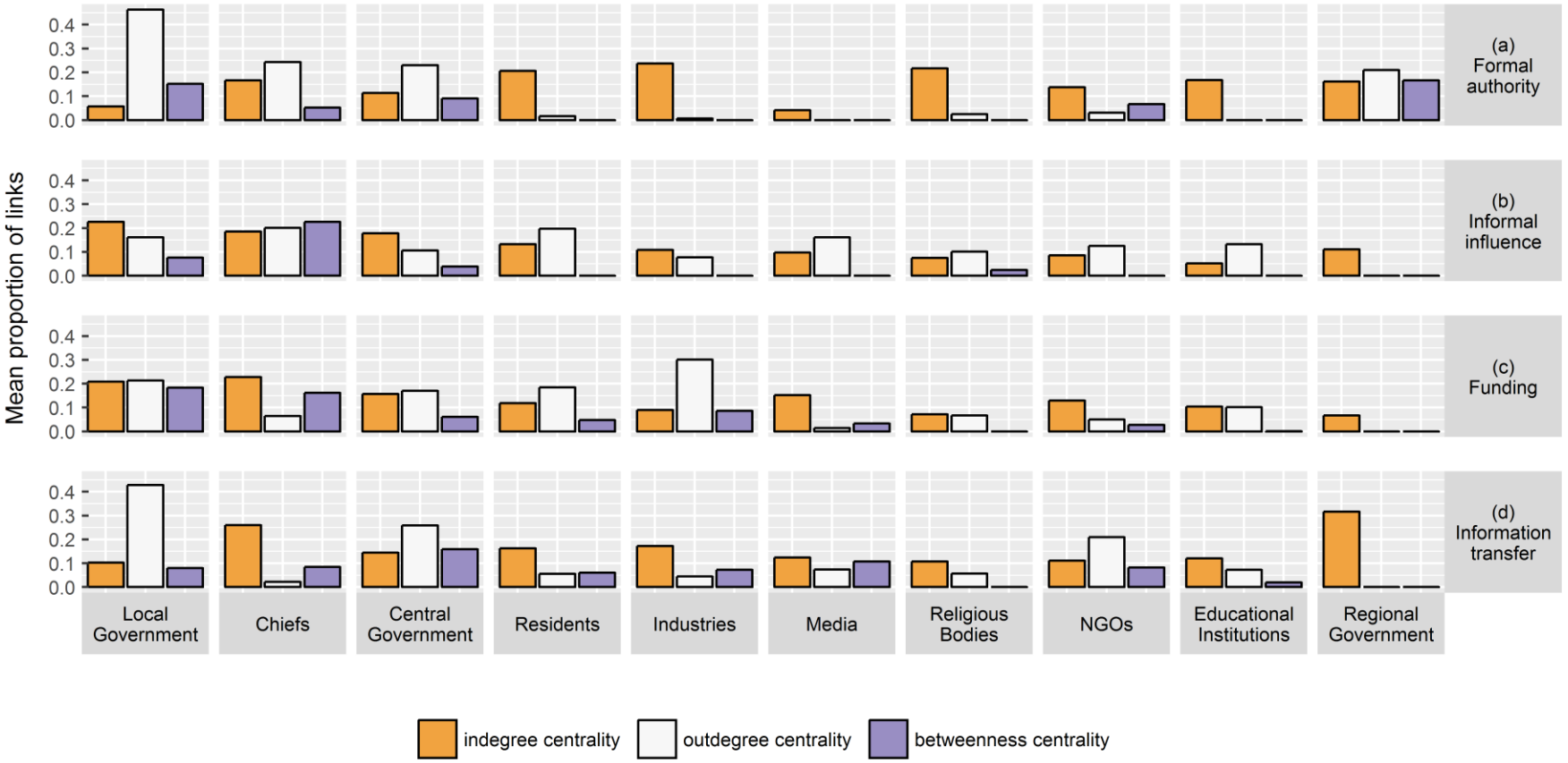


Figure 3.4. Relative importance of each stakeholder as receivers (indegree centrality, or number of incoming ties), providers (outdegree centrality, or number of outgoing ties) and intermediaries (betweenness centrality, or number of times the stakeholder rests between disconnected stakeholders) of (a) formal authority, (b) informal influence, (c) funds and (d) information transfer.

3.5.3 Conflicts and challenges affecting greenspace conservation

Conflicts mostly took place between Local Government, Central Government and Chiefs. Stakeholders with little impact on greenspaces tended to have fewer disagreements with other groups (Figure 3.5; Table D.3). Conflicts and challenges revolved around five main interconnected issues.

3.5.3.1 Development pressures

Most participants stated that urbanisation is putting pressure on greenspaces, creating conflicts between those wanting to retain greenspaces (e.g. NGOs/Local Government) and Industries, such as utility providers (Figure 3.5). Such conflicts were exacerbated by the fact that, in Ghana, greenspaces are perceived as vacant land. Development pressures were thus perceived as the critical challenge facing greenspace conservation: *"You know the number one enemy to the environment is development and I keep saying that there is no development that will not impact on the environment"* (GW05).

3.5.3.2 Conflicting governing institutions

Competing land uses could be more easily resolved if there was a clear understanding of who was responsible for land allocation and planning. Another issue affecting greenspace conservation that participants identified was a lack of enforcement. Different responsibilities and lack of coordination between Local and Central Government institutions resulted in situations where Local Government allocated land to greenspaces while Central Government institutions authorised its sale to Industries. Similar conflicts were also described between Local Government and Chiefs (Figure 3.5.a). Despite the legal basis of the government authority, perceptions varied on which of Local Government or Chiefs had the most power, particularly when land ownership was contested.

3.5.3.3 Funding

Local Government participants stated that revenues were mainly received from Central Government, and often, *"there is nothing on [financing the implementation of] the greens on all projects" (LD03)*. Systemic lack of funds was generally described as a barrier to the implementation of urban plans as

insufficient resources prevent relevant departments from undertaking site visits. This is acknowledged by the Park and Gardens Department who stated *"financial constraint has made the department dormant" (GW04)*. Government agencies were perceived to be susceptible to receiving bribes to rezone areas designated as greenspaces, or to issue permits for natural resource extraction, such as timber production. Chiefs also granted permission to build in exchange for part of the plots.

3.5.3.4 Accountability

Participants mentioned occasions when the ambiguity around governance and accountability led to situations in which no highly influential stakeholder felt accountable for greenspace conservation. Local Government 'technocrats' would be blamed by Chiefs and NGOs for the loss of greenspaces. Conversely, Local Government 'technocrats' blamed greenspace loss on Chiefs. The only stakeholders clearly defending greenspaces, the members of environmental NGOs and the Parks and Gardens Departments, had limited influence and funds as well as being constrained by governance structures.

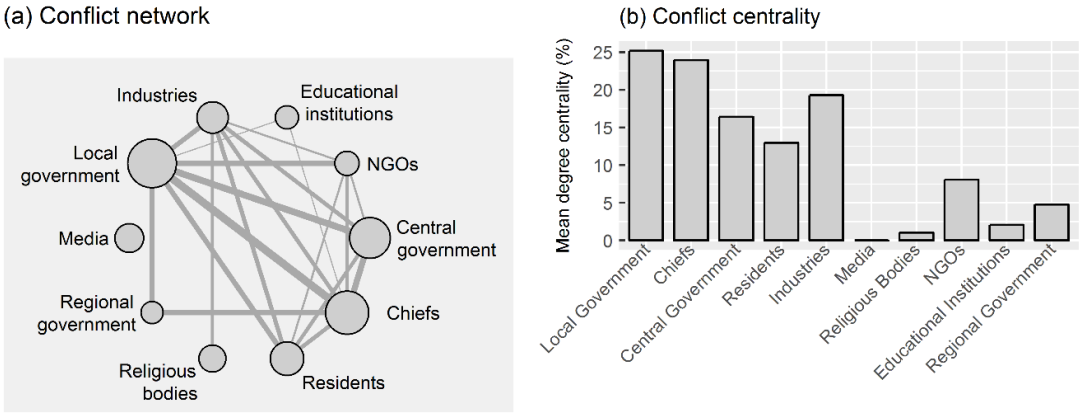


Figure 3.5. Conflicts identified between different stakeholders: (a) graphical representation of the number of conflicts recognised (thicker lines, more conflicts) and (b) degree centrality of the conflict network for each stakeholder, which indicates the number of conflicts the stakeholder has been identified as being involved in, as a percentage of the total identified conflicts.

3.6 Discussion

In the context of rapid urbanisation and biodiversity loss in Sub-Saharan Africa, our findings show that a relatively small number of stakeholders, including government, land developers, chiefs, residents and the media, have an impact on whether urban greenspaces are conserved and how they are managed. However, those with the most impact on greenspaces and influence on others tended to carry out actions and hold views that threaten greenspace retention and conservation.

Governments are often described as amongst the key stakeholders impacting urban greenspaces and ecosystem services (Wilkinson et al., 2013). Several participants mentioned that legislation to protect greenspaces was in place, however loss of urban vegetation is common across the region (Yao et al., 2019). We highlighted conflicts between different government offices. A lack of collaboration has been exacerbated by recent decentralization processes, something that was implemented to foster participation and empower Local Government. However, decentralization also led to a mismatch between urban planning, managed at the local level, and environmental and land tenure issues, managed centrally, creating situations in which centralised policies encouraging greenspaces (e.g. Government of Ghana, 2015) are drafted without input from local governments, which then struggle to implement them. Difficulties in enforcement also arise from lack of funding for local governments (Yeboah and Obeng-Odoom, 2010), which was perceived by participants to hinder both basic greenspace maintenance and proper acquisition of land titles.

As a counterbalance to a lack of financial resources in local government, central government recommends the involvement of private and civil society sectors (Government of Ghana, 2015). Industries, including developers, were identified as the main source of income in our study. However, industries did not support the provision of greenspaces. Incentives from the government such as incorporation of the insurance value of ecosystem services (Dallimer et al., 2020) in regulations or development of compensation policies for conserving greenspaces would be needed to ensure conservation measures are taken by industries (Razzaque and Visseren-Hamakers, 2019).

Lack of community participation can be partly attributed to the confusion surrounding decentralization (Fridy and Myers, 2019). Although community-based conservation is often depicted as the ideal situation (Berkes, 2007), urban residents were here perceived to have a negative impact on greenspaces. Their involvement would require changes in perceptions among the wider population regarding the benefits of conserving urban greenspaces. In light of the government's failure to protect greenspaces, a governance arrangement acknowledging alternative stakeholders for promoting urban greenspaces and shifting the role of government to facilitators of social initiatives through social and economic incentives is needed (Bodin and Crona, 2009; Armitage et al., 2012).

NGOs were acknowledged to play a central role in contributing to the conservation of urban greenspaces. However, their level of influence was modest. Similarly, we found that NGOs were a trusted source of expertise but that their work was dismissed as being voluntary (Hauck et al., 2015). Consequently, engaging NGOs to articulate the value of greenspaces might not be the most far-reaching practice to increase the uptake of greenspace conservation.

The Media in Ghana can influence priority-setting by the government through their role in communicating public grievances to mass audiences (Lenhardt and Rocha Menocal, 2015). Here, the Media's role was described as being mainly supportive of greenspace conservation, through their support of NGOs. However the media was also described as being an expression of residents' concerns. Given that residents can be uncooperative towards conservation (Mensah, 2014) and perceive few benefits from greenspaces (Guenat, Dougill, et al., 2019), medias are likely to reflect this view and reinforce the negative perception of greenspaces within the urban population. Potential ways to harness the media for widespread greenspace promotion could arise from more messaging by NGOs and Local Government on the benefits of urban greenspaces for humans (Dearborn and Kark, 2010). For instance, given that greenspaces can contribute to climate change mitigation (Demuzere et al., 2014) and that the need for temperature control in urban Africa is appreciated

by residents (Guenat, Dougill, et al., 2019; Dumenu, 2013), focusing media coverage of greenspace conservation on its importance for climate change mitigation could prove crucial for wider uptake.

Faiths and religions are important drivers of moral values which can be critical for nature conservation (Dudley et al., 2009). One example are African sacred groves which can be positive resources for conservation (O'Neal Campbell, 2004). Faith-based protection is often difficult to manage. Formal recognition as a protected area might erode spiritual value (Dudley et al., 2009), while the ongoing lessening of traditional faiths can reduce the value given to nature (Bhagwat et al., 2011). Despite these risks, formal conservation projects with potential socio-economic benefits are often adopted more readily by followers of monotheist religions (Murray and Agyare, 2018) and church grounds can provide multiple cultural ecosystem services (De Lacy and Shackleton, 2017). In countries like Ghana where most of the population now self-identify as Christian or Muslim (Ghana Statistical Services, 2013), preaching on the linkages between conservation and religious texts can enhance awareness and potential involvement in conservation practices (McKay et al., 2013).

Urbanisation processes are expected to differ regionally (McHale et al., 2013) and chiefs play critical leadership roles in many African countries (Logan, 2017). Due to the research bias on urban greenspace governance towards the Global North, where such traditional structures are non-existent, social network research has not recognised their importance (Wilkinson et al., 2013). Our work illustrates that in an urban context, chiefs are highly influential in determining if and how conservation proceeds. However, as chiefs are perceived to be part of Ghanaian cultural identity (Ubink, 2007), decisions they make are above blame and therefore go unchallenged. This lack of accountability, together with the limited support Chiefs have for greenspace conservation, ultimately means that Chiefs are a negative influence on greenspace conservation (Armitage et al., 2012). However, our analyses identified chiefs as bridging organizations with a unique role in binding together networks around urban greenspace management and use. Harnessing their role through a change to their approaches to greenspaces could therefore deliver substantial conservation gains. Such change could be brought about by using the "expert" position of NGOs to educate them about the wider benefits of urban greenspaces for their

communities, by incorporating non-material values of greenspaces in its appraisal (Razzaque and Visseren-Hamakers, 2019) or by encouraging development of lucrative uses of greenspaces.

Retention and implementation of urban greenspaces in fast-growing cities is critical for improving their liveability, resilience, and mitigating their impact on biodiversity. In African cities, social network analysis identified chiefs as critical stakeholders whose endorsement is needed for the implementation of city-wide conservation practices yet who are thus far largely not engaged with, or interested in this process. Our analyses also showed that the main barriers to implementing greenspace conservation initiatives were a lack of funding, and that the main sources of funding were industries, which have little interest in greenspace conservation. This suggests that until the full value of urban greenspaces for society is recognised in land development policies and projects, greenspaces will continue to be lost.

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Chapter 4:
Untangling the motivations of different stakeholders for urban greenspace conservation in Sub-Saharan Africa

Solène Guenat[a]*, Andrew J. Dougill[a], William E. Kunin[b], Martin Dallimer[a]

[a] Sustainability Research Institute, School of Earth and Environment, University of Leeds, Leeds, LS2 9JT, UK

[b] School of Biology, University of Leeds, Leeds, LS2 9JT, UK

*Correspondence author. Email: eesgu@leeds.ac.uk

4.1 Abstract

Urban expansion is threatening ecosystem service delivery, especially in sub-Saharan Africa where urbanisation rates are among the fastest globally. Greenspaces offer opportunities to prioritise ecosystem services for city residents. However, the success of greenspace conservation is more often driven by their acceptability to a range of stakeholders than by scientific evidence, highlighting the need to acknowledge multiple perspectives when implementing greenspace conservation activities.

We used the Q-methodology to describe and compare the viewpoints of three stakeholder categories for the services and disservices provided by greenspaces in two fast-growing Ghanaian cities. Ecosystem services were generally valued, however there was strong heterogeneity in viewpoints among respondents. The main concerns included regulating services, heritage aspects and contributions to economic development. Comparisons between viewpoints revealed both substantial differences between stakeholder categories and consensus around specific ecosystem services.

Recognising shared viewpoints and areas of disagreement may increase the acceptability of greenspace implementation measures. Furthermore, addressing the disservices brought about via greenspace degradation is crucial. Our study shows that, in fast-growing cities in Ghana, a forerunner of urban development in Sub-Saharan Africa, specific ecosystem services such as shade provision, play a pivotal role in promoting greenspace conservation.

4.2 Highlights

- Greenspaces in two African cities were generally valued across stakeholder categories
- There were many disagreements on the relative values of ecosystem services
- User viewpoints were very diverse and some dismissed the benefits of greenspaces
- Addressing disservices arising from pollution is crucial
- Emphasizing services valued by all, such as shade, could be useful for conservation

4.3 Keywords

ecosystem services; perceptions; Q-methodology; Ghana; green infrastructure; disservices

4.4 Introduction

Urbanisation has reached unprecedented levels, with more than half of the world population living in towns and cities, compared to 30% in 1950 (DESA, 2015). This rapid increase in the urban population is coupled with urban sprawl, whereby the geographical extent of land thatis built on is expanding twice as fast as the number of urban dwellers (Angel et al., 2011). Such fast land cover change has substantial negative impacts on ecosystems, including encroachment on protected areas and biodiversity hotspots (Seto et al., 2012) as well as an appropriation of resources from a much larger region than the physical area a city occupies (Folke et al., 1997).

Although urban areas can substantially alter natural ecosystems, urban greenspaces (herein defined as all vegetated areas within the urban environment; Taylor and Hochuli, 2017) play a considerable role in delivering ecosystem services, including air purification, flood protection and food provision, alongside recreational, health and social benefits (e.g. Elmqvist et al., 2013). Losing such urban ecosystem services would affect the cities' resilience as well as urbanites' health and well-being (McPhearson et al., 2015; Tzoulas et al., 2007). Retaining or retrofitting greenspaces within urban areas is crucial to the delivery of ecosystem services and, therefore, to the long-term sustainability of cities (United Nations, 2015).

In Sub-Saharan Africa, urban areas are some of the fastest-growing worldwide (DESA, 2015), with destructive effects reported on the surrounding landscape (Seto et al., 2012). Urbanisation in this region is mainly taking place in smaller towns (DESA, 2015; Elmqvist et al., 2013) and is not always associated with economic growth (Turok and McGranahan, 2013). Informal settlements with limited infrastructure and service delivery are widespread and their inhabitants experience high levels of poverty (Elmqvist et al., 2013; UN-Habitat, 2016).

Those arguments that do exist for the implementation and management of urban greenspaces for ecosystem service provision are largely based on work carried out in the Global North, with a lack of locally relevant, context specific evidence and research for Africa (Botzat et al., 2016; Luederitz et al., 2015). Even within the continent, research has thus far centred on South Africa (Cilliers et al., 2013; du Toit et al., 2018). Further, the research carried out in African

cities mostly estimated monetary values of ecosystem services, something which is not always compatible with different local value systems (Wangai et al., 2016). The few studies on how ecosystems are perceived and understood suggest limited awareness or knowledge of the benefits of conserving urban greenspaces across stakeholders (Gwedla and Shackleton, 2015; Kaoma and Shackleton, 2015).

Stakeholder categories with an interest in, or influence over, the way in which urban greenspaces are managed or are converted to other uses are diverse. Experts such as urban planners or NGOs play a key role in the Global North, as they are frequently the ones leading greenspace conservation or ecosystem management programs (Riechers et al., 2017). However, studies in Sub-Saharan Africa indicate that experts could also have a strong negative impact by being largely unaware of the role of urban greenspaces in sustainable development and so prioritising economic growth (Gwedla and Shackleton, 2015; Schäffler and Swilling, 2013), with potential long term negative consequences for the liveability of cities for their residents (UN-Habitat, 2016). Local residents are frequently the main beneficiaries of greenspaces (Johnson et al., 2004), which they use to improve their living conditions, for instance through urban agriculture or recreational use of public parks (e.g. Adekunle et al., 2013; Shackleton et al., 2015). How residents influence what happens to greenspaces is, however, unclear. Individually they have little influence on city greening plans even though participation of local communities is known to be crucial for the success of conservation initiatives (Andrade and Rhodes, 2012) and urban residents could have a strong impact by joining forces into groups (Reed et al., 2009). However, in general, little consideration is given by policy-makers to the opinions and perceptions of city residents, leading to a disengagement regarding decisions about how greenspaces are used, managed and converted into other land uses (Mensah, 2014). Consequently, another key stakeholder category consists of the people in positions of authority within the community, but without direct interest in urban planning and/or greenspaces, such as political parties, the media or churches. Indeed, they could pose both a substantial risk and an opportunity for greenspace conservation, as their opinions will likely be widely spread amongst urban residents (Reed et al., 2009). As such, should they choose to take a stand on

greenspaces, they would have the opportunity to rally the population to achieve positive change, or instil the notion that greenspaces should be removed. Additionally, they could be key to creating a link between residents and experts. However, to our knowledge, there is no research available on their perceptions of urban greenspaces. Consequently, understanding the differences and similarities in perceptions of different stakeholders of urban greenspaces and ecosystem services in Sub-Saharan Africa could help implement successful greenspace conservation programs with long-term benefits for urban residents.

Here, we investigate the viewpoints of three categories of stakeholders on the services and disservices provided by urban greenspaces in two small-sized cities in Sub-Saharan Africa. We also examine how those viewpoints compare and contrast with each other, hypothesising that stakeholders involved in the planning of urban greenspaces will have viewpoints that differ from both urban residents using such greenspaces, and people with the power to influence community perceptions. Finally, we explore how such agreements and divergences in viewpoints could offer opportunities for successful conservation of urban greenspaces and ecosystem services.

4.5 Methods

4.5.1 Study location

Ghana is at the higher end of urban growth rates in Africa (DESA, 2015) and has been praised as an example of economic development due to its efficient health and education systems, and democratic system of government (Lenhardt and Rocha Menocal, 2015). Understanding how urban greenspaces are viewed and managed in small Ghanaian cities could thus serve as a useful forerunner of what could arise as a result of the further urbanisation of neighbouring countries and provide an opportunity for sharing best practice in a rapidly urbanising Africa.

We carried out our study in Sunyani and Techiman, Ghana (Figure 4.1). The cities are both located in the Brong Ahafo region and span four districts. In 2010, Sunyani and Techiman had a total population of 162,765 and 123,971 respectively (Ghana Statistical Services, 2013). As such, they are considered small cities by global standards, similar to the cities hosting 48% of the African

urban population (DESA, 2015). Both cities are located at the fringe of the moist semi-deciduous Guinean Forests of West Africa, a biodiversity hotspot threatened by urban expansion (Ghana Statistical Services, 2013; Seto et al., 2012). Their rapid development is being encouraged as part of the Sunyani Urban Network, which is intended to ease the expansion pressures on the two largest Ghanaian cities, Accra and Kumasi (Government of Ghana, 2015). As a result, Techiman is one of the 10 fastest-growing cities of Ghana (Government of Ghana, 2015). Sunyani, the regional capital, is described as a one of the best-planned and cleanest cities of the country, although rapid and uncontrolled expansion means it is on the verge of losing this status (Adu-Gyamerah, 2016; Yaro, 2015).

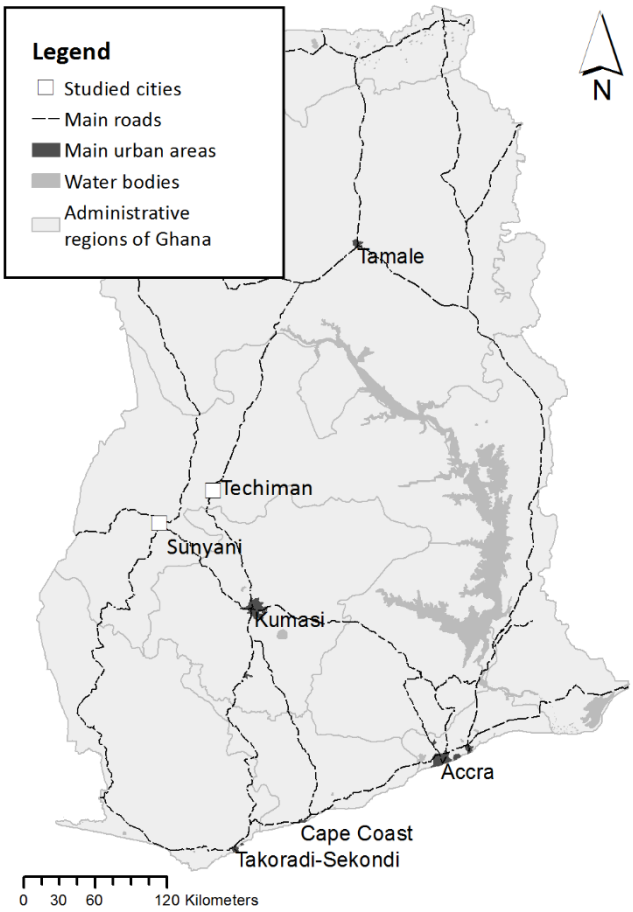


Figure 4.1. The two study cities of Sunyani and Techiman within Ghana.

4.5.2 Methods

We used Q-methodology to investigate the different viewpoints on ecosystem services and disservices held by three stakeholder categories (Experts,

Authorities and Users; see “2.2.2 Selection of the participants”). Q-methodology is a bottom-up approach used to discern people's perceptions of their world and provide an insight into different subjective views on a research topic (McKeown and Thomas, 2013). It uses a quantitative approach to collect and statistically analyse qualitative data, thus combining the strength of both approaches (ten Klooster et al., 2008). In general, data collection involves the sorting, by the participants, of a set of 40-60 statements into a forced normal distribution, such as from the most to the least agreed statement (McKeown and Thomas, 2013; Watts and Stenner, 2005). To better understand sorting patters, Q-methodology can be complemented by information on the socio-demographic background of participants, and in-depth interviews, which allow researchers to capture motivations for how statements were sorted, particularly those statements placed at the extremes of the forced normal distribution (Milcu et al., 2013). Q-methodology has the advantage of providing numerical results to support the interpretation of viewpoints (Zabala et al., 2018). While the *a priori* aim of Q-methodology is not to compare the views across different categories of participants, this can be done by using similar Q-sets across participant categories and analysing their sorts separately (Watts and Stenner, 2012).

4.5.3 Statement creation

In this study, we used 45 statements covering all sections and divisions of ecosystem services from the CICES classification relevant to non-coastal locations (Haines-Young and Potschin, 2013). We included 12, 18 and 15 statements for provisioning, regulating and cultural services respectively. Of these, 35 were framed as services and ten statements were framed as disservices (Table 4.1). Statements were developed based on interviews with experts and local greenspace users (n=16), online searches of Ghanaian newspaper content (e.g. Graphic Online, The Chronicle; n=31), Ghanaian policy document analysis regarding urban development and/or biodiversity (e.g. National Biodiversity Strategy, National Urban Policy Framework; n=5), international agendas and ecosystem assessments and scientific literature (n=4; *n* amount to more than 45 as some statements were based on several sources; Table F.1 and Table F.2). Statements were generated in English and, following best practice, double-translated to Twi (i.e. translated to Twi, then back to English by someone else, with consistency of meaning between the two

English versions verified by the researcher, Brislin, 1970). Pilot-testing of statements with four stakeholders from the different categories and in both languages confirmed a clear understanding of the statements by participants. Participants could choose to conduct the interview in English or Twi, and statements were read aloud for illiterate or visually impaired participants

Table 4.1. The 45 statements presented to participants as part of the Q-sorting exercise. Statements are organised according to the CICES sections and divisions (Haines-Young and Potschin, 2013). The positive or negative framing of the statement, i.e. whether they describe an ecosystem service (+) or disservice (-), is indicated by + and - signs. Original wording and sources are available in Table F.2.

Section	Division	Framing	Statements
Provisioning	Energy	+	Urban trees are an important source of wood and charcoal fuel.
	Materials	+	Converting urban parks and reserves to ecotourism facilities is essential to make them profitable.
		+	Livestock in cities is important as it provides manure to improve soil fertility.
		+	The job opportunities and incomes that could be earned from the development of urban parks, gardens and green spaces are significant.
		+	The presence of trees and plants that heal is crucial in a city, as traditional medicine is an economical and trusted form of health care.
		-	Backyards and parks should be cleared to provide space for businesses and accommodation for the ever increasing urban population.
		-	Cities are centres of employment, trade and job creation, green spaces are not needed.
	Nutrition	+	Backyard gardens are important to supplement incomes by selling roots and tubers, vegetables and fruits.
		+	Produce from our gardens are available when we are in dire need of them because they are scarce on the market.
		+	Small livestock in urban environments can make a big

			difference to nutrition and health.
		-	Cattle in urban areas can be dangerous if it is not properly enclosed.
		-	Vegetables grown in the city are contaminated through chemicals and dirty water use.
Regulation and maintenance	Maintenance of physical, chemical, biological conditions	+	Brong Ahafo used to be a forest so now we should be planting trees to recreate this natural environment.
		+	Greenspaces are essential for recycling the nutrient into the soil, conserving soil quality for backyard gardens.
		+	Keeping greenspaces in the city allows natural predators of pests to stay and decrease the pests' impacts.
		+	Open green spaces in the city are important to protect our waterways, essential for the provision of clean water.
		+	Parks and open green spaces offer me an opportunity to exercise to stay healthy.
		+	The insects can help produce more fruits through pollination so we can get to eat fresh fruits from our backyard gardens.
		+	Trees within the city are important to provide me with natural shade.
		-	Greenspaces in the city are not good for health because they attract malaria-carrying mosquitoes.
		-	Many plants and animals found in urban green spaces and parks can cause allergies.
		-	Urban greenspaces can harbour animals that are aggressive towards humans.
	Mediation of flows	+	In the city, trees are natural windbreaks which protects me from storms.
		+	We need the trees in our cities to help reduce the impact of climate change.
		+	With grass and trees in the city, when the rain comes, it just flows down and sinks into the ground instead of flooding the city.
		-	Trees in cities risk to fall on me or my house during storms.
	Mediation of wastes,	+	A key component of urban green spaces is to reduce the level of noise.
		+	Greenspaces are useful for dumping refuse.

	toxics and other nuisances	+	The purpose of a green space is to reduce air pollution within the city.
		+	Urban livestock can consume agricultural and household waste products, converting them into human food.
Cultural	Physical and intellectual interactions with biota, ecosystems, and landscapes [environmental settings]	+	Green spaces in school yards help to inculcate in our children good environmental practices and awareness, to become environmentally responsible adults.
		+	Greenspaces provide me with recreational opportunities.
		+	Growing cities should not affect the traditional norms of keeping the environment green and clean, which was taught by parents in the community.
		+	Parks are the heartbeats of all social gatherings.
		+	The gardens and scented flowers along the roads are making the city more attractive and beautiful.
		+	The variety of flowers and grass in the gardens acts as magnets that pulls the youth to snap pictures.
		+	Trees bring me peace and tranquillity.
		+	Urban greenspaces are a key driver of the film and advertising industry.
		-	Buildings make the environment more beautiful than trees and flowers.
		-	Green spaces and parks are often been taken over by lunatics, gangs and robbers, so I feel afraid to go there.
	Spiritual, symbolic and other interactions with biota, ecosystems, and landscapes [environmental settings]	+	Because I live in the city and will not go to the bush to see the plants and animals, I want to see them in the city.
		+	By conserving greenspaces in cities, we are continuing the work of God, who created all species to live with us.
		+	Ghanaian cities must increase their green spaces to give residents a sense of pride.
		+	Urban forests and parks are good places for religious activities, prayers and meditation.
		+	Urban forests should be preserved for the present generation and generations yet unborn.

4.5.4 Selection of the participants

We interviewed 76 people from three different categories: Experts, Authorities and Users. Each represented a category with different levels of interest and influence in greenspace planning and management.

The Experts (n=22) were defined as having both influence on the wider population in regards to greenspaces and/or urban planning and interest in the subject, making them key players to target for any urban conservation initiative (Reed et al., 2009). Experts included people working for various government offices related to land-use planning, greenspace management and environmental services, as well as representatives of the traditional authorities (the main land-owners in Ghana who, in total, own about 80% of the land; Kasanga and Kotey, 2001), estate developers and environmental outreach NGOs. Though experts have a strong influence on greenspaces, they have an intellectual and planning approach to greenspaces, and only some of them directly interact with, or spend time in, greenspaces on a regular basis. We ensured that Experts had this intellectual and planning approach to greenspaces by selecting them through snowball sampling, which specifically targeted Experts working on land-use or greenspaces planning. Initially, participants were identified by visiting government offices whose official aim is to carry out urban planning or greenspace management. Participants within those offices were then asked to identify other stakeholder groups who could be approached. By asking for groups such as organisations and institutions rather than individuals, we limited the impact of the initial participants on the sample. We also diversified the sample by contacting potential participants not directly part of the initial participants' network.

The Authorities (n=27) were stakeholders with high influence on the wider population but little interest in greenspaces and/or urban planning. Their viewpoints are important to take into consideration for urban greenspace conservation initiatives as their influence can be both a threat or an opportunity for its success (Reed et al., 2009). Authorities included representatives of the main political parties, the media, the education system and religious groups. Their relationship with greenspaces was in general even more distant than that of Experts, as they had an influence on the population rather than on

greenspaces directly. Authorities were identified by the same snowball sampling method as that of the Experts.

Users (n=27) were defined as stakeholders with an interest in urban greenspaces, but with little influence as individuals on the city-wide implementation of greenspaces through policies, planning or management. Users included urban farmers (both crop and livestock), owners of gardens and active users of public greenspaces. As opposed to the two other groups, users experience a more direct relationship with greenspaces, interacting with, or spending time in, them daily. This relationship was captured by a different sampling method, targeting urban farmers, owners of private domestic gardens and those actively using greenspaces in public areas. As the Q-methodology requires a variety of opinions rather than a representative sample (Watts and Stenner, 2012), we aimed to capture the diversity of user viewpoints by targeting people from a variety of neighbourhoods, using different types of greenspaces, as well as of different demographics, by for instance including a balance of genders, adult participants from all age groups, with varying levels of education and Ghanaians as well as migrants.

4.5.5 Data collection

Interviews took place in locations familiar to the participants, such as their offices or properties. During each interview, participants were first asked to describe in their own words what they understood by greenspaces. This ensured that they had an understanding of the subject and allowed a verification of the consistency or inconsistency of definitions. Participants were then presented with the 45 statements and asked to do a first classification by dividing them in three piles according to whether they agreed, disagreed, or neither agreed nor disagreed with each statement. They were then asked to further this classification by ordering them from the most agreed to the most disagreed on a grid representing a quasi-normal distribution of nine steps (Figure F.1), resulting in a ‘Q-sort’ of the different statements for each participant. This sorting exercise was followed by a discussion on the reasons underlying decisions made in the sort, as well as some details of their socio-demographic background. Interviews were recorded and transcribed for analysis. Data collection was conducted in the same way for each stakeholder category.

4.5.6 Analyses

The descriptions of greenspaces by the participants were quantified to take the same approach as the Q-methodology, which analyses qualitative data quantitatively. We classified the descriptions into three classes emerging from the interviews, namely a description of greenspaces (1) through the benefits they bring to society, (2) through their physical characteristics and (3) through how land is managed. Based on the different descriptions, each of those classes were then sub-divided into 10, three and three sub-classes respectively. We quantified the number of mentions of each of those classes and sub-classes by each stakeholder category. This allowed us to illustrate the diversity and similarities in the descriptions of greenspaces, while being able to discuss their implications qualitatively.

Statistical analysis of the individual Q-sorts identifies common and diverging viewpoints by grouping the participants according to the rank they assigned to each statement (Watts and Stenner, 2005). The sorts were analysed by applying a principal component analysis and a varimax rotation within the R package "qmethod" (Zabala, 2014). Individual Q-sorts were automatically assigned to a viewpoint according to how representative of a viewpoint their ranking of the statements was. The scores of the Q-sorts assigned to a viewpoint were then used to reconstruct a hypothetical Q-sort for each viewpoint by calculating the scores of each statement. Distinguishing and consensus statements were also identified (Zabala, 2014). The viewpoints were interpreted by examining the distribution of the distinguishing statements within each hypothetical Q-sort, considering the statements in the extremes of the hypothetical Q-sorts and relating them to the interviews of the participants whose Q-sorts had been assigned to the viewpoint in question. Consensus statements were used to understand the commonalities across all viewpoints. Sorts from the three stakeholder categories were analysed independently, with the number of viewpoints extracted determined by having at least one distinguishing statement and two participants per viewpoint (Coogan and Herrington, 2011).

Comparisons of viewpoints across stakeholder groups in Q-methodology is usually carried out by analysing them separately and qualitatively comparing the results (Watts and Stenner, 2012). An index to quantify those comparisons has

been developed (Giannichi et al., 2017), allowing a detailed detection of differences amongst all, or a subset of, statements between two viewpoints. We used an adapted version of this index to account for the fact that all our participants were exposed to the exact same set of statements. This index was defined as:

$$(1)\ \mathrm{CI}(\{s\}) = \frac{\sum_{i \in s} |V_i - W_i|}{C_s}$$

where V_i and W_i are the factor rankings (zsc_n) for statement i for the two compared viewpoints and C_s is the maximum potential $\sum_{i \in s} |V_i - W_i|$ for the subset of statements within the given Q-set (here, C_{Total}=164, $C_{Provisioning}$=84, $C_{Regulating}$=112 and $C_{Cultural}$=100). C_s ensures that the comparison index (CI) ranges from 0 to 1, with zero representing the most agreement and one the most disagreement between the compared viewpoints. With this index, we quantified the differences in viewpoints within and between stakeholder categories, for all statements and separately for the subsets of statements covering the three ecosystem services sections (provisioning, regulating and cultural, Table 4.1).

4.6 Results

Participants were between 18 and 87 years old. Around a third had spent a portion of their lives in rural areas, while half had lived in a larger city such as Accra or Kumasi. Participants in the Experts and Authorities categories were relatively homogenous, while we were able to select a more diverse sample of Users. Experts and Authorities were overwhelmingly male and more likely to have had tertiary education and be of working age (25-60 years) compared to Users (Figure 4.2).

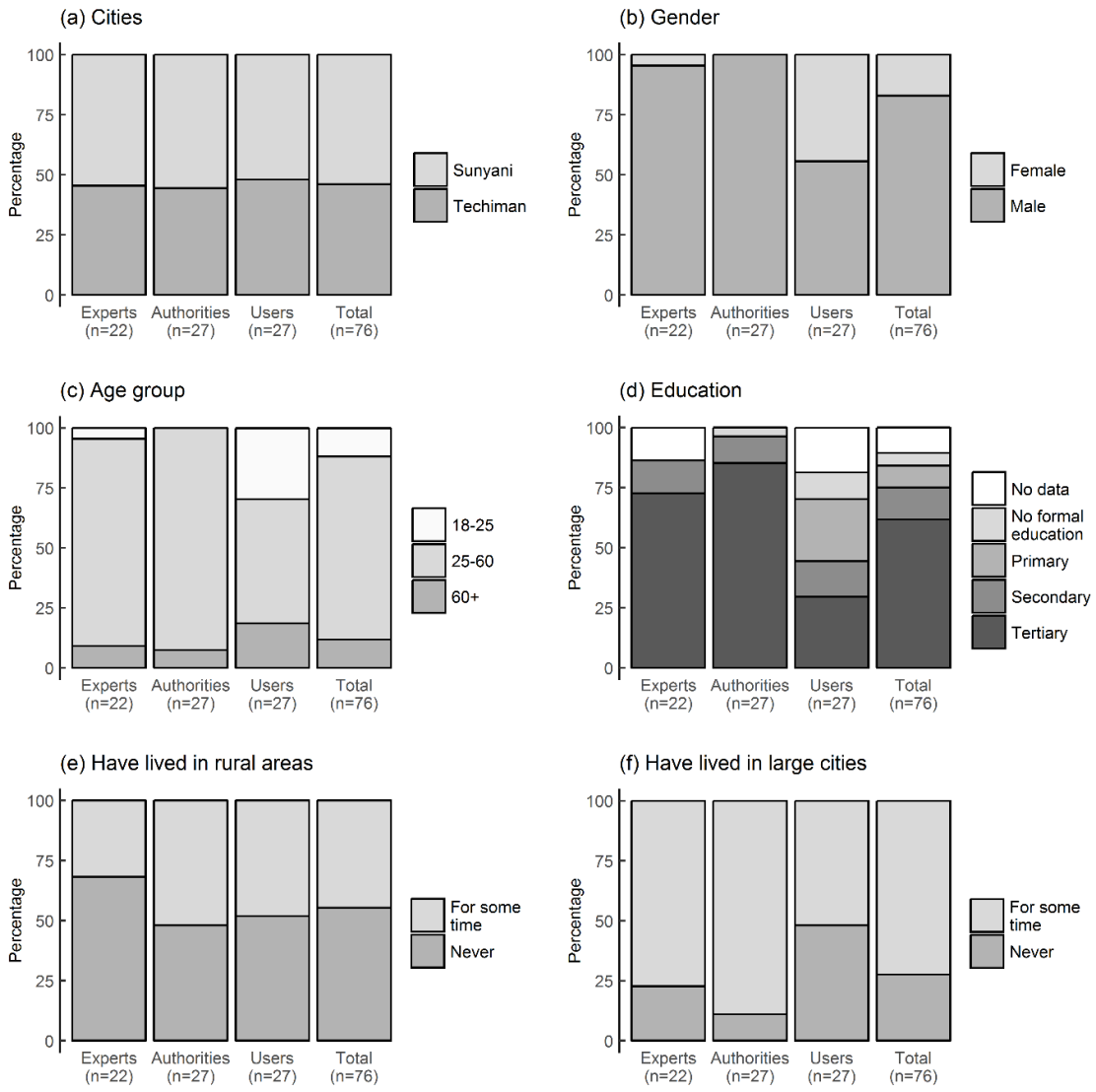


Figure 4.2. Socio-demographic characteristics of the 76 participants, divided into three categories. Experts had both influence on the wider community and interest in urban greenspaces and/or planning, Authorities had influence on the wider community, but no specific interest in urban greenspaces and/or planning. Users had an interest in urban greenspaces but no influence over their conservation or implementation at a city scale. See Table F.3 for socio-demographics per viewpoints.

4.6.1 Understanding of greenspaces

When asked to define what they understood by urban greenspaces, 53 out of 76 participants described them by the benefits they bring to humans (e.g. food provision, shade), 51 by their physical characteristics (e.g. trees, mix of trees of grasses) and 32 by the management practices leading to their presence (e.g.

setting aside land from development, deliberately planted sites; Figure 4.3.a). Eleven participants mentioned all the three aspects in their understanding, and 25 participants only mentioned one of the aspects (10, 13 and two for benefits, physical characteristics and management respectively).

Benefits mentioned were varied (Figure 4.3.b). The four most common were food provisioning through urban gardening or fruit trees (n=19), climate regulation (including both macro- and micro-climate, n=16), improvement of the city's aesthetics (n=16) and general environmental health (n=15). Amongst those describing greenspaces by their physical characteristics, the most common description of greenspaces included stating that they contained a mix of different vegetation types ranging from trees to flowers and lawns (n=26). Fewer descriptions only mentioned trees or forest (n=16). Nine participants described greenspaces as being open spaces with only grasses (Figure 4.3.c). When describing greenspaces through the management practices leading to their presence, active plantation (through agriculture, tree nurseries or decorative planting, n=18), setting land aside to protect it from physical development (n=12), and remnant patches of naturally occurring vegetation (n=3) were mentioned (Figure 4.3.d).

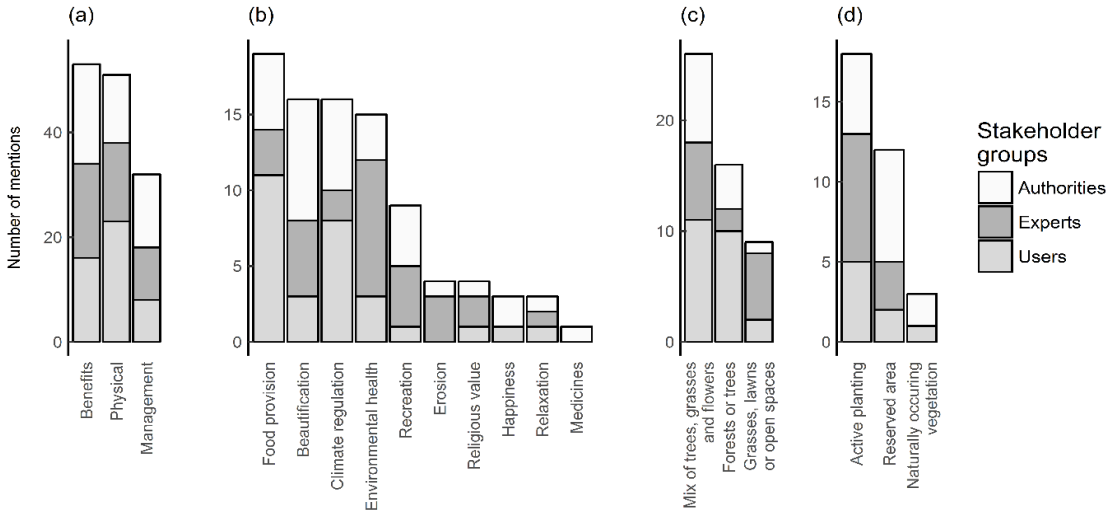


Figure 4.3. Descriptions of urban greenspaces by stakeholders (n=76). (a) General description of greenspaces; more detailed by a differentiation of (b) the benefits they are perceived to offer, (c) their physical characteristics and (d) the way they are managed. Totals exceed 76 as participants were not restricted to reporting a single aspect.

4.6.2 Experts

The Q-methodology revealed that consensus amongst Experts focused on the need for greenspaces in cities despite development pressures, but that they should be well maintained and pose no health risks. Experts also considered that conserving greenspaces was part of their religious duty. Shade provision was the main motivation for greenspace conservation (Table 4.2). Four different viewpoints were identified:

4.6.2.1 Greenspaces for environmental regulation

This group of Experts highly valued greenspaces for their regulating functions as provided when in a "natural" state. They saw a need to plant urban forests to keep services such as such as flood prevention, waterway protection, nutrient recycling and adaptation to climate change in the city: *"We can bring it back if conscious efforts are done because we have grown and realised the relevance of trees on the lives of mankind".* They also considered greenspaces to be at risk of disappearing in the face of development, partly because of the "*intangible aspects*" of those services: *"it was a planned forest but they pulled down all those trees and they are now building a hotel or something there so that is an issue we are facing currently".*

4.6.2.2 Greenspaces for well-being

Experts sharing this viewpoint highly valued greenspaces for the peace and tranquillity they provide, offering a place for people to be quiet, away from the noise of the city: *"Trees, they don't talk, they only whistle and […] you hear the trees singing their own song peacefully. […] Every man wants peace and tranquillity and harmony and trees will offer that."* Greenspaces therefore were seen to offer opportunities to relax but also to be a place for social interactions and exercise: *"When it is warm people like to go under the tree – for the shade, because it's cool, but not only. They play games […] meet and get social".*

4.6.2.3 Greenspaces as source of danger

What differentiated these Experts was their fear of potential dangers from greenspaces, such as the health hazards from urban farming (through vegetables contaminated by dirty water use, disease transmissions and attacks by livestock) or the criminals that vegetation can help to hide: "*if somebody*

wants to trap you, the person can hide on the tree or in the bushy area". They saw crime as a reason to keep greenspaces well maintained, rather than destroying them and replacing them by housing or other buildings: *"If the urban centres are being over-populated, clearing the backyard gardens will not resolve the problem. There should be other social policy interventions that will […] decongest the city."* They also highly valued the education potential of urban greenspaces: *"you want to inculcate […] the spirit of cultivation and maintenance among the school children".*

4.6.2.4 Greenspaces for income and socialisation

For these Experts, the value of greenspaces originated in the income they provide, for instance through backyard farming: *"[backyard gardens] are necessary for providing food".* They also appreciated the space they provide for recreation and social interaction: *"In my leisure time, maybe I will call my colleagues, if they want to play a local game like draughts, you need […] a place that is having shade so we can go there and enjoy our game".* However, they also mentioned that business and accommodation is more important in cities and should take priority over greenspaces.

4.6.3 Authorities

Authorities highly valued greenspaces and saw it as their religious duty to conserve them. They were not concerned about any health impacts from greenspaces and acknowledged other benefits such as the role of greenspaces for improving the appearance of a city, the provision of traditional medicine, protection against flooding and the importance of urban animal husbandry on both human nutrition and soil fertility. Three distinct viewpoints were identified:

4.6.3.1 Greenspaces as a legacy

People holding this viewpoint had a long-term worldview in which greenspaces were perceived as part of their heritage, to be passed on to future generations through education. They considered that urban greenspaces should be conserved and replanted as source of pride for residents: *"we have to plant trees to get our lost glory, so the environment must be recreated again. […] anybody who gets here will admire [the city]"*. As part of this desire to conserve greenspaces, they were also aware of the pressures greenspaces face and

tried to think strategically about it: *"there is competition in terms of the use of any piece of land that is available for development in urban space. So in order to actually stay in competition, you should look at […] how we can also generate directly income from whatever parcel of land we are deliberating on."*

4.6.3.2 Greenspaces for their multi-functionality

For this group, the multi-functionality of greenspaces was thought to be their main value. They highly valued them for climate regulation, provision of household incomes, partly through urban farming (*"if I have [crops] at the back of my house, I will not need money to buy them at the market"**[2]), and the social interactions they help facilitate (*"it can serve for weddings […] and it can serve as a nice place for recreation").*

4.6.3.3 Greenspaces for religion

People with this viewpoint thought that greenspaces play two roles in their faith. Firstly, it was their religious duty to conserve greenspaces for future generations and secondly, greenspaces offered them the opportunity to exercise their faith: *"Anything that can bring about peace and unity is good. To be able to meet and discuss about God and worship him"*.* Additionally, greenspaces were thought to play a role in both education and in beautifying the city.

4.6.4 Users

There was less consensus amongst greenspace Users compared to the two other categories. Users only agreed on four statements, compared to nine and ten for Experts and Authorities respectively, and not all Users were in favour of increasing urban greenspace cover. Nevertheless, they were all in agreement that the shade provided by urban greenspaces is very important. They also acknowledged that greenspaces can be positive for the aesthetics of the city and highly disapproved of littering. Four distinct viewpoints were identified:

4.6.4.1 Greenspaces as cultural heritage

This group of Users saw forests as a defining aspect of the region, which should be maintained in the city for their heritage value: *"Every city has its heritage,*

[2] Quotes indicated with a * were translated from Twi

something that marks it out there. And Brong Ahafo, we are known for forests reserves, but now […] we are losing all our [forest reserves] for buildings.". Greenspaces were also valued from a religious aspect: *"In the beginning, God created trees and grasses and bushes on the earth. […] If they were not important, God could have designed the earth with terrazzo or tiles.",* and for the protection they offer against harsh climatic conditions. They also recognised and valued the contribution that urban farming can make to household food supplies, although they did not necessarily farm as a full-time job: *"Originally it started like just fun, so just to see things, so just plant them and keep watering them. And now they became a major source of vegetables."*

4.6.4.2 Greenspaces for children

Users sharing this viewpoint regretted the disappearance of trees in the landscape, which some remembered fondly from their childhood: *"When I was a kid, we used to have all these places full of trees and other stuff. We used to climb there, play around there."* They thought replanting and conserving trees was important for the children, both to provide them with places to play and as a legacy from their elders. They also valued the complementary income that greenspaces can bring to the poor through food and fuel, and the flood protection greenspaces offer. While greenspaces were not perceived as a source of danger, they were not a source of peacefulness either.

4.6.4.3 Greenspaces for beauty and cleanliness

For this group of Users, greenspaces were highly valued for their cleansing properties, providing fresh air and purifying waterways, and the role they play in providing protection against the weather. Their beauty was perceived as important for promoting the city to the outside world, in order to attract people and profitable businesses: *"Flowers beautify cities more than buildings. Buildings also play a role in beautifying the cities, but flowers are really the key element of city beautification."*. However, in comparison with other user viewpoints, they were more concerned about the detrimental effects of retaining greenspaces for economic and social development and the problems they might create, such as serving as hideouts for criminals. They acknowledged the presence of urban agriculture but did not value it, wary of the impact of urban pollution on the quality of city-grown crops, thinking that urban livestock are

dangerous for residents, and dismissing regulating services linked to farming, such as nutrient cycling and pollination.

4.6.4.4 Greenspaces for development

These Users typically thought that housing and commercial enterprises should be allowed to expand and be prioritised over greenspaces: *“It is appropriate to eliminate backyard gardens to build houses for people to live in”*.* Yet they still valued greenspaces for their provision of resources such as fuel, and their provision of serenity, by reducing the noise and providing a space for meditation. They thought that greenspaces should be free and accessible for all and insisted on intensive management to maintain them: *“It does makes the town beautiful. Visitors can appreciate the cleanliness of the people living there.”*.* Despite valuing greenspaces for their part in increasing the city’s beauty, they also thought that buildings can sometimes be more aesthetic than greenspaces. They gave little value to regulating services such as flood protection, storm protection, nutrient recycling or protection of waterways.

Table 4.2. Factor rankings for each statement for the hypothetical Q-sort (i.e. Q-sort reconstituted for each viewpoint from the factor scores), ranging from 4 (most agree) to -4 (most disagree). Bold scores indicate consensus amongst viewpoints within each stakeholder category and asterisks indicate that the statement is a distinguishing statement for the viewpoint in question within the stakeholder category. For instance, all authorities agreed on the relative importance of "Livestock in cities is important as it provides manure to improve soil fertility", rating it as slightly negatively (score of -2). However, "Urban trees are an important source of wood and charcoal fuel" was distinguishing for the Authority viewpoints on *greenspaces for multi-functionality*, meaning it was more important for them than for the others, with a statistically higher rating of -1 as compared to -3 than for both the other Authority viewpoints. See Table F.4 for the z-scores, Table F.5 for the statistical significance of distinguishing and consensus statements and Table F.6 for the factor loadings per participant.

		Factor ranking										
		Experts				**Authorities**			**Users**			
Section	**Statements**	**Environmental regulation**	**Well-being**	**Source of danger**	**Incomes and socialisation**	**Legacy**	**Multi-functionality**	**Religion**	**Cultural heritage**	**Children**	**Beauty and cleanliness**	**Development**
	Urban trees are an important source of wood and charcoal fuel.	-1	-4	-4	-1	-3	-1*	-3	-3	1*	-4	4*
	Converting urban parks and reserves to ecotourism	0	0	3	2	1*	0*	2*	0	0	2*	-2*

Provisioning	facilities is essential to make them profitable.										
	Livestock in cities is important as it provides manure to improve soil fertility.	-2	-1	-2	-1	-2	-2	-2	-2	1	-1	1
	The job opportunities and incomes that could be earned from the development of urban parks, gardens and green spaces are significant.	1	0	-1	1	1*	3*	-2*	0	-1	-3*	0
	The presence of trees and plants that heal is crucial in a city, as traditional medicine is an economical and trusted form of health care.	2*	0	-1	-2*	0	0	0	2	1	3	0
	Backyards and parks should be cleared to provide space for businesses and accommodation for the ever increasing urban population.	-4	-4	-4	2*	-4*	-3*	0*	-4	-2	-4	-1
	Cities are centres of employment, trade and job creation, green spaces are not needed.	-4	-4	-4	-4	-4	-4	-4	-4	-4	-2*	-1*
	Backyard gardens are important to supplement incomes by selling roots and tubers, vegetables and fruits.	0	1	2	4	0*	3	2	0	4	-1	2
	Produce from our gardens are available when we are in dire need of them because they are scarce on the market.	0	0	1	-2*	-1	1*	-1	3*	-1	0	-1
	Small livestock in urban environments can make a big difference to nutrition and health.	0*	-2	-2	-1	-1	-1	0	1	-1	0	-2
	Cattle in urban areas can be dangerous if it is not properly enclosed	1	-1	4*	0	0	1	2	-1	1	3	0
	Vegetables grown in the city are contaminated through chemicals and dirty water use.	-2	-2	3*	-4	-1	-2	-1	-2*	-1	2*	1

Regulation and maintenance	Brong Ahafo used to be a forest so now we should be planting trees to recreate this natural environment.	4*	2	2	2	3	0*	3	4	3	-2*	3
	Greenspaces are essential for recycling the nutrient into the soil, conserving soil quality for backyard gardens.	2*	0	0	0	1	1	1	3	2	-1*	-3*
	Keeping greenspaces in the city allows natural predators of pests to stay and decrease the pests' impacts.	-2	-1	-3	-2	-2	-1	-1	-1	-2	-1	1*
	Open green spaces in the city are important to protect our waterways, essential for the provision of clean water.	2	2	0	2	0	-1*	2	-1*	2	3	-3*
	Parks and open green spaces offer me an opportunity to exercise to stay healthy.	1	3	1	1	1	1	-1*	1	2	1	-1*
	The insects can help produce more fruits through pollination so we can get to eat fresh fruits from our backyard gardens.	1	-1	-2*	0	0	2*	0	1	1	-3*	2
	Trees within the city are important to provide me with natural shade.	3	2	4	1	2	3	4	3	2	3	3
	Greenspaces in the city are not good for health because they attract malaria-carrying mosquitoes.	-3	-3	-3	-3	-3	-3	-4	-3*	-1	-2*	-1
	Many plants and animals found in urban green spaces and parks can cause allergies.	-2	-2	-2	-1	-2	-3	-2	-2*	-3*	-1*	1*
	Urban greenspaces can harbour animals that are aggressive towards humans.	-3	-3	-2	-3	-3	-1*	-4	-3	-2	0	-1
	In the city, trees are natural windbreaks which protects me from storms.	4	1	3	3	2*	4*	1*	2	1	4*	0*
	We need the trees in our cities to help reduce the impact of climate change.	4	3	1	0	4	4	1*	4	3	0	1

	With grass and trees in the city, when the rain comes, it just flows down and sinks into the ground instead of flooding the city.	3	1	1	0	2	1	1	1	4*	0	-4*
	Trees in cities risk to fall on me or my house during storms.	-2	-2	0	-1	-1	-2	-3	-2	-3	-1	-4
	A key component of urban green spaces is to reduce the level of noise.	0	2*	-1	-1	0*	-2	-3	-1*	-3	-3	3*
	Greenspaces are useful for dumping refuse	-4	-3	-4	-3	-4*	-3*	-1*	-4	-4	-4	-4
	The purpose of a green space is to reduce air pollution within the city.	2	1	0	1	2	1	0*	-1	0	4	4
	Urban livestock can consume agricultural and household waste products, converting them into human food.	-1	-1	-1	1	-1*	0*	-3*	0	-2	2	-2
Cultural	Green spaces in school yards help to inculcate in our children good environmental practices and awareness, to become environmentally responsible adults.	3	1	4	0	3	3	1	2	0	1	-1
	Greenspaces provide me with recreational opportunities.	0*	4	2	3	1	4	3	0	1	1	1
	Growing cities should not affect the traditional norms of keeping the environment green and clean, which was taught by parents in the community.	2	1	0	-2*	3	1	-2*	2*	0*	-2	-3
	Parks are the heartbeats of all social gatherings.	-1	1	-1	3	-1	2*	-1	1	3	-1	0
	The gardens and scented flowers along the roads are making the city more attractive and beautiful.	1	3	2	3	1	2	2	1	2	0	2
	The variety of flowers and grass in the gardens acts as magnets that pulls the youth to snap pictures.	-1	0	1	1	-1	0	3*	1	0	4*	-2*

Trees bring me peace and tranquillity.	0	4*	1	-2*	1	0	0	0	-2*	1	0
Urban greenspaces are a key driver of the film and advertising industry.	-1	0	-1	1	0*	-2	-1	-1	-1	2	4
Buildings make the environment more beautiful than trees and flowers.	-3	-3	-3	-4	-3	-4	0*	-3	0*	-3	2*
Green spaces and parks are often been taken over by lunatics, gangs and robbers, so I feel afraid to go there.	-3	-2	3*	-3	-2	-1	1	-1	-4*	1*	-2
Because I live in the city and will not go to the bush to see the plants and animals, I want to see them in the city.	-1	-1	-1	-1	-2	-4	-2	-2	-3	-2	0*
By conserving greenspaces in cities, we are continuing the work of God, who created all species to live with us.	1	2	2	1	4	2	3	4	-1*	2	1
Ghanaian cities must increase their green spaces to give residents a sense of pride	-1	3	0	2	3*	-1	1	0	3	1	2
Urban forests and parks are good places for religious activities, prayers and meditation.	1	-1	0	4*	2*	0*	4*	2	0	1	3
Urban forests should be preserved for the present generation and generations yet unborn.	3	4	1*	3	4	2	4	3*	4*	0*	-3*

4.6.5 Comparisons

The comparison analysis highlighted strong differences between the viewpoints of three stakeholder categories when considering all sections of ecosystem services (comparison indexes (CI) up to 0.71; with one indicating total disagreement; Table 4.3.a). However, the main disagreements were found between the User viewpoint *greenspaces for development* and the other viewpoints (CI from 0.60 to 0.71) and, to a lesser extent, between Users perceiving *greenspaces as a source of cleanliness* and the other viewpoints (CI from 0.41 to 0.66). Both were quite different from each other (CI=0.7), but more accepting than other viewpoints to the possibility of actively prioritising urban expansion over conserving greenspaces. Aside from these, viewpoints were generally in agreement (most CI under 0.5). Comparisons between stakeholder categories highlighted a higher level of similarity between Experts and Authorities (maximum CI of 0.46) than between Users and the other two stakeholder categories (max. CI=0.71 with Experts and 0.70 with Authorities). One viewpoint from each category, namely the Experts for *regulation,* the Authorities for *legacy* and the Users for *cultural heritage* were in high agreement with each other (CI of 0.21 to 0.24). All emphasised the importance of regulating ecosystem services and the heritage value of greenspaces. Within stakeholder category variation was relatively low for Experts and Authorities (max. CI=0.49 and 0.48 respectively). Users were the most heterogeneous category (max. CI=0.79), mirroring the socio-demographic backgrounds of the stakeholder groups.

No single ecosystem service section underpinned all of the disagreements between viewpoints. There were similar agreement levels within provisioning and regulating services (average CI=0.25 for both), and only slightly more disagreements for cultural services (average CI=0.28). However, (dis)agreement patterns for both provisioning and cultural services were relatively representative of the agreement patterns found when considering all categories of ecosystem services, whereas regulating services showed a slightly different picture.

For provisioning services (Table 4.3.b), the highest disagreements were found between the viewpoints of the Users valuing greenspaces *for beauty and cleanliness* and the Experts valuing greenspaces for *income* (CI=0.44), with

Users emphasising the risks of urban farming, while the Experts praised the incomes it creates. In general, Authority viewpoints were in high agreement with each other (maximum CI=0.21) as well as with the Experts (max. CI=0.26), but diverged more with some of the User viewpoints (especially with the one for *beauty and cleanliness*, CI=0.36). The slightly higher agreement for the overall classification between the User viewpoints *greenspaces for development* and *children* than with the other viewpoints was explained mainly through a higher consensus on the role of provisioning services (CI=0.20), mainly focusing on urban agriculture, highlighting both the benefits of crop farming and the risks of urban livestock.

As opposed to the other services sections, the highest disagreements for regulating services (Table 4.3.c), were systematically found between the User viewpoint on *greenspaces for development* and all other viewpoints (CI from 0.38-0.43), followed by the Users seeing *greenspaces for beauty and cleanliness* to all other viewpoints (CI from 0.21 to 0.37). Except for those two differing viewpoints, there was high agreement between all stakeholders on the value of regulating services.

The disagreements regarding the relative valuation of cultural services (Table 4.3.d) were marginally larger than for the other service sections. The highest disagreement was found between Users seeing greenspaces *for development*, and Authorities appreciating their *multi-functionality,* with the former dismissing the importance of legacy, focusing more on beautification and income-generating aspects, whereas the later highly valued recreation, education and legacy.

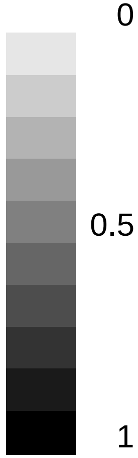
Table 4.3. Comparison indexes (CI) contrasting the viewpoints both across and within the three stakeholder categories.(a) Overall comparison, (b) provisioning services, (c) regulating services and (d) cultural services. Light cells, closer to zero, represent agreement while darker cells, closer to one, represent disagreement.

(a) All ecosystem services

		Experts			Authorities			Users			
		Well-being	Source of danger	Income and socialisation	Legacy	Multi-functionality	Religion	Cultural heritage	Children	Beauty and cleanliness	Development
Experts	Environmental regulation	0.35	0.41	0.45	0.21	0.30	0.46	0.22	0.39	0.51	0.67
	Well-being		0.40	0.40	0.28	0.37	0.44	0.35	0.41	0.55	0.65
	Source of danger			0.49	0.37	0.40	0.41	0.41	0.54	0.41	0.71
	Income and socialisation				0.43	0.44	0.43	0.50	0.44	0.56	0.65
Authorities	Legacy					0.37	0.40	0.24	0.41	0.51	0.63
	Multi-functionality						0.48	0.32	0.43	0.56	0.70
	Religion							0.43	0.43	0.49	0.63
Users	Cultural heritage								0.46	0.54	0.71
	Children									0.66	0.60
	Beauty and cleanliness										0.70

(b) Provisioning services

		Experts			Authorities			Users			
		Well-being	Source of danger	Income and socialisation	Legacy	Multi-functionality	Religion	Cultural heritage	Children	Beauty and cleanliness	Development
Experts	Environmental regulation	0.14	0.29	0.27	0.11	0.12	0.21	0.11	0.20	0.24	0.33
	Well-being		0.21	0.27	0.11	0.17	0.21	0.13	0.23	0.26	0.29
	Source of danger			0.37	0.23	0.26	0.21	0.30	0.32	0.21	0.38
	Income and socialisation				0.24	0.23	0.23	0.36	0.24	0.44	0.35
Authorities	Legacy					0.15	0.15	0.14	0.21	0.25	0.30
	Multi-functionality						0.21	0.20	0.18	0.36	0.31
	Religion							0.25	0.20	0.24	0.31
Users	Cultural heritage								0.29	0.27	0.39
	Children									0.35	0.20
	Beauty and cleanliness										0.40



(c) Regulating services

		Experts			Authorities			Users			
		Well-being	Source of danger	Income and socialisation	Legacy	Multi-functionality	Religion	Cultural heritage	Children	Beauty and cleanliness	Development
Experts	Environmental regulation	0.18	0.21	0.20	0.09	0.18	0.25	0.13	0.17	0.32	0.41
	Well-being		0.19	0.16	0.14	0.21	0.21	0.20	0.21	0.32	0.38
	Source of danger			0.15	0.15	0.21	0.22	0.19	0.25	0.26	0.40
	Income and socialisation				0.16	0.21	0.23	0.21	0.26	0.21	0.41
Authorities	Legacy					0.18	0.23	0.13	0.19	0.32	0.38
	Multi-functionality						0.27	0.14	0.24	0.27	0.39
	Religion							0.23	0.21	0.36	0.39
Users	Cultural heritage								0.21	0.36	0.39
	Children									0.37	0.40
	Beauty and cleanliness										0.43

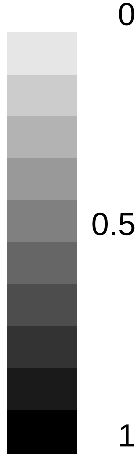
0

0.5

1

(d) Users

		Experts			Authorities			Users			
		Well-being	Source of danger	Income and socialisation	Legacy	Multi-functionality	Religion	Cultural heritage	Children	Beauty and cleanliness	Development
Experts	Environmental regulation	0.26	0.20	0.29	0.15	0.20	0.30	0.13	0.28	0.28	0.36
	Well-being		0.26	0.25	0.21	0.22	0.30	0.25	0.26	0.32	0.40
	Source of danger			0.33	0.25	0.20	0.24	0.21	0.34	0.20	0.40
	Income and socialisation				0.32	0.29	0.25	0.28	0.23	0.31	0.31
Authorities	Legacy					0.27	0.27	0.14	0.29	0.27	0.37
	Multi-functionality						0.30	0.19	0.28	0.32	0.44
	Religion							0.23	0.30	0.20	0.34
Users	Cultural heritage								0.29	0.25	0.39
	Children									0.38	0.36
	Beauty and cleanliness										0.32



4.7 Discussion

By differentiating viewpoints on the values held for the suite of ecosystem services in relation to each other, we obtained a rich picture of the varying viewpoints on urban greenspaces across multiple stakeholders. We highlighted that, despite the existence of a diversity of viewpoints, greenspaces were generally valued, providing opportunities for coordination and communication about the benefits of urban greenspaces across stakeholders. However, strong divergences in regards to which services were most valued, especially between stakeholders with more influence on policies and city-wide implementation and those with more direct contact with greenspaces, emphasises the importance of bottom-up approaches to greenspace conservation. Such understanding of the diversity of viewpoints provides keys for better targeting urban greenspace conservation programs either with different approaches for each stakeholder group or by concentrating on areas of consensus.

4.7.1 Including viewpoints of urban residents

Given that uncooperativeness from residents and communication issues between stakeholders can be major barriers to the conservation of greenspaces (du Toit et al., 2018), shaping discourses on the promotion of greenspaces according to the values of urban residents could help decrease misunderstandings and increase engagement by urban residents. In Ghana, public participation in urban planning has been promoted by the government as a way to gain a better understanding of residents' values and develop cities in a more equitable and sustainable fashion (Andrade and Rhodes, 2012; UN-Habitat, 2016), yet its application remains limited (Government of Ghana, 2012). Such lack of participation, together with the limited knowledge of urban residents' perceptions of greenspaces, can lead to dissatisfaction from the urban population either about the lack of public greenspaces or regarding how they are managed (Shackleton and Blair, 2013) and a disengagement on their part (Mensah, 2014).

As such, framing discourses on urban greenspaces around benefits specifically valued by greenspace Users, such as the reduction of air pollution or the beautification of the city, could help build support among the general public for

their retention. However, User viewpoints tended to be very diverse. This higher diversity was to be expected due to the differences in sampling methods, as the snowball sampling method used for Experts and Authorities can decrease the diversity of the participants (Kirchherr and Charles, 2018); something which was apparent in our sample (Figure 4.2). This diversity of viewpoints amongst the Users is also likely to be more aligned with the variety of viewpoints held by the wider urban society than that of the Experts or the Authorities, as their socio-economic situation is more similar (Ghana Statistical Services, 2013). Additionally, acknowledging that services detrimental to the long-term conservation of greenspaces, such as the provision of fuelwood, are valued by some greenspace users could prompt Experts to help provide alternative solutions and thus minimise extraction. If no effort is made to do so, there is a risk that the divergences in opinions between greenspace Users and Experts, and the lack of both funds and political will to preserve greenspaces (Schäffler and Swilling, 2013; Shackleton and Blair, 2013) could increase the lack of support by the urban population and lead to a rapid decrease of urban greenspaces.

4.7.2 The impact of pressures to develop land

Some Users did not think that greenspaces should be retained at all, arguing instead that such areas should be converted to buildings in order to generate income. Such pressures to develop land were perceived as a threat to the provision of ecosystem services by many stakeholders from the Experts and Authorities categories. This is a common feature throughout Sub-Saharan Africa, where economic development and the provision of basic services is prioritised by policy-makers (Schäffler and Swilling, 2013). Policy guidelines do emphasize the importance of the built environment (Government of Ghana, 2015), yet we highlighted that not all Ghanaian Experts, as individuals, valued businesses and buildings at the expense of greenspaces, and that they mostly have a fair understanding of the ecosystem services provided by greenspaces, in contrast with experts in other parts of the continent (Gwedla and Shackleton, 2015).

Despite holding personal opinions on the value of retaining greenspaces, most of the Experts did not tend to mention that their official roles actually included ensuring that greenspaces were retained as economic development plans are

implemented. Given that Ghanaian policy documents recognise the unsustainable nature of conventional economic growth (Environmental Protection Council, 1988) and legal frameworks exist for the retention of greenspaces (Government of Ghana, 2012), empowering individuals to translate their own values into practice could result in substantial gains for urban greenspace conservation.

4.7.3 Diversity of opinions

Discussions around the valuation of urban ecosystem services necessarily require an understanding of the biophysical properties of greenspaces that underpins them. However, the greenspace concept is, even within academia, defined only in very broad terms (Taylor and Hochuli, 2017). Similarly, the description of greenspaces by our participants yielded a variety of definitions, of which some, but not all, included a wide array of ecosystem services. Additionally, many descriptions centred on how greenspaces are managed. Although such descriptions tended to indicate that the benefits of greenspaces were recognised, many did not appreciate the variety of forms that greenspaces can take. There was a general dismissal of naturally occurring urban vegetation, and an assumption that greenspaces were either locations where vegetation is highly managed, such as in parks or urban farms, or protected areas where natural processes could occur. However, remnants of native vegetation can provide more ecosystem services than retro-fitted greenspaces (Mexia et al., 2018), while also requiring lower management. Such differences in the conceptualisation of greenspaces and dismissal of specific greenspace types need to be recognised and overcome if the full range of benefits and types of urban greenspaces are to be retained as cities expand.

We also showed that even within relatively homogenous stakeholder categories such as the Experts and Authorities and within a geographically homogenous region, different values could be identified. However, the few studies examining the perceived benefits of greenspaces in Africa thus far have focused on how the population as a whole perceived urban ecosystem services, with mixed findings highlighting a variety of perspectives likely influenced by both the geographical location of the study and the different stakeholders studied (Dumenu, 2013; Adekunle et al., 2013; Shackleton and Blair, 2013; Mensah et al., 2017). Several of the perspectives highlighted by previous work were

mirrored in this study. For instance, Experts who valued *greenspaces for environmental regulation* had a similar viewpoint to Ghanaian academics valuing regulating services provided by protected greenspaces such as air quality regulation, shade or temperature reduction (Dumenu, 2013) despite dismissing the opportunities of naturally occurring greenspaces to provide such services. Similarly, the Users viewpoint *greenspaces for children* reflects the perception of some South African and Nigerian urban residents who highly value greenspaces for recreation or relaxation (Adekunle et al., 2013; Shackleton et al., 2015). This validates the importance of those viewpoints but also highlights the need to assess their prevalence within the population.

4.7.4 Tackling disservices to improve acceptability

Though the value of greenspaces was recognised by most, not all stakeholders perceived them as beneficial. Disservices such as providing locations for crime and antisocial behaviour or their polluted state was a concern for some groups (e.g. Experts seeing greenspaces *as a source of danger*), supporting findings from other parts of Africa (Shackleton and Blair, 2013; Shackleton et al., 2015). Additionally, although greenspaces were recognised as being able to help regulate and remediate biodegradable waste, there is a consensus within both Experts and User groups that the use of open greenspaces for the disposal of waste is problematic and has a strong negative effect on their attractiveness as well as raising contamination concerns.

The prevalence of disservices was also acknowledged regarding urban farming, with both Experts seeing greenspaces as *a source of danger* and Users *for beauty and cleanliness* being wary of the effect of pollution on the quality of food produced and the risks related to roaming livestock. Contamination of urban farms is a real concern in the area (Amoah et al., 2005; Binns et al., 2003) and the overuse of pesticides can affect production through decreasing pollinator abundances in urban farms (Guenat et al., 2019). Urban agriculture can, nevertheless, help increase social equality by empowering women (Orsini et al., 2013) and improve the livelihood of poor urban residents who are highly dependent on greenspaces (Cilliers et al., 2013; Kaoma and Shackleton, 2015). Indeed, food provision through urban agriculture was described by many Users as an important service provided by urban greenspaces (see Figure 4.3.b). Further, urban agriculture was central for several viewpoints (User viewpoint

greenspaces as cultural heritage or *for children,* Authorities for *multi-functionality* and Experts for *incomes and socialisation*). Consequently, some of the highest disagreements between viewpoints were linked to the risks and benefits of urban agriculture. Addressing the pollution of the urban environment, including of greenspaces, water and vegetable production in African cities, and thus decreasing the impact of ecosystem disservices, might be an important step to improve not only urban residents' health but also the perception of greenspaces.

4.7.5 Regulating services and their place in the conservation discourse

Regulating services are often used in the urban conservation discourse (Luederitz et al., 2015), with a relatively large body of research available on their valuation (du Toit et al., 2018). However, regulating services were also the section for which disagreements between one of the Users viewpoints and other viewpoints was consistently high. This highlights potential conflicts if regulating services were to be emphasized due to the agreements between Experts and Authorities. The only regulating service for which we found consensus across Users and another stakeholder category, the Experts, was the provision of shade, being highly valued by both. This was also reflected in the description of greenspaces by many participants as trees or forests, where high standing vegetation would provide protection against the sun, and is mirrored in other African studies (Dumenu, 2013; Shackleton et al., 2015). However, for some Authorities (*greenspaces for multi-functionality*), shade was not amongst the most important services provided by greenspaces. Such mismatches in discourses from a stakeholder category with high influence on the urban population could lead to a missed opportunity for conserving urban trees.

In light of the lack of local, context specific knowledge that would help to integrate the diversity of perspectives of the urban population and counteract uncooperative attitudes towards greenspaces (Mensah, 2014; du Toit et al., 2018), we recommend assessing the extent to which shifting the focus of arguments for greenspace conservation from regulating services as a whole to the few for which there are consensus on their importance might help promote the retention of greenspaces within cities.

4.8 Conclusion

Ghana has one of the highest urbanisation and economic growth rates in Africa. Understanding how people value the multiple ecosystem services that urban greenspaces provide in one of the most urbanised countries of the continent could provide insights that are relevant throughout Africa as cities expand and economic growth progresses.

Ecosystem services provided by urban greenspaces were valued by all stakeholder categories. There is therefore potential for conservation and retention measures to be implemented despite continuing development pressures on land. However, not all ecosystem services were a source of agreement either within or between stakeholder categories. Targeting discourses towards the audience and ensuring that messaging is focussed on ecosystem services with as broad a consensus as possible across stakeholders will be necessary if more widespread support for the retention of greenspaces within fast growing cities is to be successful. We therefore caution against focusing communication solely on ecosystem services consistently valued by Experts and Authorities, without taking into consideration that the opinions and values held by those stakeholders frequently diverged from the opinions of greenspace Users.

Despite this, there are some areas of consensus between Users and Experts, such as the provision of shade, whose benefits could, therefore, be emphasized to improve the dialogue around greenspace, thus increasing their acceptance.

4.9 Acknowledgments

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Chapter 5:
Synthesis and conclusions

5.1 Introduction

Greenspaces and the ecosystem services they provide are critical for improving the liveability and resilience of urban areas to climate change and other ecological disturbances (McPhearson et al., 2015). Greenspaces also contribute to the mitigation of the biodiversity crisis (Elmqvist et al., 2013). However, most of what is known about the conservation potential of greenspaces emerges from studies carried out in the Global North, even though the African and Asian continents are those experiencing the fastest urban growth (Seto et al., 2012). This thesis has taken a multi-perspectives approach to investigate the conservation potential of small fast-growing cities in West Africa. It considered their biodiversity by investigating whether and how the pollinator populations were maintained across a urbanisation gradient. It also explored the socio-economic system influencing their conservation by describing the social networks of stakeholders impacting greenspaces and the different viewpoints that various of those stakeholders hold for greenspaces. This synthesis chapter discusses the key findings from each chapter, the linkages between them and their contribution to the wider discourse of urban greenspace conservation in Sub-Saharan Africa.

5.2 Revisiting the research objectives

The three research objectives of this thesis were addressed sequentially in empirical Chapters 2-4. The main findings from these chapters, their knowledge contributions and some policy recommendations are summarised in Table 5.1. The integration of the findings here enables the consideration of the overall aim

of the thesis, namely to understand the potential for urban greenspace conservation in small cities of Sub-Saharan Africa through a multi-perspective approach to ecosystem services.

In the ecosystem service cascade framework (Figure 5.1), the environment, encompassing the ecological structure and the functions it provides, constitutes the base for the provision of any final service (Potschin-Young et al., 2018). Baseline data on the ecological structure of urban greenspaces is often lacking in the African context (du Toit et al., 2018). Chapter 2 explored the urban ecological structure by addressing objective (a), namely to evaluate the potential for urban greenspaces to maintain pollinator populations. Findings provided evidence that remaining urban greenspaces in small African cities can maintain some pollinator abundances at similar levels to that of the surrounding agricultural landscapes, although with some variations across taxa. Specifically in this case study research from two Ghanaian cities, bee, Lepidoptera and non-fruit fly abundances were maintained while beetle and wasp abundances were not. Neither bee diversity nor the distribution of their functional traits varied across the urbanisation gradient, but patterns of occurrence of and dominance of genera shifted along the gradient. Management practices were also critical, with fewer bees in farmed greenspaces and fewer beetles in amenity lands. This result suggests that retaining urban greenspaces can contribute to pollinator conservation and that future threats to biodiversity might be mitigated through appropriate measures. Such mitigation measures include the conservation of a variety of management practices, including both amenity lands and informal greenspaces, a protection of nesting sites for ground-nesting bees and a limitation of pesticide application.

Conservation of pollinator abundances is not necessarily the only factor to consider in order to maintain a stable delivery of the pollination service (Hoehn et al., 2008). Limited resources did not allow for a full assessment of pollination success but pilot data were collected on pumpkin (*Cucurbita* spp.) pollination. Pumpkins are both highly dependent on animal pollination (Klein et al., 2007) and their seed set is related with fruit size (Hoehn et al., 2008). Additionally, pumpkins can be efficiently pollinated in other urban settings (Petersen et al., 2014). Cucurbits, including pumpkins, are crops of national importance in West Africa, where their flesh is frequently used to complement stews or eaten as

sweets, their leaves are used to wrap food, their flowers eaten as vegetables, their seeds as soup thickener (Ajuru and Nmom, 2017), and their stems can be used to cure boils (Inngjerdingen et al., 2004). This pilot data indicated that the decrease in abundances of some of the pollinator taxa and the community shifts did not affect the pollination function for pumpkin crops, which was maintained across the urbanisation gradient (Appendix G, Figure G.1).

For an ecosystem function to be considered a final service, the benefits it provides need to be recognised and valued by its users (Potschin-Young et al., 2018). Though the provision of services is relatively well understood, data on the demand for ecosystem services is often lacking (Wolff et al., 2015). The socio-economic side of the ecological cascade was explored through Chapters 3 and 4. Chapter 3 addressed objective (b), namely understanding the influence of social networks on urban greenspaces. Social network analyses are known to be a useful way of understanding how to target conservation programs towards stakeholders with the capability to increase uptake within the wider population (Folke et al., 2005; Prell et al., 2009). Findings from Chapter 3 revealed the critical role of social networks for contextualising urban greenspace conservation. Chapter 3 identified ten stakeholder groups impacting greenspace conservation, with none identified as actively protecting greenspaces while having enough influence to change the behaviour of others. It highlighted that chiefs could not be overlooked in the implementation of greenspace conservation measures, and that their views on land development were mainly driven by financial and community development concerns. The social networks analysis conducted in Chapter 3 also identified media and religious bodies as pivotal stakeholders for spreading information to the urban population and revealed the existence of initiatives for greenspace conservation. Such initiatives, including both the development of a policy-framework led by the government and citizen-led planting projects, were however hindered by low implementation capability or financial constraints. Social networks thus highlighted the necessity to change the perspective of chiefs on urban greenspaces for any conservation measures to take place. Social networks also revealed that conservation messaging on the benefits greenspaces can bring to the community could be one of the most efficient ways to bring about this change in the chiefs' perspectives.

Gaining an understanding of the different viewpoints on urban greenspaces contributes to increasing the impact of conservation messages towards the given stakeholders (Hine et al., 2014; Wright et al., 2015). Existing research on the perception of urban ecosystem services showed a wide range of motivations behind the conservation of greenspaces, with opinions varying from their importance as a place for spiritual services (Ngulani and Shackleton, 2019) to the high value given to their ability to conserve soils (Mensah, 2017). Chapter 4 addressed objective (c), namely describing and comparing the values given to different ecosystem services by residents, local experts and influencers. Findings showed that ecosystem services were generally valued across stakeholders, despite a heterogeneity in viewpoints. The most valued ecosystem services covered regulating services, heritage aspects and contributions to economic development. Values perceived by greenspace users were the most diverse, with some dismissing the importance of greenspaces entirely. Pollination, as investigated in Chapter 2, was not central to any of the identified viewpoints, which is consistent with the general lack of recognition of the role of bees in Africa (Eardley et al., 2009). Findings from Chapter 4 highlight the importance of recognising shared viewpoints and areas of disagreement to increase the acceptability of greenspace conservation. They also suggest areas of consensus, such as the importance of shade provision or the need to address disservices brought about via greenspace degradation, around which conservation measures could be taken with limited conflicts.

Acknowledging both the social networks surrounding greenspaces (Chapter 3) and the different viewpoints on the ecosystem services provided by greenspaces (Chapter 4) enables us to better understand what threats the greenspaces and the biodiversity they contain are facing. The main threat, identified in Chapter 3, is encroachment for infrastructure development, mainly through influential stakeholders prioritising infrastructure development. Another threat comes both from the focus of current conservation measures, identified in Chapter 3, on tree planting and the preferences for tree-related ecosystem services such as shade or cultural heritage provided by trees revealed in Chapter 4. Indeed, the urban greenspace management practice identified in Chapter 2 as hosting the higher abundances of all pollinators were the informal greenspaces (open greenspaces with high flowering plant diversity receiving

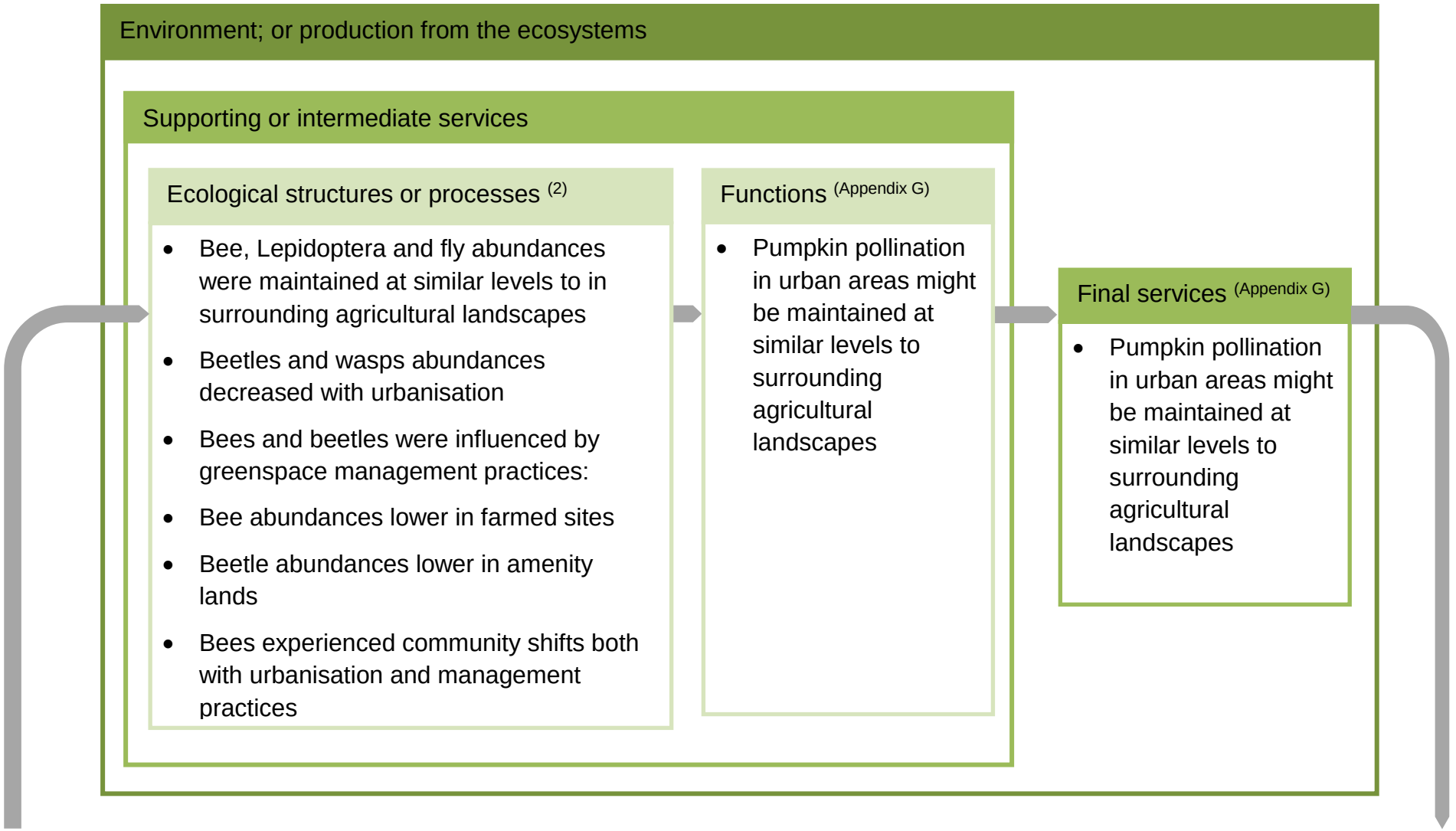
minimal to no management, Figure B.2.c). However, the focus on tree planting creates greenspaces of relatively high management intensity and with limited ground vegetation, which might not host high pollinator density. Another preference posing a threat to informal greenspaces is the preference for greenspaces contributing to the beautification of the city identified in Chapter 4. Greenspaces described as visually appealing were mainly highly managed amenity lands (Appendix H). Though such amenity greenspaces can contribute to bee conservation, they host different bee communities and lower beetle abundances than other management practices. Conversely, informal greenspaces were, due to their low management, often the ones plagued with worst litter, an aspect that was consensually described, in Chapter 4, as decreasing the visual appeal of greenspaces and the motivations for greenspace conservation.

Such mismatches between the socio-economic and environmental sides of the ecosystem service cascade emphasize the necessity of using inter-disciplinary approaches to urban ecosystem services studies and highlights the necessity of understanding how such mismatches might further impact ecological functions and ecosystem services delivery.

Table 5.1. Summary of research objectives, the key results and their policy implications

Ch.	Objective	Justification	Key findings	Importance	Policy implications
2	(a) Evaluate the potential for greenspaces to maintain pollinator populations	Pollinators are a pivotal and threatened part of the biodiversity of an ecosystem and provide an important service. They are known to have the potential to adapt to urban environments in other contexts yet are rarely studied in urban Africa.	• Urbanisation decreased abundances of two out of the five studied pollinator groups, though bee and fly abundances were maintained • Management was critical: farmed greenspaces hosted fewer bees and amenity lands fewer beetles • Occurrence and dominance patterns of bees changed with urbanisation	The findings from this chapter highlight that the potential of African cities to conserve some pollinator communities and pollination as a service exists, but caution that both conservation and careful management of urban greenspaces is needed.	• Retain informal greenspaces and amenity lands • Protect nesting sites for stingless bees • Limit pesticide application
3	(b) Understand the influence of social networks on urban greenspaces	Good understanding of social networks around conservation areas enable conservationists to efficiently target the most influential stakeholders with the most appropriate arguments, yet little is	• Chiefs are central stakeholders and cannot be overlooked • Monetary exchanges were perceived as decisive and led by industries with limited interest in greenspaces • Media and religious bodies can reach wide audiences for	The findings from this chapter emphasize the importance of understanding social networks to efficiently contextualise and target conservation communication.	• Include chiefs in any the decision-making process • Incorporate greenspace values in land appraisal • Use media and religious bodies

		known about social networks around urban greenspaces.	education on conservation issues		for city-wide education
4	(c) Describe and compare the viewpoints of residents, local experts and influencers on the ecosystem services and disservices provided by urban greenspaces	Different perceptions of the benefits and disservices provided by urban greenspaces will influence the willingness to engage in and support their conservation.	• Ecosystem services were generally valued across stakeholders • There were many disagreements on their relative values, with some users dismissing greenspaces' benefits • Consensus was found on the important value of shade and the issues of pollution	The findings from this chapter highlight the importance of taking multiple perspectives into consideration while communicating about greenspace conservation and reveal some ecosystem services provided by greenspaces around which there is more consensus.	• Focus protection efforts on shade-providing trees • Address disservices arising from pollution • Target messages according to specific perspectives


Environment; or production from the ecosystems
Supporting or intermediate services
Ecological structures or processes (2)
• Bee, Lepidoptera and fly abundances were maintained at similar levels to in surrounding agricultural landscapes
• Beetles and wasps abundances decreased with urbanisation
• Bees and beetles were influenced by greenspace management practices:
• Bee abundances lower in farmed sites
• Beetle abundances lower in amenity lands
• Bees experienced community shifts both with urbanisation and management practices
Functions (Appendix G)
• Pumpkin pollination in urban areas might be maintained at similar levels to surrounding agricultural landscapes
Final services (Appendix G)
• Pumpkin pollination in urban areas might be maintained at similar levels to surrounding agricultural landscapes

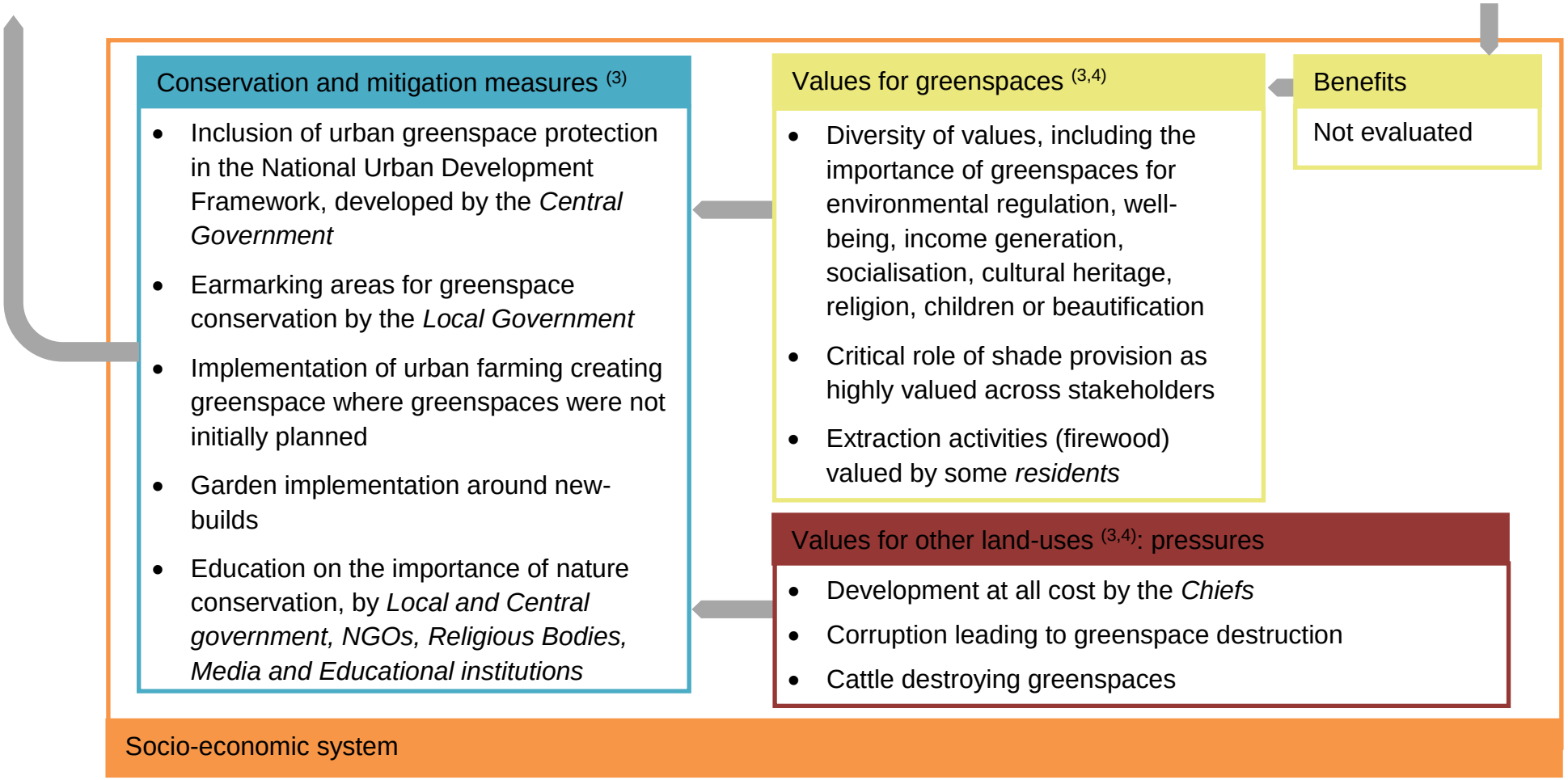


Figure 5.1. Integration of the thesis findings into the ecosystem services cascade. Findings from this thesis are presented in the white boxes, with stakeholders italicised, and superscript numbers indicate the Chapter from which those findings are extracted.

5.3 Contributions to global urban conservation

Urban greenspace conservation faces many challenges such as the lack of reliable baseline ecological data or a poor understanding of the social interactions and motivations impacting its implementation (Botzat et al., 2016; du Toit et al., 2018; Groce et al., 2019). Knowledge is also lacking on the interactions between several ecosystem services, as most studies examine them individually (Luederitz et al., 2015). It has been suggested that urbanisation processes are likely to differ regionally (McHale et al., 2013) and that African cities should consequently be studied as following alternative development pathways than cities of the Global North (Kestemont et al., 2011). However, existing knowledge on the potential for urban greenspace conservation is extremely geographically biased, focusing mainly on the Global North while urban areas of the Global South are the largest, fastest growing, and closest to biodiversity hotspots (Seto et al., 2012; Guneralp and Seto, 2013; Luederitz et al., 2015; Botzat et al., 2016). Every Chapter of this thesis suggested, by revealing new insights in both the ecological structure of and the socio-economic motivations behind urban greenspace conservation, that alternative processes are at play in the Global South compared to the Global North. In addition to the interconnections described in the previous sections, several common themes on the context-specificity of urban greenspace conservation emerged from the findings of this thesis.

5.3.1 Urban farming: an integral part of Sub-Saharan urban conservation?

One of the ways in which African urbanisation differs from urbanisation in the Global North is through the reliance of its poorest population on agriculture for their livelihoods (Zezza and Tasciotti, 2010). Urban agriculture is not only critical in providing a diverse diet and increased income for an important subset of the African urban population (Zezza and Tasciotti, 2010), it also empowers women and contributes to improving cities' liveability by reducing waste, diminishing the environmental impact of food transportation, improving air quality and harbouring some biodiversity (Orsini et al., 2013). Urban farming practices also increase the nature-human connection and community cohesion in highly urbanised landscapes (Dunlap et al., 2013; Olivier and Heinecken, 2017).

The biodiversity of urban agricultural land is rarely studied in Africa. The only studies thus far found either stable diversity and species richness along an urbanisation gradient (for herbaceous vegetation; Stenchly et al., 2017) or an increase of biodiversity in urban farms as compared to rural ones (for woody vegetation; Stenchly et al., 2018). Similarly, urban farming practices in the Global North host higher abundances of pollinators than in other greenspace management practices (Gunnarsson and Federsel, 2014; Baldock et al., 2019). Such biodiversity conservation contributions, coupled with the socio-economic benefits of urban agriculture, would suggest that including urban farming practices in African greenspace conservation programs can be highly beneficial.

Chapter 2 highlighted that urban agricultural sites in West Africa had lower abundances of bees, the pollinators considered to contribute to up to 75% of all pollination (Rader et al., 2016), than other greenspace management practices, probably because of the use of agricultural pesticides. This lack of pollinators is critical for the sustainability of urban farming as crops planted in West African cities include not only wind-pollinated staples, but also high-value vegetable and fruit crops reliant on pollination for high yields (Ayerakwa, 2017; Klein et al., 2007).

Support for urban agriculture was also not guaranteed as Chapter 4 of this thesis revealed that food provision was a divisive ecosystem service. Urban agriculture was valued by some for its contribution to incomes and food diversity, while others pointed out the risks of food contamination through pollutants and safety risks related to roaming livestock. Cattle farming was also perceived, in Chapter 4, to have negative feedback on the residents' willingness to protect urban greenspaces, as their efforts risked being destroyed by cattle. This highlights the double-edged effect of urban agriculture, which could both motivate and alienate stakeholders to greenspace conservation.

Extensive research in the rural context showed that some ecosystem services are largely incompatible (Foley et al., 2011). Delivery of provisioning services through agriculture notably tends to conflict with many regulating and cultural services, as well as with biodiversity conservation (Raudsepp-Hearne et al., 2010; Phalan et al., 2011). Seeing both the divisions brought about by urban agriculture found in Chapter 4 and its potential negative impact on biodiversity conservation identified in Chapter 2, caution should be taken on its

implementation as a conservation measure. Consequently, in the current situation, crop farming practices should be encouraged for its contribution to the livelihood of urban residents rather than as a biodiversity conservation strategy, and livestock rearing dissuaded altogether.

Despite the low pollinator abundances in urban farms, agricultural practices can still provide many other ecosystem services, including energy efficiency, storm-water runoff, air pollution removal, carbon storage and sequestration, water quality provision, sense of place and community cohesion (Lin et al., 2015; Olivier and Heinecken, 2017). Chapter 3 identified urban farming practices as a way to enhance the level of vegetation in areas where their implementation was not officially planned. Emphases on the delivery of non-provisioning ecosystem might thus be critical if the informal protection given by urban agricultural land against infrastructure development is to be maintained as the dependence on urban agriculture for livelihood decreases with increased urban wealth.

5.3.2 Conservation communication

To increase participation in, and support for, urban greenspace conservation, relevant communication on the benefits provided by urban greenspaces is crucial. Chapter 3 highlighted how important it is for promotion of greenspace conservation to stem from trusted and influential sources. Some sources identified in the Global North, such as NGOs (Ernstson et al., 2010), lack the necessary influence in the African context. A critical alternative stakeholder never identified in the Global North was the chiefs, who play a key role of community leader and land manager in Ghanaian society (Tieleman and Uitermark, 2019). They were identified to have a mixed or negative perspective on urban greenspace but, given their role both in land management and attribution and in leading the community, changing such perspective would be crucial to conserve and implement urban greenspaces. For such change to occur, personalised approaches by less influential stakeholders such as members of NGOs, teachers or researchers are necessary as targeted or personalised approaches are known to be better for changing opinions (de Lange et al., 2019; Hine et al., 2014). In Sub-Saharan African cities, gaining support from chiefs would be an important step forward as they could implement best practices in urban conservation on a large scale.

Other alternative stakeholders identified in Chapter 3, to have to potential to influence perceptions of urban greenspaces in the wider population are religious bodies. Though not currently engaging with greenspaces, religious bodies were aware of conservation issues and involved in some conservation programs. Their viewpoints, described in Chapter 4, focused heavily on their religious duty to conserve nature and the continuity aspect whereas they have to protect greenspaces for future generations. Such perspectives were relatively similar to those of experts, including chiefs. Consequently, use of those arguments could be central in swaying opinions, especially given that increasing emphasis on the linkage between conservation and the religious texts during preaching enhance awareness and potential involvement in conservation practices (McKay et al., 2013). However, users of greenspaces had more diverse perspectives on ecosystem services provided by greenspaces. Using a single argument, even emanating from a trusted source, might not be sufficient to gain their support (Hine et al., 2014).

Media were also identified as critical for spreading conservation messages widely. One of the successful media communication campaigns for biodiversity conservation in the Global North has been around the loss of pollinators, with insect and bee declines gaining public attention (see for instance Bodkin, 2019; Briggs, 2019; Carrington, 2019). Such mass media campaigns are pivotal in raising concern and attracting the attention of both policy-makers and the wider public (Underwood et al., 2017; Schönfelder and Bogner, 2017). Chapter 4 showed that pollination is currently unlikely to serve as a successful communication tool for conservation of urban insects in Sub-Saharan Africa. Conversely, Chapter 2 illustrated how stingless bee populations could be maintained in urban areas, as has already been confirmed in other tropical regions (Vieira et al., 2016). Stingless bees have long been used for honey production in various tropical countries (Cortopassi-Laurino and Gelli, 2000; Mustafa et al., 2018). A single stingless bee colony can produce up to 4kg of honey a year and provide additional benefits through derived products (Kwapong et al., 2010; Mustafa et al., 2018). Chapter 4 revealed that the contribution of greenspaces to income generation, for instance through farming or medicinal plants, was amongst the main concerns of some stakeholders working with urban planning and of some greenspace users. Consequently,

given that effective bee rearing requires conservation of their environment and that impedes the destruction of hives in their natural settings (Dietemann et al., 2009; Mustafa et al., 2018), messaging on the potential stingless bee rearing opportunities offered by urban greenspaces could be appealing to some stakeholders. Other stakeholders groups identified in Chapter 4 were more interested in the well-being benefits that urban greenspaces can provide and the role of the chiefs was described in Chapter 3 to related to the general care of the community. Targeted messaging for such stakeholders could thus focus on recent studies highlighting spatial synergies between urban pollinator protection measures and improvement of well-being for the most deprived urban residents (Bellamy et al., 2017). Both those perspectives on urban pollinators are different angles at which to target different stakeholders. Consequently, even a description of the biological structure of urban greenspaces such as the one provided in Chapter 2 can provide pathways as to how to better target the conservation discourse.

5.3.3 Tackling ecosystem disservices

Although the services brought about by urban greenspaces are critical for communicating the benefits of urban greenspaces, recognising that greenspaces can also have some negative effects on human well-being, here called ‘ecosystem disservices’, is crucial in order to address those properly (Schaubroeck, 2017). Urban ecosystem disservices are less studied than services and suffer the same geographical bias (Roy et al., 2012). However, given that the tropics are more biodiverse than temperate regions, greenspaces might bring more disservices for human health, with harmful effects such as disease vectors or venomous animals (Keniger et al., 2013).

Chapter 2 of this thesis revealed that, even though urban areas have the potential to maintain pollinator populations, they also maintain other insects including flies, some of which are from families with negative impacts on human health and agriculture, such as crop pests, bee predators, or human and livestock disease vectors (Picker et al., 2002). This is highly important in tropical areas where malaria is one of the main causes of death (WHO, 2018). Malaria control has a strong impact on the biodiversity of urban greenspaces as official recommendations for *Anopheles* control malaria-spreading mosquitoes

(*Anopheles*) includes drastic changes in the urban ecosystems such as the drainage of the land surrounding rivers and chemical control (Ministry of Local Government and Rural Development, 2010). Spread of diseases is one of the disservices identified in the Global North (von Döhren and Haase, 2015) and concerns have been raised about the impact of irrigated urban agriculture in sustaining *Anopheles* populations in West Africa (Afrane et al., 2004). However the spread of malaria was not perceived, in Chapter 4, to be a problematic disservice. Further assessment of the use of greenspaces by mosquitoes could help reveal whether or not different types greenspaces increase the spread of malaria and what are the best management practices to decrease Anopheles spread with limited impact on the delivery of other ecosystem services.

Chapter 4 highlighted a varied array of viewpoints on ecosystem services whereas some could be branded as either a service or a disservice depending on the stakeholder. For instance, some stakeholders viewed agriculture as a service for the food and/or leisure it provided while others perceived the dangers it created by putting contaminated vegetables on the market or causing attacks by livestock. Similarly, differences can be found between some of the identified disservices in the Global North and the services preferred in Chapter 4. For instance, the presence of shade was perceived as a disservice in Finnish urban areas where sun is scarce (Tyrväinen, 2001) but was amongst the most preferred service for stakeholders in the tropical cities of Sub-Saharan Africa, where thermal control is necessary. Such differences in the perceptions of what is a service and a disservice, both within the same population and between various geographic contexts, highlight the need to consider multiple perspectives before branding an ecosystem function a disservice and consequently acting to diminish its impact.

5.3.4 The role of financial initiatives in urban greenspace conservation

The importance of financial motivations for conserving greenspaces is a theme that emerged both from some of the viewpoints identified in Chapter 4 and from the social network analysis in Chapter 3. Critically, the chiefs, identified as amongst the most influential stakeholders, were described as highly motivated by financial incentives, emphasizing the need to find a way to finance or give

alternative value to urban greenspaces. Consequently, opportunities to provide income through greenspaces should be explored. Those could include stingless bee rearing, as suggested in the section on urban agriculture (5.3.1), installation of fee-paying greenspaces, indirect incentives in which the government or other agencies encourage greenspace protection or implementation through tax reductions, or market-based certification for areas with more greenspaces (Cerra, 2017).

An option increasingly used to finance the provision of ecosystem services is payments for ecosystem services*, defined as “a voluntary transaction where a well-defined environmental service or a land use likely to secure that service is being ‘bought’ by a service buyer from a service provider if and only if the service provider secures service provision” (Engel et al., 2008; p. 667). Payment for ecosystem services schemes thus target specific highly-valued ecosystem services and take a “beneficiary-pays” rather than a “polluter-pays” approach, which is advantageous in situations where providers of ecosystem services are poor (Engel et al., 2008). However, the high cost of land in urban areas drives up the opportunity cost of setting land aside for ecosystem service provision. Additionally, the large heterogeneity of stakeholders interacting in urban areas makes it difficult to identify both providers and beneficiaries of ecosystem services (Richards and Thompson, 2019). Given that many ecosystem services are considered public goods (Cerra, 2017), they are more likely to be funded by the government, which was identified in Chapter 3 to have low levels of funding available. Additionally, the high levels of urban poverty in Sub-Saharan Africa, where 56% of the population lives in slums (UN-Habitat, 2016), suggests that other beneficiaries would not be able to afford such payments. Finally, analysis of payment for ecosystem services schemes along urbanisation gradients in the Global South have revealed that such schemes were not sufficient to motivate large scale community conservation (Caro-Borrero et al., 2015) or that their implementation increased inequalities (Bleeker and Vos, 2019). There is a need to find alternative options to finance urban greenspace conservation and ecosystem services delivery without increasing inequalities in contexts of high urban poverty.

Inequality and environmental issues are often raised regarding urban greenspace conservation (Wolch et al., 2014). Such issues are especially

critical to address in Sub-Saharan Africa were urban poverty is rampant and inequalities high and increasing (UN-Habitat, 2016). There are important disparities in provision of and access to urban greenspaces, where wealthier populations have more opportunities to interact with greenspaces (McConnachie and Shackleton, 2010). Such disparities in greenspace access risk increasing inequalities as the poorest do not benefit from the local services delivered by greenspaces (Wolch et al., 2014). Additionally, caution should be taken while increasing greenspaces as there are then risks of property prices increasing and pushing the poorer population away (Wolch et al., 2014). Strategies suggested to avoid this gentrification problem of urban greenspaces emphasize the need of not only greening "just enough", but also of greening, through bottom-up approaches, according to community concerns rather than following conventional urban design or ecological restoration approaches (Wolch et al., 2014). Consequently, the tree planting initiatives described in Chapter 3, led by local NGOs, are a typical example of measures which, properly supported, could contribute to environmental justice. Conversely, other approaches increasingly used in the Global North such as rooftops are perceived in Appendix H as elitist and unrealistic in smaller towns and might increase inequalities in access to greenspaces. Engaging with developing greenspaces targeted to the different viewpoints on the benefits of urban greenspaces described by greenspace users in Chapter 4 would prove critical.

5.4 Suggestions for future research

Integrating the findings from the three Chapters of this thesis provided new insights into the conservation potential of urban greenspaces, but also highlighted that data on African urban areas are still very limited. Several remaining research gaps emerge:

- *What is the potential for other African cities to conserve or retro-fit urban greenspaces?* Sunyani and Techiman were selected as case studies for this thesis due to their position at the fringe of a biodiversity hotspot increasingly threatened by urban extension (Seto et al., 2012) as well as for their high growth rates (Ghana Statistical Services, 2013). Combined with Ghana's higher proportion of urban residents than most African countries (DESA, 2015) and the praise it received for as being an

example of stable development (Lenhardt and Rocha Menocal, 2015), Sunyani and Techiman were postulated to be characteristic of small African cities while a useful forerunner of further urbanisation on the African continent. However, there are eight hotspots facing increasing threats from urbanisation in Sub-Saharan Africa[1]. In those hotspots, urban expansion is threatening up to 4.2 million square kilometres (Seto et al., 2012). Additionally, more than half of Africa's urban population lives in cities with fewer than 500,000 residents and they virtually all experience a fast growth (DESA, 2015). Studies on urban greenspaces in Africa have so far focused on only 74 cities spread across 20 of the 53 countries of Sub-Saharan Africa, but with most in South Africa (du Toit et al., 2018). Broadening the geographical range of urban greenspaces and ecosystem services studies will thus be critical to reveal general patterns.

- *What type of biodiversity could be conserved in African urban areas?* From a biodiversity perspective, this thesis focused on one specific subset of the urban ecosystem, the pollinators, but investigated neither the tree diversity nor the potential of urban trees to regulate the micro-climate. However local temperature reduction by shading was amongst the most valued ecosystem service across stakeholders, implying that the conservation of shading trees might benefit from strong support. Given that shade can be provided by a variety of tree species, maximising the biodiversity benefits of shade provision could be central for protecting the local flora and providing additional ecosystem services. Tree species are however known to differ in their ability to mitigate temperatures in the urban environment and data of the shading potential per species is mainly focused on trees from the Global North (McPherson et al., 2018; Rahman et al., 2015). Additionally, not all tree species are adapted to urban environments, as trees planted in cities need to be highly resistant to stress (heat, drought, soil compaction, pH) in addition to being aesthetically attractive and relatively easy to maintain (Pauleit,

[1] Cape Floristic Region, Coastal Forests of Eastern Africa, Eastern Afromontane, Guinean Forests of West Africa, Horn of Africa, Madagascar and the Indian Ocean Islands, Maputaland-Pondoland-Albany, Succulent Karoo

2003). However, context-specific knowledge on the different species' ability to adapt to the urban environment is already limited in the Global North (Sjöman and Busse Nielsen, 2010) and totally lacking from the Global South. Knowledge on which tree species are currently found in African cities could provide a starting point as to which species might have potential to be implemented for shading urban areas, however the few studies monitoring urban trees in Africa showed that current tree species are mainly non-native (Raoufou et al., 2011; De Lacy and Shackleton, 2017). Though non-native trees have potential for shade provision and other ecosystem services and might be needed to increase biodiversity in some contexts (Sjöman et al., 2016), having an understanding of which set of native species could provide ample shading and survive healthily in the urban environment is critical for local biodiversity conservation.

Urban agriculture is also considered, from studies in the Global North, to play a key role in increasing urban biodiversity (Lin et al., 2015). However, evidence from Africa is limited (Stenchly et al., 2017; Stenchly et al., 2018) and Chapter 2 showed that urban agriculture might negatively affect pollinators. As African cities transition away from a state of poverty where urban agriculture contributes to the livelihoods of many of its residents, understanding the contribution of various urban farming practices to biodiversity conservation and ecosystem services delivery would be important to better inform on the importance of maintaining agricultural land in cities as opposed to other greenspaces.

- *What is the prevalence within the urban population of the different viewpoints on urban greenspaces identified through this thesis?* The Q-methodology, used in this thesis to explore the motivations of different stakeholders for greenspace conservation, is an exploratory method allowing the identification of different viewpoints from a small set of diverse stakeholders (Watts and Stenner, 2012). However, Q-method does not allow for the quantification of the different viewpoints' prevalence within a wider population (Watts and Stenner, 2012). Exploring the prevalence of the viewpoints identified through this thesis

within the urban population could inform on the prioritization of different measures when trade-offs are necessary.

- *Which mechanisms could be used to increase stakeholders engagement?* Stakeholder participation is often described as key for the success of conservation measures (Reed, 2008). The stakeholders identified in this thesis as being the most influential also had little interest in greenspace conservation. Gaining a better understanding of their motivations as well as of the mechanisms to increase pro-environmental behaviours (Prévot et al., 2018; Whitburn et al., 2019) will be crucial to gain their support and thus increase their engagement in greenspace conservation.

- *What are the potential spatial synergies between the ecological structure of urban greenspaces and the well-being benefits of urban greenspaces?* Because urban areas have such a high density of inhabitants, taking into consideration different motivations for conserving urban biodiversity is critical (Dearborn and Kark, 2010). Specifically, land is a limited resource for which decisions will need to be taken as to what to prioritise, involving trade-offs between different land-uses and different ecosystem services (Turkelboom et al., 2018). Those decisions, often taken by the most influential stakeholders, tend to impact mostly the non-influential users of ecosystem services (Turkelboom et al., 2018). However, knowledge of the spatial trade-offs and synergies between different ecosystem services or between the biological structures and the derived well-being benefits is still scarce (Luederitz et al., 2015). This thesis, by linking the ecological structures with the motivations for conserving urban greenspaces, provided some insight on how the feedbacks between the environment and the socio-economic systems work. Further investigations of those linkages, including of the direct benefits received from urban greenspaces, will better inform conservation priorities in African urban areas.

5.5 Conclusion

Urban conservation is relatively recent domain of study. However, in light of the fast pace of urbanisation, especially in the Global South, and the increasing

tendency of urban areas to sprawl (Seto et al., 2011), there is an urgent need to understand how to conserve urban biodiversity before its disappearance. Through its inter-disciplinary multi-perspectives approach to urban greenspace conservation, this thesis provides valuable insight into the complexities of urban greenspace conservation in Sub-Saharan Africa.

This thesis highlighted that, from an ecological point of view, small cities in Sub-Saharan Africa have the potential to conserve at least some subsets of biodiversity in a region where biodiversity is threatened. However, it also highlighted that very low priority is given to urban greenspaces by a large variety of stakeholders, including those whose support is critical. Influential stakeholders justify their lack of interest for greenspaces as opposed to other infrastructures by the need to develop land for the general good of their community. In Sub-Saharan Africa, urban poverty is a prominent issue, with about 56% of the urban population living in slums (UN-Habitat, 2016). In circumstances of such financial insecurity and lack of resources for most of the urban population, it is to be expected that urban residents and those whose role it is to care for the community would more be concerned about their fulfilling essential needs than about focusing on conservation issues (Kenrick et al., 2010).

There is international recognition, through the inclusion of cities as an SDG (goal 11), of urban areas' contribution to a more inclusive, safe, resilient and sustainable future (United Nations, 2015). One of the ways to increase the sustainability of the city is through densification, as inhabitants of dense urban areas are less likely to own a car, thus reducing energy use, more likely to use local services and might be more community-oriented than in more sprawling cities (Dempsey et al., 2011; Neuman, 2005). Additionally, dense urban areas in general are perceived to provide many advantages for their populations in terms of the availability of infrastructures and services (Satterthwaite, 2017).

Though densifying urban areas can be advantageous in regards to service provision and reducing energy use, total destruction of urban greenspaces can also have some consequences that might not be deemed critical while poverty is still high but which could affect the long-term liveability of urban areas. This thesis revealed that pollination and urban farming were seen to be contentious. Given that urban farming is known to contribute to food security in developing

countries (Zezza and Tasciotti, 2010), their attractiveness might further might decrease as the urban areas become more wealthy. However, urban greenspace can provide plenty of other locally delivered services such as local temperature regulation (Rizwan et al., 2008), flood control and mitigation (Bai et al., 2018), improvement of cognitive development (Dadvand et al., 2015), health (Tzoulas et al., 2007) and well-being (Marselle et al., 2019), provision of recreation opportunities (Bolund and Hunhammar, 1999) and increased community attachment (Arnberger and Eder, 2012). Consequently, destruction of urban greenspaces and resulting loss of such locally delivered ecosystem services would be a critical blow to many of the Sustainable Development Goals that they contribute to. Solely focussing on SDG 8 (decent work and economic growth) might then prejudice other sustainability targets. Additionally, even though not prioritised over and development, this thesis revealed that many of those ecosystem services are recognised and valued by influential stakeholders as well as urban residents.

This thesis highlights that urban greenspace conservation will not happen unless drastic action is taken to change the current perception of greenspaces as being less valuable than the built environment in African urban areas. Such change of perception can take place only by acknowledging the other priorities of both residents and influential stakeholders, and by depicting greenspace conservation not as an aim in itself, but as a tool to achieve sustainable urban development.

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Appendix A:

Ethics clearance

Performance, Governance and Operations
Research & Innovation Service
Charles Thackrah Building
101 Clarendon Road
Leeds LS2 9LJ Tel: 0113 343 4873
Email: ResearchEthics@leeds.ac.uk

UNIVERSITY OF LEEDS

Solène Guenat
Sustainability Research Institute
School of Earth and Environment
University of Leeds
Leeds, LS2 9JT

ESSL, Environment and LUBS (AREA) Faculty Research Ethics Committee
University of Leeds

23 June 2018

Dear Solène

Title of study: **Ecosystem services in small African cities: land-use, biodiversity conservation, pollination and human well-being**

Ethics reference: **AREA 15-145**

I am pleased to inform you that the above research application has been reviewed by the ESSL, Environment and LUBS (AREA) Faculty Research Ethics Committee and following receipt of your response to the Committee's initial comments, I can confirm a favourable ethical opinion as of the date of this letter. The following documentation was considered:

Document	Version	Date
AREA 15-145 SG_Ethical_review_form_v2.pdf	3	17/06/16
AREA 15-145 SG_Information_sheet_V2.pdf	3	17/06/16
AREA 15-145 SG_Consent_form_V2.pdf	3	17/06/16
AREA 15-145 Fieldwork_Assessment_Form_SG_MD.pdf	2	03/06/16

Please notify the committee if you intend to make any amendments to the information in your ethics application as submitted at date of this approval as all changes must receive ethical approval prior to implementation. The amendment form is available at http://ris.leeds.ac.uk/EthicsAmendment.

Please note: You are expected to keep a record of all your approved documentation, as well as documents such as sample consent forms, and other documents relating to the study. This should be kept in your study file, which should be readily available for audit purposes. You will be given a two week notice period if your project is to be audited. There is a checklist listing examples of documents to be kept which is available at http://ris.leeds.ac.uk/EthicsAudits.

We welcome feedback on your experience of the ethical review process and suggestions for improvement. Please email any comments to ResearchEthics@leeds.ac.uk.

Yours sincerely

Jennifer Blaikie

Senior Research Ethics Administrator, Research & Innovation Service

On behalf of Dr Andrew Evans, Chair, AREA Faculty Research Ethics Committee

CC: Student's supervisor(s)

The Secretariat
University of Leeds
Leeds, LS2 9JT
Tel: 0113 343 4873
Email: ResearchEthics@leeds.ac.uk

UNIVERSITY OF LEEDS

Solène Guenat
Sustainability Research Institute
School of Earth and Environment
University of Leeds
Leeds, LS2 9JT

ESSL, Environment and LUBS (AREA) Faculty Research Ethics Committee

University of Leeds

23 June 2018

Dear Solène

Title of study: **Ecosystem services in small African cities: pollination, perception and governance of urban greenspaces**

Ethics reference: **AREA 16-184**

I am pleased to inform you that the above research application has been reviewed by the ESSL, Environment and LUBS (AREA) Faculty Research Ethics Committee and following receipt of your response to the Committee's initial comments I can confirm a favourable ethical opinion as of the date of this letter. The following documentation was considered:

Document	Version	Date
AREA 16-184 EthicalReview_SG_AREA16-184_v2.pdf	2	12/09/17
AREA 16-184 InfoLetter_NetMap_v1.pdf	1	26/07/17
AREA 16-184 InfoLetter_Q_v1.pdf	1	26/07/17
AREA 16-184 InfoSheet_Q_v2.pdf	1	26/07/17
AREA 16-184 Consent_form.pdf	1	26/07/17
AREA 16-184 Contract_employement.pdf	1	26/07/17
AREA 16-184 RiskAssesment_SG.pdf	1	26/07/17

Please notify the committee if you intend to make any amendments to the information in your ethics application as submitted at date of this approval as all changes must receive ethical approval prior to implementation. The amendment form is available at http://ris.leeds.ac.uk/EthicsAmendment.

Please note: You are expected to keep a record of all your approved documentation and other documents relating to the study, including any risk assessments. This should be kept in your study file, which should be readily available for audit purposes. You will be given a two week notice period if your project is to be audited. There is a checklist listing examples of documents to be kept which is available at http://ris.leeds.ac.uk/EthicsAudits.

We welcome feedback on your experience of the ethical review process and suggestions for improvement. Please email any comments to ResearchEthics@leeds.ac.uk.

Yours sincerely

Jennifer Blaikie

Senior Research Ethics Administrator, the Secretariat

On behalf of Dr Kahryn Hughes, Chair, AREA Faculty Research Ethics Committee

CC: Student’s supervisor(s)

Appendix B:
Supplementary information to Chapter 2

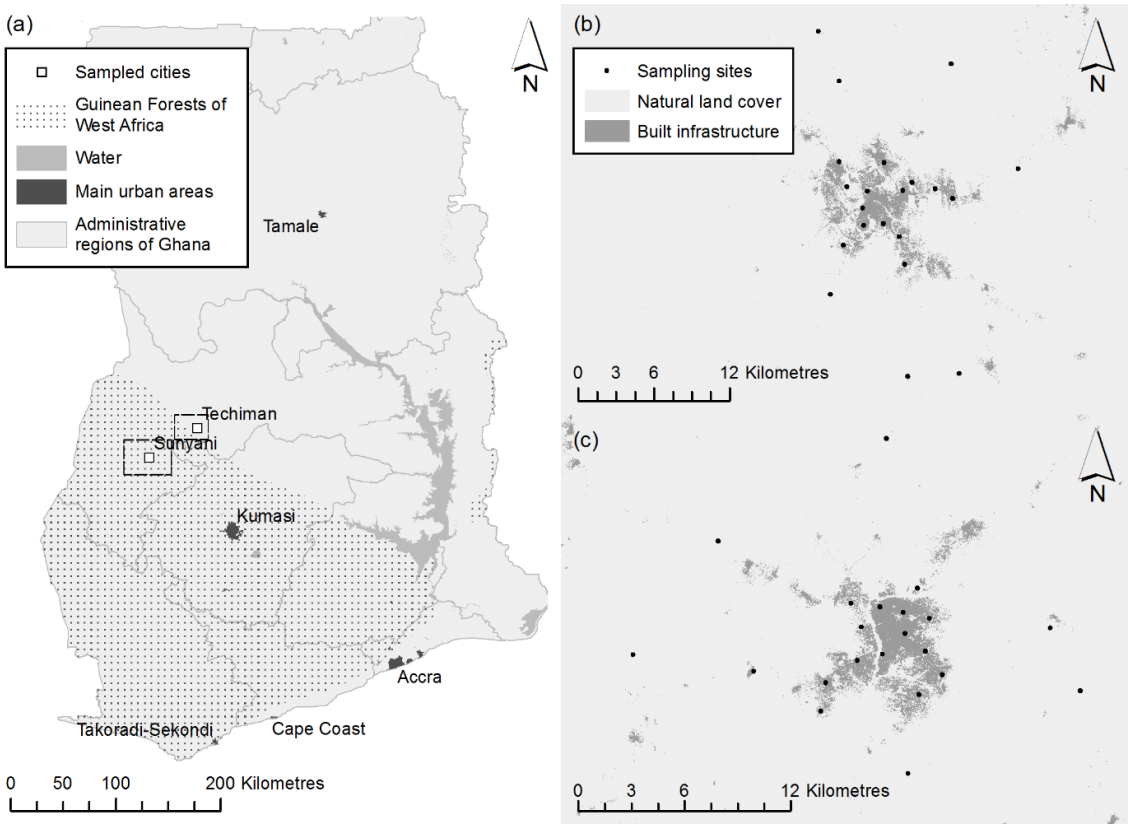

Figure B.1. Maps of the study area. (a) The two studied cities within Ghana. Dotted lines represent the extend of figures (b) and (c); (b) the sampling areas in the Sunyani and (c) Techiman regions, with each point representing a sampling area within which three sites of different management practices were selected. Contains modified Copernicus Sentinel data (2015).

Figure B.2. Example of the sites surveyed. (a) urban amenity land, (b) urban farmed vegetation, (c) urban informal greenspace, (d) rural amenity land, (e) rural farmed vegetation and (f) rural informal greenspace. Photo credit: S. Guenat

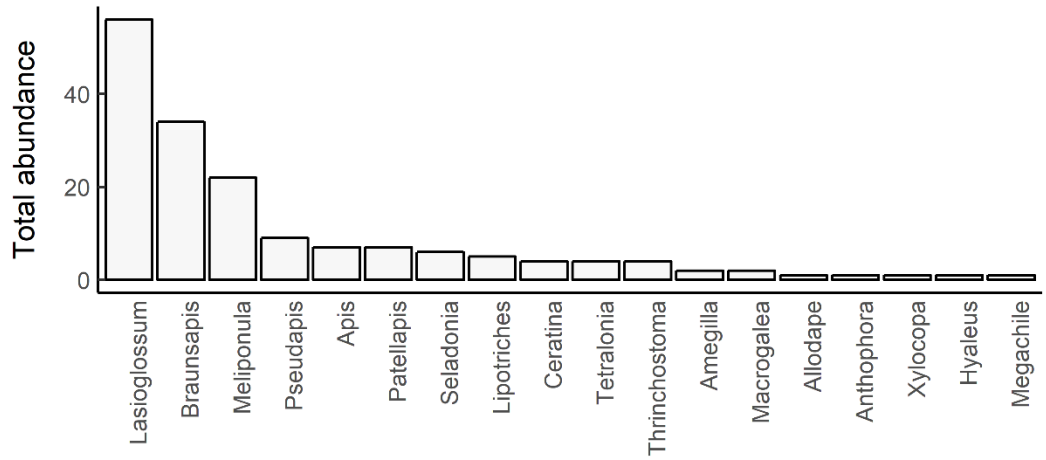

Figure B.3. Relative abundances of the different bee genera sampled in the whole community.

Table B.1. Traits used in the analysis of bee functional diversity in relation to urbanisation and management practices in western Ghana. Trait information was compiled from the indicated sources and includes their relevance of ecosystem services delivery.

Traits	Type	Categories	Relevance for ecosystem service delivery	Source
Habitat	Categorical	Generalists Specialists Woodlands Savannah	Indicates type of habitat structure in which bees fare best	Pauly (1998); Pauly *et al.* (2001); Eardley *et al.* (2010)
Body size (inter-tegular distance, ITD)	Continuous	N/A	Correlated with bee foraging range (Greenleaf et al., 2007)	All bee specimens were measured using a caliper.
Tongue length	Categorical	Short-tongued Long-tongued	Affects the type of plants bees can pollinate	Eardley *et al.* (2010)
Pollen specialisation	Categorical	Oligolectic Polylectic	Efficiency as pollinators	Michener (2000; 1971); Pauly (1998); Eardley *et al.* (2010)
Sociality	Categorical	Social Solitary	Social bees are more affected by pesticides and isolation from natural habitat (Williams et al., 2010)	Michener (1971; 2000); Eardley *et al.* (2010)
Nesting location	Categorical	Cavity nesting Soil nesting	Affects the resistance to disturbances	Michener (1968; 1971); Eardley *et al.* (2010)

Table B.2. Abundance of all bee sub-genera, the number of morpho-species identified and their assigned functional traits. Based on the literature cited in Table B.1. Inter-tegular distance was measured with a calliper on every specimen and used as a continuous variable in the analysis. Distribution of the categorical traits amongst the sampled bees are presented in Table B.9.

				Assigned functional traits					
Family	Genera (sub-genera)	Abundances	Nb of morphospecies	Habitat	ITD (average +/- SE)	Tongue length	Pollen specialisation	Sociality	Nest location
Apidae	*Allodape* Lepeletier and Serville	1	1	Woodlands	0.18 +/- 0	Long	Polylectic	Social	Cavity
	Amegilla Friese	2	1	Ubiquitous	0.36 +/- 0.035	Long	Polylectic	Solitary	Soil
	Anthophora (Paramegilla) Friese	1	1	Savannah	0.32 +/- 0	Long	Polylectic	Solitary	Soil
	Apis Linnaeus	7	1	Ubiquitous	0.27 +/- 0.007	Long	Polylectic	Social	Cavity
	Braunsapis Michener	34	15	Ubiquitous	0.14 +/-0.005	Long	Polylectic	Social	Cavity
	Ceratina (Ceratina) Latreille	1	1	Ubiquitous	0.14 +/- 0	Long	Polylectic	Social	Cavity
	Ceratina (Megaceratina) Hirashima	1	1	Ubiquitous	0.12 +/- 0	Long	Polylectic	Social	Cavity
	Ceratina (*Protopithitis*) Hirashima	2	2	Ubiquitous	0.17 +/- 0.013	Long	Polylectic	Social	Cavity

	Macrogalea Cockerell	2	2	Ubiquitous	0.19 +/-0.015	Long	Polylectic	Social	Cavity
	Meliponula (Axestotrigona) Moure	22	1	Woodlands	0.09 +/- 0.003	Long	Polylectic	Social	Cavity
	Tetralonia (*Thygatina*) Cockerell	4	2	Ubiquitous	0.29 +/- 0.011	Long	Oligolectic	Solitary	Soil
	Xylocopa (*Koptortosoma*) Gribodo	1	1	Ubiquitous	0.60 +/- 0	Long	Polylectic	Social	Cavity
Megachilidae	*Megachile* (*Chalicodoma*) Lepeletier	1	1	Ubiquitous	0.25 +/- 0	Long	Polylectic	Solitary	Cavity
Colletidae	*Hylaeus* (*Nothylaeus*) Bridwell	1	1	Woodlands	0.14 +/- 0	Short	Polylectic	Solitary	Cavity
Halictidae	*Lasioglossum* (*Ctenonomia*) Cameron	15	7	Savannah	0.14 +/- 0.008	Short	Polylectic	Social	Soil
	Lasioglossum (*Ipomalictus*) Pauly	41	17	Ubiquitous	0.13 +/- 0.004	Short	Oligolectic	Social	Soil
	Lipotriches (Austronomia)	2	2	Ubiquitous	0.15 +/- 0.033	Short	Oligolectic	Solitary	Soil
	Lipotriches (*Lipotriches*)	2	2	Ubiquitous	0.18 +/- 0.032	Short	Oligolectic	Solitary	Soil
	Lipotriches (*Macronomia*)	1	1	Ubiquitous	0.22 +/- 0	Short	Oligolectic	Solitary	Soil
	Patellapis (*Dictyohalictus*) Michener	7	6	Woodlands	0.13 +/- 0.009	Short	Polylectic	Solitary	Soil
	Pseudapis (*Pachynomia*) Pauly	3	2	Savannah	0.14 +/- 0.006	Short	Polylectic	Solitary	Soil

	Pseudapis (*Pseudapis*) Kirby	6	3	Savannah	0.17 +/- 0.011	Short	Polylectic	Solitary	Soil
	Seladonia (Seladonia) Robertson	6	3	Ubiquitous	0.15 +/- 0.005	Short	Oligolectic	Solitary	Soil
	Thrinchostoma (*Thrinchostoma*) Saussure	4	2	Woodlands	0.19 +/- 0.010	Short	Oligolectic	Solitary	Soil
Totals		167	68		1.50 +/- 0.051				

Table B.3. Variables included in the habitat characterisation analysis, with the analysis of their distribution, heterogeneity of variance and comparison between management practices.

Variable	Description	Shapiro-Wilk test of normality		Figner-Killeen Test of Homogeneity of Variances			Kruskall-Wallis comparison with management			Spearman correlation with urbanisation	
		W	p-value	Chi-squared	df	p-value	Chi-squared	df	p-value	rho	p-value
Floral resources	Flower count multiplied by their visually estimated size on a 1m radius around the trap	0.782	<0.001	2.922	2	0.023	0.171	2	0.918	-0.07	0.451
Flowering plant species richness	Average number of flowering plants in each site	0.944	<0.001	5.015	2	0.082	26.086	2	<0.001	-0.03	0.776
Flowering plant diversity	Simpson’s diversity index for flowering plants at each sites	0.934	<0.001	13.069	2	0.001	16.7	2	<0.001	0.01	0.874
Shrub layer	Visual estimation of the	0.813	<0.001	17.945	2	<0.001	40.095	2	<0.001	0.02	0.804

Tree layer	proportion of the feature in 200m around the sampling site.	0.777	<0.001	1.483	2	0.476	2.797	2	0.247	0.07	0.421
Ground layer		0.898	<0.001	0.607	2	0.037	71.71	2	<0.001	0.14	0.118
Mown vegetation		0.466	<0.001	95.23	2	<0.001	49.367	2	<0.001	-0.17	0.053
Bare ground		0.903	<0.001	10.422	2	0.005	21.938	2	<0.001	0.07	0.465
Concrete		0.488	<0.001	37.974	2	<0.001	13.791	2	0.001	-0.32	<0.001

Table B.4. Variables included in the generalised linear models for analysis of bee, wasp, lepidoptera, beetle and fly abundances, bee diversity and bee functional traits, with their description, summary statistics and the source of the data.

Variable name	Description	Source	Unit	Mean	SE	VIF
Management	Categorical: amenity lands, farmed sites, informal greenspaces	On-site data collection	NA	NA	NA	2.34
Urbanisation	Continuous: proportion of built infrastructure within 600m of the sampling site	Land-cover maps based on Sentinel 2 imagery	%	37.55	2.74	1.50
Cities	Categorical: Sunyani and Techiman	On-site data collection	NA	NA	NA	1.37
Floral resources	Flower count multiplied by their visually estimated size on a 1m radius around the trap	On-site data collection	cm^2	149.34	15.42	1.47
Flowering species richness	Species richness of the flowering plants 1m around the trap	On-site data collection	Nb of species	2.28	0.15	2.26
Flowering diversity	Simpson's index of diversity of the flowering plants 1m around the traps	On-site data collection	1-*D*	0.49	0.03	1.42
Wind speed	Average of the estimation (Beaufort scale) during set-up and removal	On-site data collection	Beaufort number	2.37	0.08	1.19
Temperature	Mean temperature of the two days of exposure	MetOffice Ghana	°C	26.47	0.05	1.64
Cloud cover	Mean of the visual estimation of cloud cover during set-up and removal	On-site data collection	Percent	75.63	2.14	1.38

Rainfall	Total rainfall at sampling site during trap exposure, measured with a rain gauge	On-site data collection	mm	5.47	0.92	1.31
Habitat structure						
Shrub layer			%	21.19	2.11	1.25
Tree layer			%	13.40	1.42	1.13
Mown vegetation	Visual estimation of the proportion of the feature in 200m around the sampling site.	On-site data collection	%	10.21	2.20	2.31
Bare ground			%	36.11	2.53	2.21
Concrete			%	6.73	1.43	1.56
Sampling area	Categorical random variable: area in which each management practice was sampled	On-site data collection	NA	NA	NA	1.30

Table B.5. Crops found in the study region, with their presence in sample urban and rural farms and, for those whose fruits are consumed, their pollinators in Africa.

Common names	Latin name	Urban	Rural	Pollinators	Source
Aubergine	*Solanum melongena*	Present	Present	Wild bees	(Rodger et al., 2004)
Beans	*Phaseolus* spp.	Present	Absent	Self and bees	(Rodger, Balkwill & Gemmill 2004)
Cabbage	*Brassica chinensis*	Absent	Present	-	
Carrots	*Daucus carrota*	Present	Present	-	
Cashew	*Anacardium occidentale*	Present	Present	Flies, ants and bees	(Rodger, Balkwill & Gemmill 2004)
Cassava	*Manihot esculenta*	Present	Present	-	
Cocoa	*Theobroma cacao*	Present	Present	Ceratopogonid midges, thrips and ants	(Rodger, Balkwill & Gemmill 2004)
Coconut	*Cocos nucifera*	Present	Present	Wind and bees	(Rodger, Balkwill & Gemmill 2004)
Coffee	*Coffea arabica*	Absent	Present	Self and bees	(Rodger, Balkwill & Gemmill 2004)
Groundnut	*Arachis hypogea*	Present	Absent	Self, but bees and thrips increase production	(Rodger, Balkwill & Gemmill 2004)

Maize	*Zea mais*	Present	Present	Non-animal	(Klein et al., 2007)
Mango	*Mangifera indica*	Present	Present	Bees, flies, ants, wasps	(Klein *et al.* 2007)
Millet	*Echinocloa frumentaceae*	Present	Absent	Non-animal	(Klein *et al.* 2007)
Moringa	*Moringa oleifera*	Present	Present	Wild bees (India)	(Jyothi et al., 1990)
Oil palm	*Elaeis guineensis*	Present	Present	Beetles	(Rodger, Balkwill & Gemmill 2004)
Okra	*Abelmoschus esculentus*	Present	Present	Self, bees, wasps, flies, beetles, but no information from Africa	(Rodger, Balkwill & Gemmill 2004)
Onion	*Allium cepa*	Present	Absent	-	
Oranges	*Citrus sinnensis*	Present	Present	Bees and other insects	(Rodger, Balkwill & Gemmill 2004)
Papaya	*Caricia papaya*	Present	Present	Hawkmoths, skipper butterflies	(Rodger, Balkwill & Gemmill 2004)
Pepper	*Capsicum* spp.	Present	Present	Self and bees	(Rodger, Balkwill & Gemmill 2004)
Pineapple	*Ananas comosus*	Present	Present	Butterflies, ants, sunbirds	(Kudom and Kwapong, 2010)
Plantain	*Musa sapientum*	Present	Present	Bats, honeybees, birds	(Ortiz and Crouch, 1997)

Potatoes	*Solanum tuberosum*	Present	Absent	-	
Pumpkin	*Cucurbita* spp.	Present	Present	Bees	(Rodger, Balkwill & Gemmill 2004)
Soursop	*Annona muricata*	Present	Absent	Beetles	(Rodger, Balkwill & Gemmill 2004)
Sweet potatoes	*Ipomoea patatas*	Present	Absent	-	
Taro	*Colocasia esculenta*	Present	Present	-	
Tomatoes	*Lycopersicon esculentum*	Present	Present	Self and large bees	(Rodger, Balkwill & Gemmill 2004)
Turkey berry	*Solanum torvum*	Present	Present	Insects	(CABI, 2018)
Yam	*Dioscorea* spp.	Present	Present	-	

Table B.6. Abundance of all insects by taxonomy and management practices. All insects were identified to order in the field. Bees and wasps were pinned and differentiated with microscopy based on Goulet and Huber (1993). Bees were identified with microscopy as per training received at Oxford University Museum of Natural history, based on (Eardley et al., 2010).

			Abundances			
Order	Family	Genera	Amenity lands	Farmed vegetation	Informal greenspaces	Total
Diptera	Drosophilidae	NA	11196	17556	17371	46123
	All other families	NA	975	861	1267	3103
Coleoptera	NA	NA	160	389	541	1090
Hymenoptera	Apidae	*Allodape* (Lepeletier and Serville)	0	0	1	1
		Amegilla (Friese)	0	0	2	2
		Anthophora (Latreille)	0	0	1	1
		Apis (Linnaeus)	1	2	4	7
		Braunsapis (Michener)	4	11	19	34

		Ceratina (Latreille)	1	0	3	4
		Macrogalea (Cockerell)	0	1	1	2
		Meliponula (Cockerell)	17	0	5	22
		Tetralonia (Spinola)	0	1	3	4
		Xylocopa (Latreille)	0	1	0	1
	Megachilidae	*Megachile* (Latreille)	0	0	1	1
	Colletidae	*Hylaeus* (Fabricius)	0	0	1	1
	Halictidae	*Lasioglossum* (Curtis)	15	15	26	56
		Lipotriches (Gerstaecker)	1	3	1	4
		Patellapis (Friese)	5	1	1	7
		Pseudapis (Kirby)	0	5	4	9
		Seladonia (Latreille)	0	1	5	6
		Thrinchostoma (Saussure)	1	2	1	4
	Wasps (paraphyletic)	NA	103	97	116	316
Lepidoptera	NA	NA	97	48	77	222

Table B.7. Parameter estimates, standard error, z-values and p-values for the averaged models (DeltaAICc≤2) for bee abundance, genera diversity, morpho-species diversity, wasp, lepidopteran, beetle and fly abundances.

	Estimate	Std. Error	Adjusted SE	z value	Pr(>|z|)
Bee abundances					
(Intercept)	-0.664	1.660	1.671	0.397	0.691
Cloud cover	1.005	0.470	0.475	2.117	0.034 *
Management					
Farmed-Amenities	-1.511	0.729	0.736	2.054	0.040 *
Informal-Amenities	0.628	0.606	0.611	1.028	0.304
Mown vegetation	-1.157	0.618	0.624	1.853	0.064
Urbanisation	0.001	0.007	0.007	0.118	0.906
Rainfall	-0.031	0.013	0.013	2.401	0.016 *
Management * Urbanisation					
Farmed-Amenities * Urbanisation	0.019	0.008	0.009	2.237	0.025 *
Informal-Amenities * Urbanisation	-0.001	0.007	0.007	0.179	0.858
Zero-inflation	-1.947	0.619	0.625	3.116	0.002 **
Concrete	1.141	0.690	0.697	1.636	0.102
Flowering plant species richness	-0.100	0.071	0.072	1.394	0.163
Flowering plant diversity	-0.588	0.422	0.426	1.379	0.168
Wind speed	0.187	0.122	0.123	1.518	0.129
Temperature	0.208	0.236	0.238	0.873	0.383
Floral resources	-0.001	0.001	0.001	0.936	0.349

Techiman-Sunyani	0.196	0.237	0.240	0.819	0.413
Tree layer	-0.523	0.708	0.715	0.731	0.465
Bee genera diversity					
(Intercept)	0.137	0.025	0.025	5.380	<0.001 ***
Tree layer	0.296	0.145	0.149	1.985	0.047 *
Concrete	-0.170	0.091	0.094	1.811	0.070
Bee morphospecies diversity					
(Intercept)	0.202	0.011		18.440 (t-value)	
Wasp abundances					
(Intercept)	-0.744	1.364	1.372	0.542	0.588
Techiman-Sunyani	-0.223	0.137	0.139	1.606	0.108
Cloud cover	1.382	0.302	0.305	4.533	<0.001 ***
Floral resources	0.001	0.000	0.000	2.431	0.015 *
Urbanisation	0.005	0.002	0.002	2.151	0.032 *
Rainfall	-0.015	0.007	0.007	2.071	0.038 *
Mown vegetation	-0.288	0.276	0.278	1.032	0.302
Temperature	0.125	0.126	0.127	0.980	0.327
Tree layer	0.331	0.407	0.411	0.805	0.421
Flowering plant species richness	0.031	0.043	0.043	0.705	0.481
Flowering plant diversity	0.167	0.231	0.234	0.716	0.474
Wind speed	0.047	0.076	0.077	0.614	0.540
Lepidoptera abundances					
(Intercept)	-22.080	7.038	7.104	3.108	0.002 **
Flowering plant diversity	0.893	0.478	0.483	1.850	0.064
Rainfall	-0.028	0.018	0.018	1.536	0.125
Temperature	0.833	0.261	0.264	3.161	0.002 **
Zero-inflation	-19.920	6706	6775	0.003	0.998

Bare ground	-0.666	0.473	0.478	1.392	0.164
Wind speed	-0.176	0.166	0.168	1.052	0.293
Tree layer	-0.882	0.888	0.897	0.984	0.325
Cloud cover	0.583	0.617	0.623	0.935	0.350
Mown vegetation	0.474	0.550	0.555	0.853	0.394
Shrub layer	-0.425	0.541	0.546	0.778	0.436
Floral resources	0.000	0.001	0.001	0.612	0.540
Urbanisation	0.003	0.005	0.005	0.569	0.570
Beetles abundances					
(Intercept)	-0.255	0.389	0.393	0.649	0.516
Techiman-Sunyani	0.250	0.137	0.138	1.811	0.070
Management					
Farmed-Amenities	1.936	0.392	0.396	4.889	<0.001 ***
Informal-Amenities	2.101	0.391	0.396	5.310	<0.001 ***
Mown vegetation	0.826	0.358	0.362	2.284	0.022 *
Urbanisation	0.019	0.004	0.004	4.582	<0.001 ***
Rainfall	-0.023	0.007	0.007	3.251	0.001 **
Management * Urbanisation					
Farmed-Amenities * Urbanisation	-0.012	0.005	0.005	2.497	0.013 *
Informal-Amenities * Urbanisation	-0.009	0.005	0.005	1.946	0.052
Bare ground	0.306	0.250	0.253	1.209	0.227
Wind speed	-0.076	0.076	0.076	1.000	0.317
Shrub layer	0.217	0.252	0.254	0.852	0.394
Non-fruit flies					
(Intercept)	2.901	0.539	0.541	5.364	<0.001 ***
Techiman-Sunyani	0.368	0.117	0.118	3.110	0.002 **

Cloud cover	0.616	0.217	0.219	2.814	0.005 **
Management					
Farmed-Amenities	-0.157	0.211	0.212	0.740	0.460
Informal-Amenities	0.151	0.215	0.217	0.698	0.485
Mown vegetation	-0.438	0.258	0.260	1.686	0.092
Urbanisation	-0.004	0.002	0.002	1.679	0.093
Flowering plant species richness	0.055	0.034	0.035	1.585	0.113
Rainfall	-0.024	0.006	0.006	4.107	<0.001 ***
Bare ground	-0.290	0.207	0.209	1.390	0.165
Floral resources	0.000	0.000	0.000	1.265	0.206
Flowering plant diversity	0.233	0.174	0.176	1.323	0.186
Management					
Farmed-Amenities	-0.006	0.003	0.004	1.849	0.064
Informal-Amenities	-0.005	0.003	0.003	1.488	0.137
Temperature	-0.078	0.021	0.021	3.735	<0.001 ***

N=126 for all models but the diversity ones, for which *N*=43. **P*<0.05; ***P*<0.01; ****P*<0.001.

Table B.8. Association, specificity and fidelity of the different genera to management practices and urbanisation categories.

Grouping variable	Genera associated	Specificity	Fidelity	Stat	P-value
Management					
Amenity lands	*Meliponula*	77.27	23.81	0.429	0.009 **
Farmed sites	NA	NA	NA	NA	NA
Informal greenspaces	Seladonia	83.33	11.90	0.315	0.048 *
Farmed + informal	*Braunsapis*	88.24	25.00	0.47	0.021 *
Urbanisation					
Urban	NA	NA	NA	NA	NA
Rural	*Braunsapis*	90.32	47.62	0.656	0.001 ***

N=42 amenities, 42 informal greenspaces, 42 agricultural, 84 urban, 42 rural. *P<0.05; **P<0.01; ***P<0.001.

Table B.9. Distribution of the different function traits amongst the sampled bees.

	Bee	
	Abundance	Proportion
Habitat specialisation		
Generalists	107	64.07%
Woodland specialists	35	20.96%
Savannah specialists	25	14.97%
Pollen specialisation		
Polylectic	107	64.07%
Oligolectic	60	35.93%
Nesting specialisation		
Cavity-nesting	73	43.71%
Soil-nesting	94	56.29%
Tongue length		
Short-tongued	88	52.69%
Long-tongued	79	47.31%
Sociality		
Social	127	76.05%
Solitary	40	23.95%

N=167

Table B.10. Spearman rank correlation among functional traits used to analyse bee functional diversity analysis in relation to urbanisation and management practices. The strength of the correlation (rho) and significance are given.

	Body size	Tongue	Pollen specialisation	Nest location	Sociality (social or solitary)
Habitat specialisation (generalists or specialists)	0.26 *	0.14	-0.42 ***	0.01	-0.16
Habitat speciality (woodland or savannah)	0.21	-0.42 **	-0.26	-0.46 **	-0.13
Body size (continuous)		-0.06	-0.22	-0.24 *	0.45 ***
Tongue (long-tongued or short-tongued)			0.55 ***	0.86 ***	-0.32 **
Pollen specialisation (polylectic or oligolectic)				0.68 ***	-0.22
Nest location (cavity or soil nesting)					-0.41 ***

N=162. **P*<0.05; ***P*<0.01; ****P*<0.001.

Table B.11. Parameter estimates, standard error, z-values and p-values for the averaged models (DeltaAICc≤2) for bee functional traits, including habitat specialisation and speciality, body size, tongue length, pollen specialisation, sociality and nest location.

	Estimate	Std. Error	Adjusted SE	z-value	Pr(>|z|)
Habitat specialisation					
(Intercept)	12.890	10.750	10.850	1.188	0.235
Bare ground	-2.665	0.796	0.808	3.298	<0.001 ***
Concrete	-3.252	1.296	1.318	2.467	0.014 *
Mown vegetation	-2.939	1.629	1.647	1.784	0.074
Temperature	-0.416	0.408	0.412	1.010	0.312
Shrub layer	0.228	0.590	0.594	0.383	0.702
Management					
Farmed-Amenity	0.267	0.584	0.586	0.455	0.649
Informal-Amenity	0.166	0.435	0.438	0.379	0.705
Cloud cover	0.060	0.296	0.298	0.202	0.840
Flower	0.000	0.000	0.000	0.159	0.874
Wind speed	-0.020	0.087	0.088	0.233	0.816
Rainfall	0.001	0.007	0.007	0.136	0.892
Habitat speciality					
(Intercept)	7.693	17.545	17.854	0.431	0.667
Management					
Farmed-Amenity	-2.629	0.877	0.907	2.898	0.004 **
Informal-Amenity	-1.605	0.762	0.787	2.040	0.041 *
Rainfall	0.284	0.171	0.177	1.607	0.108
Cloud cover	-1.469	2.034	2.067	0.711	0.477

Temperature	-0.205	0.613	0.625	0.328	0.743
Body size					
(Intercept)	-2.210	0.055	0.055	40.193	<0.001 ***
Management					
Farmed-Amenity	0.340	0.080	0.081	4.198	<0.001 ***
Informal-Amenity	0.299	0.064	0.064	4.656	<0.001 ***
Shrub layer	0.057	0.113	0.114	0.502	0.616
Tongue length					
(Intercept)	-2.187	1.577	1.594	1.372	0.170
Cloud cover	-0.991	1.188	1.198	0.828	0.408
Management					
Farmed-Amenity	-1.539	0.705	0.715	2.152	0.031 *
Informal-Amenity	0.441	0.542	0.551	0.801	0.423
Urbanisation	0.025	0.009	0.010	2.637	0.008 **
Rainfall	0.113	0.048	0.049	2.326	0.020 *
Shrub layer	1.204	1.228	1.239	0.972	0.331
Wind speed	0.323	0.313	0.316	1.022	0.307
Bare ground	-0.162	0.529	0.534	0.304	0.761
Flowering plant species richness	-0.010	0.055	0.056	0.171	0.865
Pollen specialisation					
(Intercept)	-9.020	11.515	11.600	0.778	0.437
Management					
Farmed-Amenity	-1.807	0.675	0.687	2.631	0.009 **
Informal-Amenity	-0.566	0.622	0.631	0.897	0.370
Urbanisation	0.016	0.009	0.009	1.847	0.065
Rainfall	0.065	0.040	0.040	1.608	0.108
Shrub layer	2.165	0.999	1.017	2.129	0.033 *

Temperature	0.315	0.447	0.451	0.700	0.484
Wind speed	0.116	0.195	0.197	0.590	0.555
Concrete	0.918	1.542	1.554	0.591	0.555
Bare ground	0.290	0.700	0.705	0.412	0.680
Flowering plant diversity	-0.048	0.281	0.283	0.169	0.866
Sociality					
(Intercept)	0.415	1.191	1.204	0.345	0.730
Management					
Farmed-Amenity	-1.283	1.258	1.270	1.010	0.312
Informal-Amenity	-1.468	1.367	1.378	1.066	0.287
Flowering plant diversity	2.264	1.255	1.274	1.776	0.076
Rainfall	0.111	0.071	0.072	1.535	0.125
Urbanisation	0.008	0.012	0.013	0.612	0.541
Mown vegetation	1.163	1.972	1.984	0.586	0.558
Bare ground	-0.281	0.785	0.791	0.355	0.723
Floral resources	0.000	0.001	0.001	0.262	0.794
Shrub layer	0.394	1.055	1.062	0.371	0.711
*Management * Urbanisation*					
Farmed-Amenities * Urbanisation	-0.003	0.011	0.011	0.231	0.818
Informal-Amenities * Urbanisation	0.002	0.010	0.010	0.189	0.850
Flowering plant species richness	-0.008	0.053	0.054	0.149	0.881
Cloud cover	0.063	0.376	0.380	0.165	0.869
Concrete	0.173	0.811	0.819	0.211	0.833
Nest location					
(Intercept)	-2.187	1.577	1.594	1.372	0.170
Cloud cover	-0.991	1.188	1.198	0.828	0.408

Management					
Farmed-Amenity	-1.539	0.705	0.715	2.152	0.031 *
Informal-Amenity	0.441	0.542	0.551	0.801	0.423
Urbanisation	0.025	0.009	0.010	2.637	0.008 **
Rainfall	0.113	0.048	0.049	2.326	0.020 *
Shrub layer	1.204	1.228	1.239	0.972	0.331
Wind speed	0.323	0.313	0.316	1.022	0.307
Bare ground	-0.162	0.529	0.534	0.304	0.761
Flowering plant species richness	-0.010	0.055	0.056	0.171	0.865

N=76 for all models. *P*<0.05; ***P*<0.01; ****P*<0.001.

B.1. References

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Appendix C:
Characterising social networks interview guide

C.1. Background information

- What organisation are you part of?
- What is your role as part of this organisation?
- What is the role of your organisation?
- How do you think this role affects greenspaces (and differentiation between different types of greenspaces)?
- What is your city and neighbourhood of work?

C.2. General rules and explanations

- There are no correct answers, it is your point of view that I'm interested in.
- You can always go back and change, add or delete something if you feel it's needed.

C.3. Stakeholder identification

Can you write down on those stickers the role/function of groups of persons who you think have an influence on urban greenspaces?

- You can use one sticker per person/group of persons
- This influence can be formal or informal

  Explanation through example (if needed): formal could be someone who makes the laws or who is officially responsible for maintenance, informal

could be someone who decides what to do with the land or influences the person who decides.

- This influence can any level, e.g. local patch of agricultural land, suburb, city, *district*, *region*, or country.

For each of the stakeholders (stickers), can you explain what you think is their role within the city and how you think that role is affecting (different types of) urban greenspaces?

C.4. Relationships

Can you draw lines or arrows between the different people?

- In blue: who is providing funding (paying money) to whom?
- In red: who is providing technical information or advice to whom?
- In black: who has informal influence on whom?
- In green: who is has formal oversight over whom?
- In yellow: where there is a disagreement or conflict between two stakeholders. Could you explain what those conflicts are?

C.5. Influence

Can you show the influence of each groups has on greenspaces in relation to the other through piling up those draught tokens?[4]

- The more influence an stakeholder has, the higher the tower
- The towers can be as high as the participant want
- Two stakeholder can have towers of the same size
- If a stakeholder has no influence at all, no tower is added.

[4] At this point, the participant will have a network in front of her/him with the names/role of the stakeholders on stickers and lines representing relationships between them. S/her will be presented with stackable draught pieces to pile up next to the stakeholder's stickers to represent their relative influence, with the higher pile the more influence.

Appendix D: Supplementary information to Chapter 3

Table D.1. Number of participants per sampling category and city.

	Sunyani	Techiman
Government workers	7	4
Chiefs	3	2
Estate developers	2	1
NGO members	2	2

Table D.2. Network metrics measured per stakeholders. Metrics includes the number of mentions (number of times they were mentioned in an interview, out of 23 interviews); the average (+/-SE) of the normalised influence (from 0 to 1) they were given; their in- and out-degree and betweenness centrality for formal authority, informal influence, funds and information transfers; and their degree centrality for conflicts.

			Formal authority			Informal influence		
Stakeholders	Nb of mentions	Influence (average +/- SE)	Indegree (average +/- SE)	Outdegree (average +/- SE)	Betweenness (average +/- SE)	Indegree (average +/- SE)	Outdegree (average +/- SE)	Betweenness (average +/- SE)
Local gov.	23	0.82 +/-0.03	5.70 +/-2.52	46.25 +/-6.41	7.95 +/-7.33	22.61 +/-6.52	16.14 +/-4.49	7.58 +/-4.76
Chiefs	19	0.74 +/-0.06	16.66 +/-5.72	24.36 +/-8.25	5.26 +/-5.26	18.50 +/-4.41	20.04 +/-4.29	22.59 +/-9.53
Central gov.	22	0.68 +/-0.06	11.34 +/-4.90	23.02 +/-4.64	9.09 +/-6.27	17.73 +/-5.18	10.59 +/-3.25	3.83 +/-2.67
Residents	21	0.58 +/-0.07	20.61 +/-3.29	1.59 +/-1.59	0.00 +/-0.00	13.18 +/-3.35	19.75 +/-6.95	0.00 +/-0.00
Industries	19	0.53 +/-0.07	23.74 +/-6.19	0.66 +/-0.66	0.00 +/-0.00	10.86 +/-3.56	7.64 +/-3.82	0.00 +/-0.00
Media	9	0.48 +/-0.05	4.13 +/-2.26	0.00 +/-0.00	0.00 +/-0.00	9.80 +/-4.10	16.14 +/-8.67	0.00 +/-0.00
Rel. bodies	5	0.45 +/-0.16	21.67 +/-11.59	2.50 +/-2.50	0.00 +/-0.00	7.40 +/-3.15	10.10 +/-3.48	2.40 +/-2.40
NGOs	15	0.41 +/-0.05	13.79 +/-5.11	3.06 +/-2.32	6.67 +/-6.67	8.60 +/-3.49	12.47 +/-4.53	0.00 +/-0.00
Educ. inst.	13	0.39 +/-0.08	16.76 +/-4.24	0.00 +/-0.00	0.00 +/-0.00	5.23 +/-1.96	13.25 +/-7.79	0.00 +/-0.00
Regional gov.	3	0.37 +/-0.24	16.19 +/-1.90	20.95 +/-12.38	16.67 +/-16.67	11.11 +/-11.11	0.00 +/-0.00	0.00 +/-0.00

Table D.2 (cc'd). Network metrics measured per stakeholders, Metrics includes the number of mentions (number of times they were mentioned in an interview**,** out of 23 interviews); the average (+/-SE) of the normalised influence (from 0 to 1) they were given; their in- and out-degree and betweenness centrality for formal authority, informal influence, funds and information transfers; and their degree centrality for conflicts.

	Funds			Information			Conflicts
Stakeholders	Indegree (average +/- SE)	Outdegree (average +/- SE)	Betweenness (average +/- SE)	Indegree (average +/- SE)	Outdegree (average +/- SE)	Betweenness (average +/- SE)	Degree (average +/- SE)
Local government	20.86 +/-5.25	21.37 +/-5.26	18.33 +/-7.40	10.29 +/-4.52	42.78 +/-6.94	7.95 +/-4.87	25.30 +/-3.71
Chiefs	22.80 +/-4.89	6.40 +/-2.38	16.23 +/-8.56	25.97 +/-5.12	2.21 +/-1.42	8.42 +/-5.99	23.92 +/-3.98
Central gov.	15.64 +/-3.94	17.00 +/-4.19	6.06 +/-4.72	14.44 +/-4.83	25.82 +/-5.82	15.85 +/-7.04	16.29 +/-3.70
Residents	11.90 +/-3.92	18.49 +/-5.01	4.76 +/-3.28	16.30 +/-2.85	5.55 +/-2.51	6.04 +/-4.78	12.95 +/-2.95
Industries	9.02 +/-4.04	30.08 +/-7.64	8.60 +/-5.74	17.21 +/-3.38	4.53 +/-2.69	7.24 +/-5.35	19.27 +/-4.17
Media	15.28 +/-11.27	1.39 +/-1.39	3.33 +/-3.33	12.39 +/-3.61	7.31 +/-4.02	10.68 +/-7.07	0.00 +/-0.00
Religious bodies	7.17 +/-3.33	6.67 +/-4.22	0.00 +/-0.00	10.74 +/-2.98	5.71 +/-5.71	0.00 +/-0.00	1.05 +/-1.05
NGOs	12.89 +/-5.42	5.04 +/-2.71	2.78 +/-2.78	11.03 +/-3.57	20.99 +/-7.72	8.21 +/-6.73	8.07 +/-2.86
Educational inst.	10.37 +/-3.74	10.13 +/-7.61	0.13 +/-0.13	12.08 +/-3.36	7.25 +/-4.33	1.92 +/-1.92	2.05 +/- 1.44
Regional gov.	6.67 +/-6.67	0.00 +/-0.00	0.00 +/-0.00	31.67 +/-22.42	0.00 +/-0.00	0.00 +/-0.00	4.76 +/-4.76

Table D.3. Conflicts between the different stakeholders. The values represent the number of times, out of 23 interviews, that such conflict was mentioned.

	Local government	Chiefs	Central government	Residents	Industries	Media	Religious bodies	NGOs	Educational institutions	Regional government
Local government	NA	9	9	7	6	0	0	5	1	3
Chiefs		NA	7	5	5	0	0	3	1	1
Central government			NA	5	5	0	0	2	0	0
Residents				NA	5	0	0	2	0	0
Industries					NA	0	1	2	0	0
Media						NA	0	0	0	0
Religious bodies							NA	0	0	0
NGOs								NA	0	0
Educational institutions									NA	0
Regional government										NA

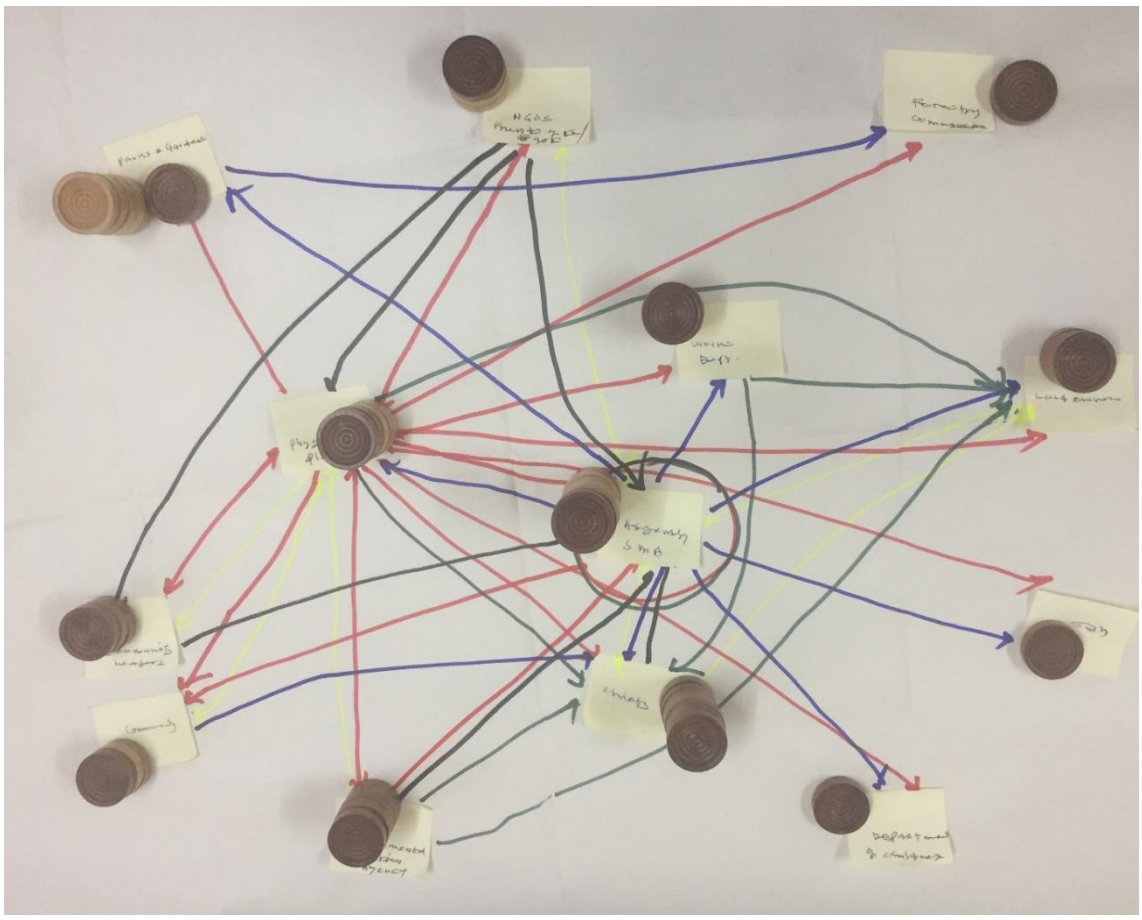

Figure D.1. Example of a NetMap. The NetMap exercise leading to the creation of such map is split into three steps as follow:

(a) identifying the stakeholders with an impact on greenspaces: each sticky note represents a stakeholder identified by the participant. Participants are free to add stakeholder later during the process if they were forgotten at the initial stage;

(b) identifying interactions between the stakeholders: five types of interactions were draw and color-coded (formal authority in green, informal influence in black, transfer of funds in blue, information sharing in red and conflict in yellow). All interactions except the conflicts (bidirectional) are drawn as arrows representing the direction of the flow (e.g. the community transfer funds to the chiefs). Stakeholders being a source of one type of interaction towards all others were circled.

(c) identifying the relative strength of the impact of each stakeholder on urban greenspaces: tokens were piled up to represent how much impact each stakeholder had on urban greenspaces. Participants were free to choose the height of the towers, whose height relative to each other was normalised from 0 to 1 in the analysis.

Appendix E: Untangling motivations interview guide

E.1. Pre-sorting interviews

E.1.1. Background information

Age: _____

Gender: _____

Religion: _____

Education level: _____

Place of origin: _____

☐ Rural ☐ Urban

If rural: when did they move to the city? _____

Function/work: _____

City and neighbourhood of domicile: _____

E.1.2. General perceptions of urban greenspaces

- How would you describe your city to someone coming to visit from somewhere else?
- How would you convince a friend to come and live in the area?
- Could you tell me which neighbourhoods you prefer in the city?

- Could you describe me shortly what you think is an urban greenspace? (*prompts:* trees, flowers, lawns, farms, weeds)

I am going to show you 5 pictures of urban greenspaces, could you order them from the one you prefer to the one you like less. Could you explain me why?

E.2. Sorting

- Can you please read through those cards and order them in three piles: those you agree with, those you don't agree with and those for which neither agree nor disagree? Do not hesitate to ask if you have any question or if there is anything you don't understand.
- On the grid, can you place the rank the cards that you agree with on the right? The further you disagree the more on the left, and the height has no importance. Can you then do the same with the other piles?

E.3. Post-sorting interviews: Q-sort explanation

- Can you explain me why you chose those as the ones you most agreed with?
- And those as the ones you most disagreed with?
- Is there any card that you didn't really understand?
- Is there any benefits or disadvantages of urban greenspaces that you can think of and that was not mentioned in the cards? If so can you write it down and rank it?

Appendix F:
Supplementary information to
Chapter 4

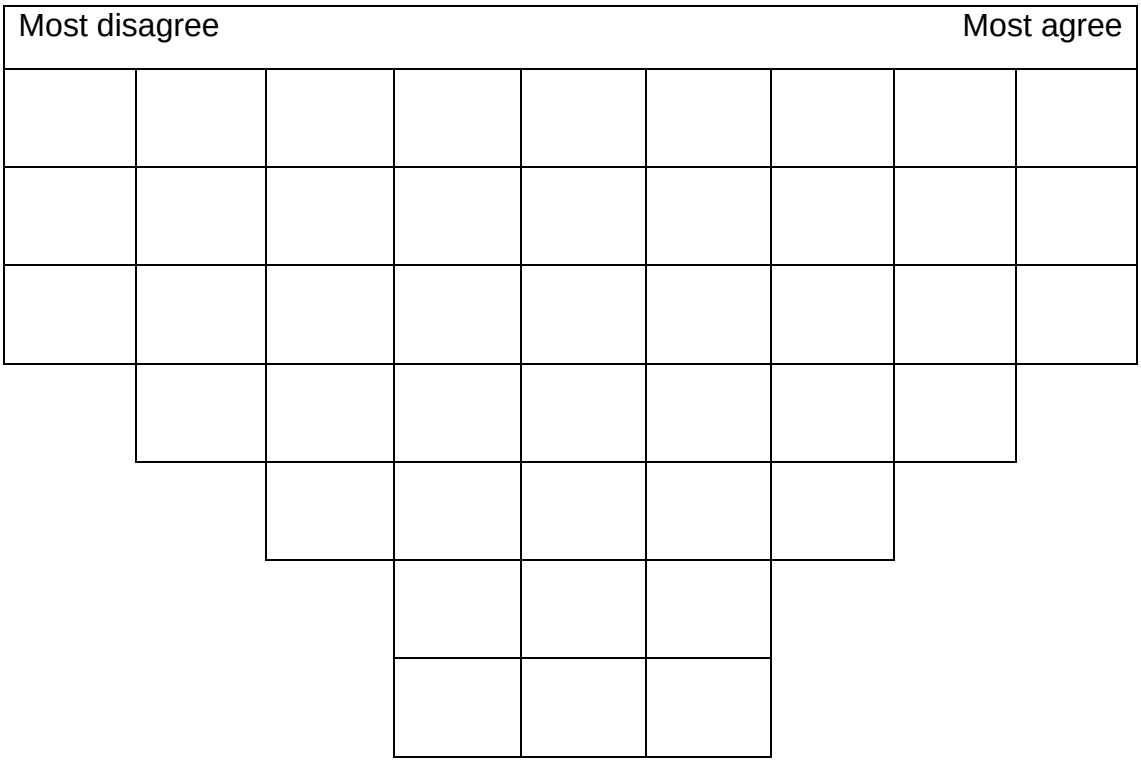

Figure F.1. Example of the grid presented to the participants for the sorting of the 45 statements on ecosystem services and disservices.

Table F.1. Sources from which statement were based. Online media were searched between July 11 and August 18, 2017 with the search string “urban” OR “city” AND “parks” OR “vegetation” OR “green” OR “wildlife” OR “tree” OR “nature” OR “environment” and without date restriction, yielding results from 2010 onwards.

Source type	Sources sampled	
Interviews	Two interviews with experts in Planning and greenspace management in Sunyani, Oct. 2016	
	Two interviews with greenspace users, Oct. 2016	
Ghanaian newspapers	Graphic online	https://www.graphic.com.gh/
	BA News Ghana	http://banewsgh.com/
	Citi FM Online	https://citinewsroom.com/
	The Chronicle	http://thechronicle.com.gh/
	Ghana Business News	https://www.ghanabusinessnews.com/
Ghanaian policy documents	Government of Ghana, 1961. Wildlife animals preservation act, Act 43.	
	Government of Ghana, 1971. Wildlife conservation regulations, LI 685.	
	Environmental Protection Council, 1988. Ghana Environmental Action Plan. Accra.	
	Government of Ghana, 1994. Environmental Protection Agency Act, Act 490.	
	Government of Ghana, 1995. Ghana - Vision 2020. Accra, Ghana.	
	Ministry of Environment and Science, 2002. National Biodiversity Strategy for Ghana.	
	Ministry of Local government and Rural Development, 2012. Ghana national urban policy action plan. Accra.	
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	Ministry of Lands and Natural Resources, 2012. Ghana forest and wildlife policy. Accra, Ghana.	
	Ministry of Environment Science Technology and Innovation,	

	2013. Ghana National Climate Change Policy. Accra, Ghana. Government of Ghana, 2015. Ghana national spatial development framework (2015-2035): overall spatial development strategy. Accra, Ghana. Mahama, J.D., 2015. Accounting to the people. Accra, Ghana.
International agendas and ecosystem assessments	United Nations, 2015. Transforming our world: the 2030 agenda for sustainable development CBD, 2012. Cities and Biodiversity Outlook - Action and Policy: A global assessment of the links between urbanization, biodiversity and ecosystem services. Secretariat of the Convention on Biological Diversity, Montreal, Canada. The World Bank, 2006. Ghana Country Environmental Analysis, Report No: 36985-GH. Environmentally and Socially Sustainable Development Department (AFTSD), Africa Region Africa. IUCN/PACO, 2010. Parks and reserves of Ghana: management effectiveness assessment of protected areas. Ouagadougou, Burkina Faso. TEEB - The Economics of Ecosystems and Biodiversity, 2011. TEEB Manual for Cities: Ecosystem Services in Urban Management.

Table F.2. Sources and original wording for each statement.

Section	Statement as used	Original statement(s)	Source
Provisioning	Urban trees are an important source of wood and charcoal fuel.	The trees suddenly become firewood and are burnt […].	Agyeman, N.K., 2015. Vandalism of trees in Accra becoming a norm. *Graphic Online*. URL http://www.graphic.com.gh/features/features/vandalism-of-trees-in-accra-becoming-a-norm.html (accessed 7.18.17).
		Whereas wood is the overwhelming source of fuel in the rural areas, charcoal predominates in the urban areas.	National Development Planning Commission, Government of Ghana, 2010. Ghana shared growth and development agenda I, 2010-2013. Accra.
	Converting urban parks and reserves to ecotourism facilities is essential to make them profitable.	The conversion of the Achimota Forest into this ecotourism facility is, therefore, a timely intervention to save the forest from further destruction, and also an opportunity to generate revenue to the government […].	Nonor, D., 2014. Accra Eco-Park project gets suitors. *The Chronicle*. URL http://thechronicle.com.gh/accra-eco-park-project-gets-suitors/ (accessed 8.17.17).
	Livestock in cities is important as it provides manure to improve soil fertility.	Manure from livestock improves soil fertility.	Apiiga, S.Y., 2014. Genetic livestock improvement in Africa. *The Chronicle*. URL http://thechronicle.com.gh/genetic-livestock-improvement-in-africa-2/ (accessed 8.18.17).

Section	Statement as used	Original statement(s)	Source
	The job opportunities and incomes that could be earned from the development of urban parks, gardens and green spaces are significant.	The job creation opportunities and the incomes that could be earned from the flower business are not insignificant.	Chris-Twum, 2012. “Garden and Flower Show” to boost arts and crafts. *The Chronicle.* URL http://thechronicle.com.gh/garden-flower-show-to-boost-arts-crafts/ (accessed 8.17.17).
	The presence of trees and plants that heal is crucial in a city, as traditional medicine is an economical and trusted form of health care.	In many slums, the presence of trees and plants that heal is extremely crucial, as traditional medicine is typically the most economical, trusted, and readily available form of health care in such settlements.	CBD, 2012. Cities and Biodiversity Outlook - Action and Policy: A global assessment of the links between urbanization, biodiversity and ecosystem services. Secretariat of the Convention on Biological Diversity, Montreal, Canada.
		Backyard garden are also important because sometimes there are quick herbs and medicine that can easily help to pain someone has before he gets to the hospital.	Interview with local expert, Oct. 2016.
Provisioning	Backyards and parks should be cleared to provide space for businesses and accommodation for the ever increasing urban population.	Maybe where people are looking for a place for industrialisation then maybe we are occupying those before by a green spaces. Maybe people are looking for a business, money-making business and then our greenspaces are occupying them.	Interview with local expert, Oct. 2016.

Section	Statement as used	Original statement(s)	Source
		[…] worried about the environmental degradation from population growth and urbanisation, which had been characterised by the emergence of unauthorised developments, for which trees and gardens had been cleared for buildings and other projects […].	Freiku, S.R., 2013. KMA to install CCTV cameras… at vantage points in Kumasi. *The Chronicle.* URL http://thechronicle.com.gh/kma-to-install-cctv-cameras-at-vantage-points-in-kumasi/ (accessed 8.18.17).
	Cities are centres of employment, trade and job creation, green spaces are not needed.	Cities are centres of employment, trade and job creation In the cities, as I said, we are supposed to create employment for the communities around.	Interview with local expert, Oct. 2016.
Provisioning	Backyard gardens are important to supplement incomes by selling roots and tubers, vegetables and fruits.	Roots and tubers, vegetables and fruits cultivated from home gardens are sometimes sold in the neighborhood or in the market to raise income to supplement budgets	Akosa, A.N.A., 2011. Feeding Ghana's growing urban population - is home gardening the answer? *Ghana Business News.* URL https://www.ghanabusinessnews.com/2011/07/20/feeding-ghanas-growing-urban-population-is-home-gardening-the-answer/ (accessed 8.17.17).

Section	Statement as used	Original statement(s)	Source
Provisioning	Produce from our gardens are available when we are in dire need of them because they are scarce on the market	Produce from our gardens are most at times untouchable unless we are in dire need of them and those times are normally when they are scarce on the market	Akosa, A.N.A., 2011. Feeding Ghana's growing urban population - is home gardening the answer? *Ghana Business News.* URL https://www.ghanabusinessnews.com/2011/07/20/feeding-ghanas-growing-urban-population-is-home-gardening-the-answer/ (accessed 8.17.17).
	Small livestock in urban environments can make a big difference to nutrition and health.	Small livestock in both rural and urban environments can make a big difference to nutrition and health in poor communities.	Apiiga, S.Y., 2014. Genetic livestock improvement in Africa. *The Chronicle.* URL http://thechronicle.com.gh/genetic-livestock-improvement-in-africa-2/ (accessed 8.18.17).
	Cattle in urban areas can be dangerous if it is not properly enclosed	We see cattle, they are not in a crowd, they should be indoor, in an enclosed areas, where they cannot cause a lot of trouble	Interview with local greenspace user, Oct. 2016.
	Vegetables grown in the city are contaminated through chemicals and dirty water use.	Many people have questioned the wholesomeness of vegetables grown in Accra following a report that health authorities could soon be grappling with an epidemic as vegetables in the markets have been found to contain up to 5000 times the permissible levels of chemical residue.	Frimpong, E.D., 2013. Vegetable farms "irrigated" with gutter water. *Graphic Online*. URL http://www.graphic.com.gh/news/health/vegetable-farms-irrigated-with-gutter-water.html (accessed 7.18.17).

Section	Statement as used	Original statement(s)	Source
		Vegetables from all three cities were faecally contaminated and carried faecal coliform populations.	
	Brong Ahafo used to be a forest so now we should be planting trees to recreate this natural environment.	Sunyani used to be a forest region. But due to fire and lumbering, a lot of trees have been destroyed. It used to be greener than this. But now the ground is also responding, and therefore ticking of the farmlands.	Interview with local expert, Oct. 2016.
Regulation and maintenance	Greenspaces are essential for recycling the nutrient into the soil, conserving soil quality for backyard gardens.	They [ecosystems] also regulate the cycling of the nutrients on which life depends. It is the source of food and other materials critical to the survival of humanity.	Ministry of Environment and Science, 2002. National Biodiversity Strategy for Ghana.
	Keeping greenspaces in the city allows natural predators of pests to stay and decrease the pests' impacts.	One of these problems is the impact on health by urban pests. Four techniques in pest control are mechanical (…), physical (…), biological (use of larvicide, introduction of other insects and animals to feed on the pest, introduction of repellent plants, etc) and chemical (…).	Atta-Agyem, F., 2016. Unlicensed pesticides sellers and applications: what impact on human health. *Environment Prototection Agency*, Ghana.

Section	Statement as used	Original statement(s)	Source
		Are species present in the city, which control pests that endanger human health; or are there any crops for which pest control is delivered by predator species?	TEEB, 2011. TEEB Manual for Cities: Ecosystem Services in Urban Management. The Economics of Ecosystems and Biodiversity.
	Open green spaces in the city are important to protect our waterways, essential for the provision of clean water.	Clean water and air, effective sani-tation, and the healthy management of livestock are core elements of urban public health that we ignore at our collective peril	CBD, 2012. Cities and Biodiversity Outlook - Action and Policy: A global assessment of the links between urbanization, biodiversity and ecosystem services. Secretariat of the Convention on Biological Diversity, Montreal, Canada.
		The provision of water and sanitation services is unable to keep pace with demand, especially in urban areas, with the attendant adverse effect on public health. Major challenges include: weak water resources management; pollution of water bodies; deforestation of vegetation cover.	National Development Planning Commission, Government of Ghana, 2014. Ghana shared growth and development agenda II, 2014-2017. Accra.
Regulation and maintenance		Apart from the recreational uses of open spaces, they are also used as protected waterways, Ramsar and nature conservation sites.	National Development Planning Commission, Government of Ghana, 2010. Ghana shared growth and development agenda I, 2010-2013. Accra.

Section	Statement as used	Original statement(s)	Source
Regulation and maintenance	Parks and open green spaces offer me an opportunity to exercise to stay healthy.	Prince of Wales Park also offered an opportunity for the youth to exercise to keep them healthy.	Arku, J., 2013. Kumasi: The Garden City without gardens? *Graphic Online*. URL http://www.graphic.com.gh/features/features/kumasi-the-garden-city-without-gardens.html (accessed 7.18.17).
	The insects can help produce more fruits through pollination so we can get to eat fresh fruits from our backyard gardens.	The insects can help produce more fruits through pollination and we can get to eat fresh fruits from our backyard gardens.	Interview with local greenspace user, Oct. 2016.
	Trees within the city are important to provide me with natural shade.	Many of such trees were said to have formed canopies which provided natural shades and offered adequate protection to both residents and visitors against the unfriendly weather	Arku, J., 2013. Kumasi: The Garden City without gardens? *Graphic Online*. URL http://www.graphic.com.gh/features/features/kumasi-the-garden-city-without-gardens.html (accessed 7.18.17).
	Greenspaces in the city are not good for health because they attract malaria-carrying mosquitoes.	They have become breeding grounds for mosquitoes which also pose serious health concerns to residents in the affected areas.	Yaro, D., 2015. Heavy rains expose deplorable Sunyani Town roads : potholes and more! *BA News Ghana*. URL http://banewsgh.com/ba-regional-capital-losing-status-cleanest-capital-due-deplorble-roads/9866 (accessed 7.18.17).

Section	Statement as used	Original statement(s)	Source
Regulation and maintenance	Many plants and animals found in urban green spaces and parks can cause allergies.	And then if they are not also well kept, they can be a source of allergies or whatever.	Interview with local greenspace user, Oct. 2016.
	Urban greenspaces can harbour animals that are aggressive towards humans.	[Animals] could be aggressive sometimes	Interview with local greenspace user, Oct. 2016.
		Most of the time before they attack you, they show, you can move, they are aggressive, then they come for some times.	Interview with local expert, Oct. 2016.
	In the city, trees are natural windbreaks which protects me from storms.	The project is to provide greening for the environment, and also to serve as windbreaks.	Freiku, S.R., 2014. KMA Launches 'Greening Kumasi' Project. *The Chronicle.* URL http://thechronicle.com.gh/kma-launches-greening-kumasi-project/ (accessed 8.17.17).
	We need the trees in our cities to help reduce the impact of climate change.	In this era of climate change, we need every single tree in our cities to help reduce the impact of climate change	Agyeman, N.K., 2015. Vandalism of trees in Accra becoming a norm. *Graphic Online*. URL http://www.graphic.com.gh/features/features/vandalism-of-trees-in-accra-becoming-a-norm.html (accessed 7.18.17).

Section	Statement as used	Original statement(s)	Source
Regulation and maintenance	With grass and trees in the city, when the rain comes, it just flows down and sinks into the ground instead of flooding the city.	There is a lot of floods so people don't come out with these lawns and they cut. Every house you see them paving, paving, concrete, concrete. So when it rains it can't penetrate to the ground. And this causes floods. And when you have these green grass, you see the rains comes, they Just flows down and sinks into the ground. Recharge the underground water.	Interview with local expert, Oct. 2016.
	Trees in cities risk to fall on me or my house during storms.	The strong winds also uprooted trees and brought down kiosks, metal containers and other wooden structures sited along the roads.	Biiya, M.A., 2017. Rainstorm renders people homeless at Dormaa-Ahenkro. *Graphic Online*. URL https://www.graphic.com.gh/news/general-news/rainstorm-renders-people-homeless-at-dormaa-ahenkro.html (accessed 7.18.17).
	A key component of urban green spaces is to reduce the level of noise.	A key component of the interchange is the provision of green strips and verges intended to reduce the level of noise pollution from vehicles.	Ghana gov't awards $100m Kwame Nkrumah circle project to Brazilian firm - Ghana Business News, 2013. *Ghana Business News.* URL https://www.ghanabusinessnews.com/2013/01/04/ghana-govt-awards-100m-kwame-nkrumah-circle-project-to-brazilian-firm/ (accessed 8.17.17).

Section	Statement as used	Original statement(s)	Source
Regulation and maintenance	Greenspaces are useful for dumping refuse	But if you have it around the corner in the city you can dump your refuse there.	Interview with local greenspace user, Oct. 2016.
	The purpose of a green space is to reduce air pollution within the city.	A greenbelt zone is a belt of parks or rural land surrounding a town or city for the preservation of a natural or semi-natural environment. The purpose is to improve on air quality within urban areas.	Issah, Z., 2014. Residents of Tema Community 7 angry over land encroachment. *Graphic Online*. URL http://www.graphic.com.gh/news/general-news/residents-of-tema-community-7-angry-over-land-encroachment.html (accessed 7.18.17).
	Urban livestock can consume agricultural and household waste products, converting them into human food.	Livestock can also consume agricultural and household waste products, converting them into human food.	Apiiga, S.Y., 2014. Genetic livestock improvement in Africa. *The Chronicle*. URL http://thechronicle.com.gh/genetic-livestock-improvement-in-africa-2/ (accessed 8.18.17).
Cultural	Green spaces in school yards help to inculcate in our children good environmental practices and awareness, to become environmentally responsible adults.	From the primary school to inculcate in our children good environmental practices and awareness. This will help them grow into environmentally responsible adults	Reintroduce 'taboo' days to preserve environment — Rev. Dr Frimpong-Manso, 2016. *Graphic Online*. URL http://www.graphic.com.gh/news/general-news/reintroduce-taboo-days-to-preserve-environment-rev-dr-frimpong-manso.html (accessed 7.17.17).

Section	Statement as used	Original statement(s)	Source
Cultural	Greenspaces provide me with recreational opportunities.	To provide affordable recreational, physical and cultural opportunities for residents, with a focus on families, youth development, and building healthy communities.	Rattray Recreational Park commissioned, 2015. *The Chronicle.* URL http://thechronicle.com.gh/rattray-recreational-park-commissioned/ (accessed 8.17.17).
		Open spaces for recreational purposes or social amenities in almost all the communities.	Better Ghana projects photo exhibition opens in Cape Coast, 2012. *The Chronicle*. URL http://thechronicle.com.gh/better-ghana-projects-photo-exhibition-opens-in-cape-coast/ (accessed 8.17.17).
	Growing cities should not affect the traditional norms of keeping the environment green and clean, which was taught by parents in the community.	Growing urban environments should not affect the traditional norms of keeping the environment clean which was taught by parents and leaders in the community some years ago.	Appiah, S., 2015. Frequent outbreak of cholera worrying — First Lady. *Graphic Online*. URL http://www.graphic.com.gh/news/general-news/frequent-outbreak-of-cholera-worrying-first-lady.html (accessed 7.18.17).
	Parks are the heartbeats of all social gatherings.	Jackson Park is the heartbeat of all social gatherings in the Eastern Regional capital, Koforidua	Lamiley Bentil, N., 2015. Jackson Park — The heartbeat of social gatherings in Koforidua. *Graphic Online*. URL http://www.graphic.com.gh/news/general-news/jackson-park-the-heartbeat-of-social-gatherings-in-koforidua.html (accessed 7.18.17).

Section	Statement as used	Original statement(s)	Source
Cultural	The gardens and scented flowers along the roads are making the city more attractive and beautiful.	The beautiful gardens of numerous and scented flowers along the roads are a spectacle for individuals who take delight in them.	Chris-Twum, 2012. “Garden and Flower Show” to boost arts and crafts. *The Chronicle.* URL http://thechronicle.com.gh/garden-flower-show-to-boost-arts-crafts/ (accessed 8.17.17).
		Kumasi was said to be very attractive in those days. This was because of the variety of trees and flowers found in front of residential areas	Arku, J., 2013a. Kumasi: The Garden City without gardens? *Graphic Online*. URL http://www.graphic.com.gh/features/features/kumasi-the-garden-city-without-gardens.html (accessed 7.18.17).
	The variety of flowers and grass in the gardens acts as magnets that pulls the youth to snap pictures.	The variety of flowers and grass in the gardens also acted as magnets that pulled the youth into the gardens for their rendezvous, inducing them to snap pictures.	Arku, J., 2013. Kumasi: The Garden City without gardens? *Graphic Online*. URL http://www.graphic.com.gh/features/features/kumasi-the-garden-city-without-gardens.html (accessed 7.18.17).
	Trees bring me peace and tranquillity.	Our development planners are oblivious of how trees bring peace and tranquillity.	Obour, S.K., 2013. Line of trees cut to give way to Giffard Road expansion works. *Graphic Online*. URL http://www.graphic.com.gh/news/general-news/line-of-trees-cut-to-give-way-to-giffard-road-expansion-works.html (accessed 7.18.17).

Section	Statement as used	Original statement(s)	Source
Cultural	Urban greenspaces are a key driver of the film and advertising industry.	Natural assets are a key driver of the film and advertising industry.	TEEB, 2011. TEEB Manual for Cities: Ecosystem Services in Urban Management. The Economics of Ecosystems and Biodiversity.
	Buildings make the environment more beautiful than trees and flowers.	Buildings make the environment more beautiful because there are not enough soil to maintain the flowers to keep its beauty. Sometimes it comes and go because even with the changing seasons. But buildings when you paint them neatly even in every other conditions it's there.	Interview with local greenspace user, Oct. 2016.
	Green spaces and parks are often been taken over by lunatics, gangs and robbers, so I feel afraid to go there.	These have been taken over by lunatics. So even people feel afraid to go there.	Interview with local expert, Oct. 2016.
		Lack of use and maintenance has turned the [park's] library into a haven for gangs and robbers.	Arku, J., 2013. Kumasi: The Garden City without gardens? *Graphic Online*. URL http://www.graphic.com.gh/features/features/kumasi-the-garden-city-without-gardens.html (accessed 7.18.17).

Section	Statement as used	Original statement(s)	Source
Cultural	Because I live in the city and will not go to the bush to see the plants and animals, I want to see them in the city.	If you have to create that green, nature atmosphere in the city before you can bring those animals there.	Interview with local expert, Oct. 2016.
		The village has its more quiet surroundings, with the sounds of birds and other animals. It just makes it enjoyable to be around but you know the cities have the sounds of cars and machines	Interview with local greenspace user, Oct. 2016.
		You don't want a city totally devoid of natural life. So after the birds and the bushes, except for the humans, the animals are the next living creatures.	
	By conserving greenspaces in cities, we are continuing the work of God, who created all species to live with us.	We have also inventing what God has created and we are continuing from God what God has created	Interview with local expert, Oct. 2016.
		That's what the Bible also say, they, the animals, live with us.	

Section	Statement as used	Original statement(s)	Source
Cultural	Ghanaian cities must increase their green spaces to give residents a sense of pride	[…] promoting architectural designs, urban landscaping, beautification of open spaces and tree-planting activities. “Accra must look attractive at all times to give residents and visitors a sense of pride.”	Awiah, D.M., 2017. AMA rolls out plans to make Accra cleanest city. *Graphic Online*. URL http://www.graphic.com.gh/news/general-news/ama-rolls-out-plans-to-make-accra-cleanest-city.html (accessed 7.19.17).
	Urban forests and parks are good places for religious activities, prayers and meditation.	The reserve was used by mainly religious groups for prayers and meditation.	Kwawukume, V., 2016. Forestry Commission, devt partner sign agreement to make Achimota Forest ecopark. *Graphic Online*. URL http://www.graphic.com.gh/news/general-news/forestry-commission-devt-partner-sign-agreement-to-make-achimota-forest-ecopark.html (accessed 7.18.17).
	Urban forests should be preserved for the present generation and generations yet unborn.	He maintained that the forest should not be sold to any investor in the first place, but rather preserved for present generation and generations yet unborn.	Asmah, K., 2016. Nduom opposes sale of Achimota Forest. *Graphic Online*. URL http://www.graphic.com.gh/news/politics/nduom-opposes-sale-of-achimota-forest.html (accessed 7.18.17).

Table F.3. Participant's demographic information for each viewpoint, classified by stakeholder categories. (a) Experts, (b) Authorities and (c) Users.

(a) Experts

		Environmental regulation (n=8)	Well-being (n=5)	Source of danger (n=3)	Incomes and socialisation (n=2)	Non-assigned (n=4)	Total (n=22)
City	Sunyani	63%	100%	67%	100%	0%	64%
	Techiman	38%	0%	33%	0%	100%	36%
Gender	Female	0%	20%	0%	0%	0%	5%
	Male	100%	80%	100%	100%	100%	95%
Age group	18-25	13%	0%	0%	0%	0%	5%
	25-60	88%	80%	100%	100%	75%	86%
	60+	0%	20%	0%	0%	25%	9%
Education	No education	0%	0%	0%	0%	0%	0%
	Primary	0%	0%	0%	0%	0%	0%
	Secondary	13%	0%	0%	0%	50%	14%
	Tertiary	63%	100%	100%	100%	25%	77%
	No data	25%	0%	0%	0%	25%	14%
Interview language[5]	English	88%	100%	100%	50%	25%	77%
	Twi	13%	0%	0%	50%	75%	23%
Have lived in	Rural areas	25%	40%	67%	0%	25%	32%
	Mega-cities	88%	100%	67%	100%	25%	77%
Understanding of greenspaces[6]	Benefits	63%	80%	100%	100%	100%	82%
	Physical	75%	60%	0%	100%	100%	68%
	Management	38%	40%	33%	50%	75%	45%

[5] Participants were free to choose the language in which they felt more comfortable to carry out the interview.

[6] Totals add up to more than 100% as participants were not restricted to one single aspect.

(b) Authorities

		Continuity (n=15)	Multi-functionality (n=6)	Religion (n=3)	Non-assigned (n=3)	Total (n=27)
City	Sunyani	53%	83%	0%	67%	56%
	Techiman	47%	17%	100%	33%	44%
Gender	Female	0%	0%	0%	0%	0%
	Male	100%	100%	100%	100%	100%
Age group	18-25	0%	0%	0%	0%	0%
	25-60	100%	67%	100%	100%	93%
	60+	0%	33%	0%	0%	7%
Education	No formal education	0%	0%	33%	0%	4%
	Primary	0%	0%	0%	0%	0%
	Secondary	0%	17%	33%	33%	11%
	Tertiary	100%	83%	33%	67%	85%
	No data	0%	0%	0%	0%	0%
Interview language	English	93%	83%	67%	100%	89%
	Twi	7%	17%	33%	0%	11%
Have lived in	Rural areas	53%	33%	100%	33%	52%
	Mega-cities	100%	83%	33%	100%	89%
Understanding of greenspaces	Benefits	87%	50%	67%	33%	70%
	Physical characteristics	33%	67%	67%	67%	48%
	Management	80%	17%	33%	0%	52%

(c) Users

		Cultural heritage (n=8)	Children (n=5)	Filtration (n=6)	Development (n=4)	Non-assigned (n=4)	Total (n=27)
City	Sunyani	63%	40%	67%	50%	25%	52%
	Techiman	25%	60%	33%	50%	75%	44%
Gender	Female	38%	40%	50%	75%	25%	44%
	Male	63%	60%	50%	25%	75%	56%
Age group	18-25	25%	60%	33%	25%	0%	30%
	25-60	50%	40%	67%	50%	50%	52%
	60+	25%	0%	0%	25%	50%	19%
Education	No formal education	25%	0%	0%	25%	0%	11%
	Primary	13%	20%	67%	0%	25%	26%
	Secondary	38%	0%	0%	0%	25%	15%
	Tertiary	25%	80%	0%	0%	50%	30%
	No data	0%	0%	33%	75%	0%	19%
Interview language	English	50%	60%	0%	0%	25%	30%
	Twi	50%	40%	100%	100%	75%	70%
Have lived in	Rural areas	63%	60%	50%	0%	50%	48%
	Mega-cities	88%	40%	17%	50%	50%	52%
Understanding of greenspaces	Benefits	63%	40%	33%	75%	100%	59%
	Physical characteristics	88%	80%	83%	75%	100%	85%
	Management	13%	80%	17%	25%	25%	33%

Table F.4. Factor z-scores on each viewpoint for each statement.

		Z-scores										
		Experts				Authorities				Users		
Section	Statements	Environmental regulation	Well-being	Source of danger	Incomes and socialisation	Legacy	Multi-functionality	Religion	Cultural heritage	Children	Beauty and cleanliness	Development
Provisioning	Urban trees are an important source of wood and charcoal fuel.	-0.74	-1.58	-1.65	-0.73	-1.68	-0.49	-1.71	-1.24	0.55	-1.59	2.38
	Converting urban parks and reserves to ecotourism facilities is essential to make them profitable.	0.25	0.18	1.31	0.82	0.34	-0.16	1.01	0.21	-0.01	0.91	-0.88
	Livestock in cities is important as it provides manure to improve soil fertility.	-0.95	-0.62	-0.80	-0.25	-1.23	-0.82	-0.76	-0.79	0.50	-0.44	0.61
	The job opportunities and incomes that could be earned from the development of urban parks, gardens and green spaces are significant.	0.66	-0.13	-0.29	0.75	0.43	1.31	-0.49	0.35	-0.35	-1.42	0.24
	The presence of trees and plants that heal is crucial in a city, as traditional medicine is an economical and trusted form of health care.	0.80	0.18	-0.17	-1.02	0.12	0.14	-0.08	0.94	0.42	1.13	0.01

Provisioning	Backyards and parks should be cleared to provide space for businesses and accommodation for the ever increasing urban population.	-1.80	-1.59	-2.05	1.04	-1.99	-1.40	0.05	-1.93	-0.79	-1.96	-0.16
	Cities are centres of employment, trade and job creation, green spaces are not needed.	-1.71	-1.76	-1.65	-1.57	-1.90	-2.17	-1.93	-1.98	-1.90	-1.21	-0.31
	Backyard gardens are important to supplement incomes by selling roots and tubers, vegetables and fruits.	0.27	0.35	0.91	1.59	0.28	1.15	1.09	0.02	1.37	-0.40	0.80
	Produce from our gardens are available when we are in dire need of them because they are scarce on the market.	0.20	-0.04	0.34	-1.29	-0.15	0.53	-0.25	1.22	-0.38	0.16	-0.45
	Small livestock in urban environments can make a big difference to nutrition and health.	0.22	-0.97	-0.68	-0.52	-0.43	-0.62	-0.14	0.48	-0.63	0.23	-1.14
	Cattle in urban areas can be dangerous if it is not properly enclosed	0.62	-0.31	1.82	-0.04	0.14	0.40	0.88	-0.12	0.69	1.18	0.01
	Vegetables grown in the city are contaminated through chemicals and dirty water use.	-1.04	-0.97	1.14	-1.54	0.04	-0.97	-0.41	-1.17	-0.27	0.94	0.25
	Brong Ahafo used to be a forest so now we should be planting trees to recreate this natural environment.	1.61	1.01	0.80	0.79	1.38	0.10	1.46	1.77	1.35	-0.94	1.26

Prov.	Greenspaces are essential for recycling the nutrient into the soil, conserving soil quality for backyard gardens.	0.99	0.22	-0.11	0.00	0.32	0.35	0.51	0.96	1.03	-0.57	-1.22
	Keeping greenspaces in the city allows natural predators of pests to stay and decrease the pests' impacts.	-0.85	-0.62	-1.37	-1.04	-0.99	-0.75	-0.16	-0.78	-0.81	-0.35	0.36
	Open green spaces in the city are important to protect our waterways, essential for the provision of clean water.	0.99	0.92	0.28	1.07	0.32	-0.19	0.65	-0.31	0.84	1.23	-1.58
	Parks and open green spaces offer me an opportunity to exercise to stay healthy.	0.30	1.14	0.51	0.77	0.51	0.58	-0.27	0.46	0.91	0.40	-0.34
Regulation and maintenance	The insects can help produce more fruits through pollination so we can get to eat fresh fruits from our backyard gardens.	0.38	-0.14	-0.97	0.25	0.27	1.05	-0.06	0.68	0.50	-1.37	0.72
	Trees within the city are important to provide me with natural shade.	1.42	1.01	1.48	0.73	0.88	1.40	1.82	1.10	0.96	1.06	1.20
	Greenspaces in the city are not good for health because they attract malaria-carrying mosquitoes.	-1.57	-1.45	-1.37	-1.32	-1.57	-1.30	-1.71	-1.79	-0.44	-1.13	-0.41
	Many plants and animals found in urban green spaces and parks can cause allergies.	-1.12	-1.19	-0.74	-0.25	-0.82	-1.11	-0.94	-0.92	-1.50	-0.21	0.56

Regulation and maintenance	Urban greenspaces can harbour animals that are aggressive towards humans.	-1.26	-1.46	-1.08	-1.34	-1.29	-0.72	-1.82	-1.23	-1.06	0.31	-0.13
	In the city, trees are natural windbreaks which protects me from storms.	1.47	0.84	1.31	1.57	1.00	1.72	0.36	0.88	0.79	1.65	-0.09
	We need the trees in our cities to help reduce the impact of climate change.	1.51	1.10	0.40	-0.02	1.51	1.67	0.25	1.57	1.09	0.35	0.32
	With grass and trees in the city, when the rain comes, it just flows down and sinks into the ground instead of flooding the city.	1.06	0.75	0.63	-0.02	0.68	0.49	0.25	0.42	1.48	0.13	-2.03
	Trees in cities risk to fall on me or my house during storms.	-1.06	-1.32	-0.11	-0.07	-0.51	-0.89	-1.32	-0.86	-1.35	-0.39	-1.80
	A key component of urban green spaces is to reduce the level of noise.	-0.13	1.09	-0.23	-0.52	0.09	-0.99	-1.16	-0.66	-1.45	-1.51	1.14
	Greenspaces are useful for dumping refuse	-1.83	-1.54	-1.71	-1.32	-1.96	-1.40	-0.24	-2.00	-2.33	-1.79	-2.14
	The purpose of a green space is to reduce air pollution within the city.	1.00	0.49	-0.06	0.29	0.99	0.66	-0.14	-0.22	0.04	1.54	1.58
	Urban livestock can consume agricultural and household waste products, converting them into human food.	-0.34	-0.53	-0.57	0.27	-0.58	-0.01	-1.40	0.32	-0.63	0.77	-0.68

Cultural	Green spaces in school yards help to inculcate in our children good environmental practices and awareness, to become environmentally responsible adults.	1.27	0.71	1.60	-0.02	1.24	1.23	0.62	0.95	0.29	0.74	-0.09
	Greenspaces provide me with recreational opportunities.	0.13	1.32	0.91	1.27	0.63	1.40	1.21	0.26	0.46	0.45	0.47
	Growing cities should not affect the traditional norms of keeping the environment green and clean, which was taught by parents in the community.	0.81	0.52	-0.06	-1.04	1.01	0.60	-0.92	0.77	-0.11	-0.76	-1.27
	Parks are the heartbeats of all social gatherings.	-0.18	0.88	-0.23	1.09	-0.22	0.88	-0.20	0.59	1.08	-0.22	0.04
	The gardens and scented flowers along the roads are making the city more attractive and beautiful.	0.56	1.09	0.85	1.57	0.66	0.95	0.71	0.73	0.82	0.35	0.94
	The variety of flowers and grass in the gardens acts as magnets that pulls the youth to snap pictures.	-0.32	0.26	0.74	0.27	-0.01	0.11	1.21	0.49	-0.02	1.55	-0.68
	Trees bring me peace and tranquillity.	0.10	1.41	0.29	-0.75	0.56	-0.08	0.14	0.39	-0.74	0.48	0.09
	Urban greenspaces are a key driver of the film and advertising industry.	-0.50	-0.05	-0.40	0.27	0.29	-0.86	-0.40	-0.40	-0.32	0.99	1.35
	Buildings make the environment more beautiful than trees and flowers.	-1.38	-1.45	-1.48	-2.09	-1.67	-1.74	0.08	-1.31	-0.23	-1.52	0.77

Cultural	Green spaces and parks are often been taken over by lunatics, gangs and robbers, so I feel afraid to go there.	-1.18	-0.92	1.37	-1.34	-0.74	-0.33	0.24	-0.36	-1.55	0.65	-0.79
	Because I live in the city and will not go to the bush to see the plants and animals, I want to see them in the city.	-0.83	-0.53	-0.57	-0.50	-0.62	-1.52	-1.16	-0.79	-1.12	-1.26	0.04
	By conserving greenspaces in cities, we are continuing the work of God, who created all species to live with us.	0.80	1.06	1.08	0.54	1.45	1.00	1.26	1.23	-0.60	0.75	0.68
	Ghanaian cities must increase their green spaces to give residents a sense of pride	-0.37	1.27	0.17	0.79	1.03	-0.35	0.25	0.11	1.13	0.47	0.71
	Urban forests and parks are good places for religious activities, prayers and meditation.	0.43	-0.17	0.06	1.59	0.80	0.11	1.76	0.76	0.26	0.50	1.03
	Urban forests should be preserved for the present generation and generations yet unborn.	1.29	1.50	0.34	1.27	1.41	1.01	1.87	1.21	2.04	0.14	-1.39

Table F.5. Distinguishing and consensus statements (qdc) for the viewpoints of (a) the Experts, (b) the Authorities and (c) the Users. Values indicate the difference in z-scores between the two factors. Significance levels are calculated by comparing the absolute difference in z-scores with the standard error of differences for each pair of factors (Zabala 2014). Significant differences are indicated at a p-value of <0.05 (*) and <0.01 (**).

(a) Experts

Sections	Statements	Factors being distinguishing from all other factors; and	Environmental regulation (ER) – Well-being (WB)		Environmental regulation (ER) – Source of danger (SD)		Environmental regulation (ER) – Incomes and socialisation (IS)		Well-being (WB) – Source of danger (SD)		Well-being (WB) – Incomes and socialisation (IS)		Source of danger (SD) - Incomes and socialisation (IS)	
Provisioning	Urban trees are an important source of wood and charcoal fuel.		0.84	**	0.91	**	-0.02		0.07		-0.85	*	-0.93	*
	Converting urban parks and reserves to ecotourism facilities is essential to make them profitable.		0.08		-1.06	**	-0.56		-1.13	**	-0.64		0.49	
	Livestock in cities is important as it provides manure to improve soil fertility.	Consensus	-0.33		-0.15		-0.70		0.18		-0.37		-0.55	

	The job opportunities and incomes that could be earned from the development of urban parks, gardens and green spaces are significant.		0.79	**	0.95	**	-0.09		0.15		-0.88	*	-1.03	*
	The presence of trees and plants that heal is crucial in a city, as traditional medicine is an economical and trusted form of health care.	ER; IS	0.62	*	0.97	**	1.82	**	0.35		1.20	**	0.85	*
	Backyards and parks should be cleared to provide space for businesses and accommodation for the ever increasing urban population.	IS	-0.22		0.25		-2.85	**	0.47		-2.63	**	-3.09	**
	Cities are centres of employment, trade and job creation, green spaces are not needed.	Consensus	0.05		-0.06		-0.14		-0.11		-0.20		-0.09	
	Backyard gardens are important to supplement incomes by selling roots and tubers, vegetables and fruits.		-0.07		-0.64		-1.31	**	-0.56		-1.24	**	-0.68	
	Produce from our gardens are available when we are in dire need of them because they are scarce on the market.	IS	0.24		-0.14		1.50	**	-0.38		1.26	**	1.64	**
Provisioning	Small livestock in urban environments can make a big difference to nutrition and health.	ER	1.19	**	0.91	**	0.75	*	-0.28		-0.45		-0.16	
	Cattle in urban areas can be dangerous if it is not properly enclosed	SD	0.94	**	-1.20	**	0.67		-2.14	**	-0.27		1.87	**

	Vegetables grown in the city are contaminated through chemicals and dirty water use.	SD	-0.08		-2.18	**	0.50		-2.10	**	0.58	2.68	**
	Brong Ahafo used to be a forest so now we should be planting trees to recreate this natural environment.	ER	0.60	*	0.81	*	0.82	*	0.21		0.22	0.00	
	Greenspaces are essential for recycling the nutrient into the soil, conserving soil quality for backyard gardens.	ER	0.76	**	1.10	**	0.99	**	0.34		0.22	-0.11	
	Keeping greenspaces in the city allows natural predators of pests to stay and decrease the pests' impacts.		-0.24		0.51		0.19		0.75	*	0.43	-0.32	
	Open green spaces in the city are important to protect our waterways, essential for the provision of clean water.		0.07		0.71	*	-0.08		0.64		-0.14	-0.78	
	Parks and open green spaces offer me an opportunity to exercise to stay healthy.		-0.84	**	-0.21		-0.47		0.63		0.37	-0.26	
	The insects can help produce more fruits through pollination so we can get to eat fresh fruits from our backyard gardens.	SD	0.52		1.35	**	0.13		0.83	*	-0.39	-1.22	**
Regulation and maintenance	Trees within the city are important to provide me with natural shade.	Consensus	0.41		-0.06		0.69		-0.47		0.29	0.75	

Regulation and maintenance	Greenspaces in the city are not good for health because they attract malaria-carrying mosquitoes.	Consensus	-0.12		-0.20		-0.25		-0.08		-0.13		-0.05
	Many plants and animals found in urban green spaces and parks can cause allergies.		0.07		-0.38		-0.87	*	-0.45		-0.94	*	-0.49
	Urban greenspaces can harbour animals that are aggressive towards humans.	Consensus	0.20		-0.18		0.08		-0.37		-0.12		0.26
	In the city, trees are natural windbreaks which protects me from storms.		0.63	*	0.15		-0.10		-0.47		-0.73		-0.26
	We need the trees in our cities to help reduce the impact of climate change.		0.41		1.11	**	1.53	**	0.70	*	1.12	**	0.42
	With grass and trees in the city, when the rain comes, it just flows down and sinks into the ground instead of flooding the city.		0.31		0.43		1.08	**	0.12		0.77		0.65
	Trees in cities risk to fall on me or my house during storms.		0.25		-0.95	**	-1.00	**	-1.20	**	-1.25	**	-0.05
	A key component of urban green spaces is to reduce the level of noise.	WB	-1.22	**	0.10		0.40		1.32	**	1.61	**	0.29
	Greenspaces are useful for dumping refuse	Consensus	-0.29		-0.12		-0.51		0.17		-0.22		-0.39
	The purpose of a green space is to reduce air pollution within the city.		0.51		1.06	**	0.71		0.54		0.19		-0.35

	Urban livestock can consume agricultural and household waste products, converting them into human food.		0.18		0.23		-0.62		0.04		-0.80	*	-0.84	
	Green spaces in school yards help to inculcate in our children good environmental practices and awareness, to become environmentally responsible adults.		0.56	*	-0.32		1.29	**	-0.88	*	0.73		1.62	**
	Greenspaces provide me with recreational opportunities.	ER	-1.19	**	-0.78	*	-1.14	**	0.41		0.05		-0.36	
	Growing cities should not affect the traditional norms of keeping the environment green and clean, which was taught by parents in the community.	IS	0.29		0.87	**	1.86	**	0.58		1.57	**	0.99	*
	Parks are the heartbeats of all social gatherings.		-1.06	**	0.04		-1.27	**	1.11	**	-0.21		-1.32	**
	The gardens and scented flowers along the roads are making the city more attractive and beautiful.		-0.53		-0.29		-1.00	**	0.24		-0.47		-0.71	
	The variety of flowers and grass in the gardens acts as magnets that pulls the youth to snap pictures.		-0.58	*	-1.06	**	-0.59		-0.48		-0.01		0.47	
	Trees bring me peace and tranquillity.	WB; IS	-1.31	**	-0.18		0.85	*	1.12	**	2.16	**	1.03	*
Cultural	Urban greenspaces are a key driver of the film and advertising industry.		-0.45		-0.10		-0.77	*	0.35		-0.32		-0.67	

	Buildings make the environment more beautiful than trees and flowers.	Consensus	0.08		0.10		0.71		0.03		0.63		0.61	
	Green spaces and parks are often been taken over by lunatics, gangs and robbers, so I feel afraid to go there.	SD	-0.26		-2.55	**	0.15		-2.29	**	0.42		2.71	**
	Because I live in the city and will not go to the bush to see the plants and animals, I want to see them in the city.	Consensus	-0.30		-0.26		-0.33		0.04		-0.03		-0.07	
	By conserving greenspaces in cities, we are continuing the work of God, who created all species to live with us.	Consensus	-0.26		-0.28		0.26		-0.02		0.52		0.54	
	Ghanaian cities must increase their green spaces to give residents a sense of pride		-1.64	**	-0.54		-1.16	**	1.10	**	0.48		-0.62	
	Urban forests and parks are good places for religious activities, prayers and meditation.	IS	0.60	*	0.37		-1.16	**	-0.23		-1.76	**	-1.53	**
Cultural	Urban forests should be preserved for the present generation and generations yet unborn.	SD	-0.21		0.94	**	0.02		1.16	**	0.23		-0.93	*

(b) Authorities

Sections	Statements	Factors being distinguishing from all other factors; and	Legacy (L) - Multi-functionality (MF)		Legacy (L) - Religion (R)		Multi-functionality (MF) – Religion (R)	
Provisioning	Urban trees are an important source of wood and charcoal fuel.	MF	-1.19	**	0.03		1.22	**
	Converting urban parks and reserves to ecotourism facilities is essential to make them profitable.	L; MF; R	0.50	*	-0.67	*	-1.17	**
	Livestock in cities is important as it provides manure to improve soil fertility.	Consensus	-0.40		-0.46		-0.06	
	The job opportunities and incomes that could be earned from the development of urban parks, gardens and green spaces are significant.	L; MF; R	-0.88	**	0.92	**	1.80	**
	The presence of trees and plants that heal is crucial in a city, as traditional medicine is an economical and trusted form of health care.	Consensus	-0.02		0.19		0.22	
	Backyards and parks should be cleared to provide space for businesses and accommodation for the ever increasing urban population.	L; MF; R	-0.59	*	-2.04	**	-1.45	**

	Cities are centres of employment, trade and job creation, green spaces are not needed.	Consensus	0.27		0.03		-0.24	
	Backyard gardens are important to supplement incomes by selling roots and tubers, vegetables and fruits.	L	-0.87	**	-0.81	**	0.06	
	Produce from our gardens are available when we are in dire need of them because they are scarce on the market.	MF	-0.69	**	0.10		0.78	*
	Small livestock in urban environments can make a big difference to nutrition and health.	Consensus	0.19		-0.29		-0.48	
Provisioning	Cattle in urban areas can be dangerous if it is not properly enclosed		-0.26		-0.74	*	-0.48	
	Vegetables grown in the city are contaminated through chemicals and dirty water use.		1.01	**	0.44		-0.56	
	Brong Ahafo used to be a forest so now we should be planting trees to recreate this natural environment.	MF	1.27	**	-0.09		-1.36	**
	Greenspaces are essential for recycling the nutrient into the soil, conserving soil quality for backyard gardens.	Consensus	-0.03		-0.19		-0.16	
	Keeping greenspaces in the city allows natural predators of pests to stay and decrease the pests' impacts.		-0.24		-0.82	**	-0.58	
	Open green spaces in the city are important to protect our waterways, essential for the provision of clean water.	MF	0.51	*	-0.34		-0.85	*
Regulation and maintenance	Parks and open green spaces offer me an opportunity to exercise to stay healthy.	R	-0.07		0.78	*	0.85	*

	The insects can help produce more fruits through pollination so we can get to eat fresh fruits from our backyard gardens.	MF	-0.78	**	0.33		1.11	**
	Trees within the city are important to provide me with natural shade.	L	-0.51	*	-0.94	**	-0.42	
	Greenspaces in the city are not good for health because they attract malaria-carrying mosquitoes.	Consensus	-0.27		0.14		0.41	
	Many plants and animals found in urban green spaces and parks can cause allergies.	Consensus	0.29		0.12		-0.17	
	Urban greenspaces can harbour animals that are aggressive towards humans.	MF	-0.57	*	0.53		1.10	**
	In the city, trees are natural windbreaks which protects me from storms.	L; MF; R	-0.72	**	0.64	*	1.36	**
	We need the trees in our cities to help reduce the impact of climate change.	MF	-0.16		1.26	**	1.42	**
Regulation and maintenance	With grass and trees in the city, when the rain comes, it just flows down and sinks into the ground instead of flooding the city.	Consensus	0.19		0.43		0.24	
	Trees in cities risk to fall on me or my house during storms.		0.38		0.82	**	0.44	
	A key component of urban green spaces is to reduce the level of noise.	L	1.08	**	1.25	**	0.18	
	Greenspaces are useful for dumping refuse	L; MF; R	-0.56	*	-1.71	**	-1.15	**
	The purpose of a green space is to reduce air pollution within the city.	R	0.33		1.13	**	0.80	*
	Urban livestock can consume agricultural and household waste products, converting them into human food.	L; MF; R	-0.57	*	0.82	**	1.38	**
Cultural	Green spaces in school yards help to inculcate in our children good environmental practices and awareness, to become environmentally responsible adults.		0.00		0.61	*	0.61	
	Greenspaces provide me with recreational opportunities.		-0.77	**	-0.59		0.19	

Cultural	Growing cities should not affect the traditional norms of keeping the environment green and clean, which was taught by parents in the community.	R	0.41		1.93	**	1.52	**
	Parks are the heartbeats of all social gatherings.	MF	-1.09	**	-0.02		1.08	**
	The gardens and scented flowers along the roads are making the city more attractive and beautiful.	Consensus	-0.29		-0.05		0.24	
	The variety of flowers and grass in the gardens acts as magnets that pulls the youth to snap pictures.	R	-0.13		-1.22	**	-1.09	**
	Trees bring me peace and tranquillity.		0.64	**	0.42		-0.22	
	Urban greenspaces are a key driver of the film and advertising industry.	L	1.15	**	0.69	*	-0.46	
	Buildings make the environment more beautiful than trees and flowers.	R	0.06		-1.76	**	-1.82	**
	Green spaces and parks are often been taken over by lunatics, gangs and robbers, so I feel afraid to go there.		-0.42		-0.99	**	-0.57	
	Because I live in the city and will not go to the bush to see the plants and animals, I want to see them in the city.		0.90	**	0.54		-0.36	
	By conserving greenspaces in cities, we are continuing the work of God, who created all species to live with us.	Consensus	0.45		0.19		-0.26	
	Ghanaian cities must increase their green spaces to give residents a sense of pride	L	1.38	**	0.78	*	-0.60	
	Urban forests and parks are good places for religious activities, prayers and meditation.	L; MF; R	0.70	**	-0.95	**	-1.65	**
	Urban forests should be preserved for the present generation and generations yet unborn.		0.40		-0.46		-0.85	*

(c) Users

Sections	Statements	Factors being distinguishing from all other factors; and consensuses	Cultural heritage (CH) – Children (C)		Cultural heritage (CH) – Beauty and cleanliness (BC)		Cultural heritage (CH) – Development (D)		Children (C) - Beauty and cleanliness (BC)		Children (C) – Development (D)		Beauty and cleanliness (BC) - Development (D)	
Provisioning	Urban trees are an important source of wood and charcoal fuel.	C; D	-1.79	**	0.35		-3.62	**	2.14	**	-1.83	**	-3.97	**
	Converting urban parks and reserves to ecotourism facilities is essential to make them profitable.	BC; D	0.22		-0.70	**	1.09	**	-0.92	**	0.87	**	1.79	**
	Livestock in cities is important as it provides manure to improve soil fertility.		-1.29	**	-0.35		-1.39	**	0.94	**	-0.11		-1.04	**
	The job opportunities and incomes that could be earned from the development of urban parks, gardens and green spaces are significant.	BC	0.69	*	1.77	**	0.11		1.07	**	-0.58		-1.66	**

	The presence of trees and plants that heal is crucial in a city, as traditional medicine is an economical and trusted form of health care.		0.53		-0.18		0.93	**	-0.71	*	0.40		1.11	**
	Backyards and parks should be cleared to provide space for businesses and accommodation for the ever increasing urban population.		-1.14	**	0.03		-1.77	**	1.17	**	-0.63		-1.81	**
	Cities are centres of employment, trade and job creation, green spaces are not needed.	BC; D	-0.08		-0.77	**	-1.67	**	-0.69	*	-1.59	**	-0.90	**
	Backyard gardens are important to supplement incomes by selling roots and tubers, vegetables and fruits.		-1.36	**	0.42		-0.79	**	1.78	**	0.57		-1.21	**
	Produce from our gardens are available when we are in dire need of them because they are scarce on the market.	CH	1.60	**	1.06	**	1.66	**	-0.54		0.07		0.60	
	Small livestock in urban environments can make a big difference to nutrition and health.		1.11	**	0.25		1.61	**	-0.86	**	0.51		1.37	**
Provisioning	Cattle in urban areas can be dangerous if it is not properly enclosed		-0.82	**	-1.31	**	-0.13		-0.49		0.68	*	1.17	**
	Vegetables grown in the city are contaminated through chemicals and dirty water use.	CH; BC	-0.90	**	-2.11	**	-1.42	**	-1.21	**	-0.52		0.70	*
Regulat	Brong Ahafo used to be a forest so now we should be planting trees to recreate this natural environment.	BC	0.42		2.71	**	0.52		2.29	**	0.09		-2.19	**

Regulation and maintenance	Greenspaces are essential for recycling the nutrient into the soil, conserving soil quality for backyard gardens.	BC; D	-0.07		1.52	**	2.17	**	1.60	**	2.25	**	0.65	*
	Keeping greenspaces in the city allows natural predators of pests to stay and decrease the pests' impacts.	D	0.03		-0.43		-1.14	**	-0.46		-1.17	**	-0.71	*
	Open green spaces in the city are important to protect our waterways, essential for the provision of clean water.	CH; D	-1.15	**	-1.54	**	1.27	**	-0.39		2.42	**	2.81	**
	Parks and open green spaces offer me an opportunity to exercise to stay healthy.	D	-0.45		0.05		0.79	**	0.51		1.25	**	0.74	*
	The insects can help produce more fruits through pollination so we can get to eat fresh fruits from our backyard gardens.	BC	0.18		2.05	**	-0.04		1.87	**	-0.22		-2.09	**
	Trees within the city are important to provide me with natural shade.	Consensus	0.14		0.04		-0.11		-0.10		-0.24		-0.15	
	Greenspaces in the city are not good for health because they attract malaria-carrying mosquitoes.	CH; BC	-1.36	**	-0.67	*	-1.38	**	0.69	*	-0.03		-0.71	*
	Many plants and animals found in urban green spaces and parks can cause allergies.	CH; C; BC; D	0.58	*	-0.71	**	-1.49	**	-1.29	**	-2.07	**	-0.77	*
	Urban greenspaces can harbour animals that are aggressive towards humans.		-0.17		-1.53	**	-1.10	**	-1.36	**	-0.93	**	0.43	

Regulation and maintenance	In the city, trees are natural windbreaks which protects me from storms.	BC; D	0.10		-0.76	**	0.97	**	-0.86	**	0.88	**	1.74	**
	We need the trees in our cities to help reduce the impact of climate change.		0.48		1.23	**	1.26	**	0.75	*	0.78	*	0.03	
	With grass and trees in the city, when the rain comes, it just flows down and sinks into the ground instead of flooding the city.	C; D	-1.06	**	0.29		2.46	**	1.35	**	3.52	**	2.17	**
	Trees in cities risk to fall on me or my house during storms.		0.49		-0.48		0.93	**	-0.96	**	0.45		1.41	**
	A key component of urban green spaces is to reduce the level of noise.	CH; D	0.79	**	0.85	**	-1.80	**	0.06		-2.59	**	-2.65	**
	Greenspaces are useful for dumping refuse	Consensus	0.33		-0.21		0.14		-0.54		-0.19		0.35	
	The purpose of a green space is to reduce air pollution within the city.		-0.26		-1.75	**	-1.80	**	-1.50	**	-1.55	**	-0.05	
	Urban livestock can consume agricultural and household waste products, converting them into human food.		0.95	**	-0.45		1.00	**	-1.40	**	0.05		1.45	**
Cultural	Green spaces in school yards help to inculcate in our children good environmental practices and awareness, to become environmentally responsible adults.		0.66	*	0.22		1.05	**	-0.45		0.38		0.83	**

	Greenspaces provide me with recreational opportunities.	Consensus	-0.20		-0.18		-0.21		0.02		-0.01		-0.03	
	Growing cities should not affect the traditional norms of keeping the environment green and clean, which was taught by parents in the community.	CH; C	0.88	**	1.52	**	2.04	**	0.64	*	1.16	**	0.51	
	Parks are the heartbeats of all social gatherings.		-0.49		0.81	**	0.54		1.30	**	1.03	**	-0.27	
	The gardens and scented flowers along the roads are making the city more attractive and beautiful.	Consensus	-0.08		0.38		-0.21		0.47		-0.12		-0.59	
	The variety of flowers and grass in the gardens acts as magnets that pulls the youth to snap pictures.	BC; D	0.50		-1.07	**	1.17	**	-1.57	**	0.67	*	2.23	**
	Trees bring me peace and tranquillity.	C	1.13	**	-0.09		0.30		-1.22	**	-0.83	*	0.39	
	Urban greenspaces are a key driver of the film and advertising industry.		-0.08		-1.40	**	-1.76	**	-1.31	**	-1.67	**	-0.36	
	Buildings make the environment more beautiful than trees and flowers.	C; D	-1.08	**	0.21		-2.09	**	1.29	**	-1.01	**	-2.29	**
Cultural	Green spaces and parks are often been taken over by lunatics, gangs and robbers, so I feel afraid to go there.	C; BC	1.19	**	-1.01	**	0.42		-2.20	**	-0.77	*	1.43	**

	Because I live in the city and will not go to the bush to see the plants and animals, I want to see them in the city.	D	0.32		0.47		-0.83	**	0.15		-1.16	**	-1.30	**
	By conserving greenspaces in cities, we are continuing the work of God, who created all species to live with us.	C	1.82	**	0.48		0.54		-1.35	**	-1.28	**	0.07	
	Ghanaian cities must increase their green spaces to give residents a sense of pride		-1.02	**	-0.36		-0.60	*	0.66	*	0.42		-0.24	
	Urban forests and parks are good places for religious activities, prayers and meditation.		0.51		0.26		-0.26		-0.25		-0.77	*	-0.52	
Cultural	Urban forests should be preserved for the present generation and generations yet unborn.	CH; C; BC; D	-0.83	**	1.08	**	2.60	**	1.90	**	3.43	**	1.53	**

Table F.6. Factor loadings on each viewpoint for each participant, divided by stakeholder categories. Bold factors indicate that the participant in question was flagged as representative of this viewpoint.

Experts				Authorities			Users			
ER	WB	SD	IS	L	MF	R	CH	C	BC	D
0.3	0.05	**0.65**	0.53	0.48	**0.65**	0.39	0.4	0.6	0.37	0.03
0.69	0.32	0.38	0.02	0.13	**0.53**	0.42	-0.14	0.44	**0.66**	-0.1
0.35	**0.74**	0.19	0.28	**0.64**	0.52	0.1	**0.68**	0.42	0.18	0.08
0.71	0.33	0.16	0.31	**0.7**	0.4	0.18	0.33	0.47	0.33	0.28
0.34	**0.64**	0.09	0.32	0.36	**0.74**	0.24	0.31	0.14	**0.5**	0.06
0.67	0.42	0.28	0.29	**0.69**	0.44	0.22	**0.53**	0.18	0.34	0.09
0.66	0.25	0.11	0.41	0.59	0.59	0.22	**0.65**	0.43	0.09	0.02
0.33	**0.64**	0.25	0.22	**0.71**	0.23	0.15	**0.73**	0.33	0.15	0.14
0.31	0.5	0.48	0.14	**0.64**	0.4	0.42	**0.74**	0.18	0.16	0.24
0.54	0.62	0.27	0.18	0.41	**0.7**	0.15	0.36	0.04	**0.46**	0.14
0.19	**0.74**	0.31	0.23	**0.63**	0.18	0.41	-0.05	0.39	0.28	**0.53**
0.66	0.19	0.2	0.37	0.53	0.56	0.29	0.07	0.29	-0.09	**0.46**
0.18	0.18	0.3	**0.73**	**0.7**	0.45	0.06	0.1	**0.5**	-0.15	0.03
0.68	0.43	0.13	0.36	**0.71**	0.21	0.4	0.44	0.24	0.27	**-0.63**
0.23	0.37	**0.8**	0	0.17	0.19	**0.57**	0.01	-0.21	**0.75**	0.14
0.69	0.42	0.17	-0.02	**0.75**	0.21	0.27	0.35	0.1	**0.62**	-0.28
0.12	0.37	-0.06	**0.75**	0.32	0.14	**0.65**	0.26	**0.56**	0.31	0.1
0.5	**0.65**	0.27	0.15	**0.6**	0.29	0.4	**0.76**	0.02	0.15	0
0.22	0.26	**0.74**	0.2	**0.56**	0.37	0.24	0.49	0.53	0.35	-0.15
0.62	0.12	0.47	-0.02	0.21	0.08	**0.7**	**0.74**	0.16	0.29	0.05
0.57	0.43	0.42	0.26	**0.75**	0.15	0.25	0.48	0.47	0.37	0.19
0.58	0.52	0.35	0.05	0.25	**0.72**	0.07	0.54	**0.59**	0.04	0.14
				0.68	0.35	0.26	**0.7**	0.28	0.07	-0.19
				0.62	0.42	0.27	0.37	0.1	**0.65**	-0.11
				0.55	0.55	0.2	0.19	**0.81**	-0.01	0.07
				0.1	**0.59**	0.56	0.35	0.01	0.1	**0.6**
				0.61	0.29	0.52	0.39	-0.03	0.45	0.36

Appendix G:
Pumpkin pollination in urbanising Ghana

G.1. Methods

G.1.1. Data collection

Pumpkins were selected as a target crop to assess pollination due to their high dependence on bees (Klein et al., 2007) and their usage in both urban and rural agriculture in Ghana. Pumpkins were sampled between October 4 and November 11 2017 at 35 different locations across the same urbanisation gradient as for the pollinator sampling (Figure B.1; see Chapter 2). The sampling sites were selected by visiting farms sampled for bee abundance and diversity (Chapter 2) and by scoping around to find pumpkin growing farms (32 out of the 37 sampling sites) or wild growing pumpkins (5 out of 37). Due to access and availability, one pumpkin only was collected per location. I simultaneously recorded, when possible, the weeding practices, which could be arrange in three categories, namely not weeded, manually weeded and chemically weeded. Seed count being a proxy measure for pollination success (Walters and Taylor, 2006), I counted every seed of the 35 collected pumpkins, and noted the different varieties.

The height and maximum diameter of each pumpkin was measured and their seeds were manually counted. Harvesting date and variety were recorded, and so was the use of tilling and pesticide when farmers were available to provide such information (26 cases out of 37).

G.1.2. Data analysis

I ran generalised linear mixed-effect models to test the effect of urbanisation on the pumpkin pollination success (seed numbers). Urbanisation was quantified as the proportion of built infrastructure, extracted from the land-cover maps, in a 600m radius, the average foraging range of solitary bees (Gathmann and Tscharntke, 2002).

After excluding correlated explanatory variables with variance inflation factors >3 (Zuur, 2009), models included four variables, namely the proportion of built infrastructure, weeding practices, altitude and pumpkin variety, and a random grouping variable representing the pumpkin sampling date. I used negative binomial error distributions to compensate for the over-dispersion observed in the seed numbers (Burnham and Anderson, 2002). Models were run with all possible combinations of variables and compared according to the AIC_c, selecting those with $\Delta AICc \leq 2$ and averaging them using Akaike weights (Burnham and Anderson, 2002). All analysis were carried out in R, v.3.4.3 (R Core Team, 2017), with the model selection using the R statistical package MuMIN, v.1.40.4 (Barton, 2018).

G.2. Results

Pumpkins had a mean of 436 seeds (standard error: 26). Only the pumpkin variety and the altitude were selected in the best-fitting variables, but none had any significant effect (Table G.1). Urbanisation consequently did not affect the pumpkin pollination success (Figure G.1).

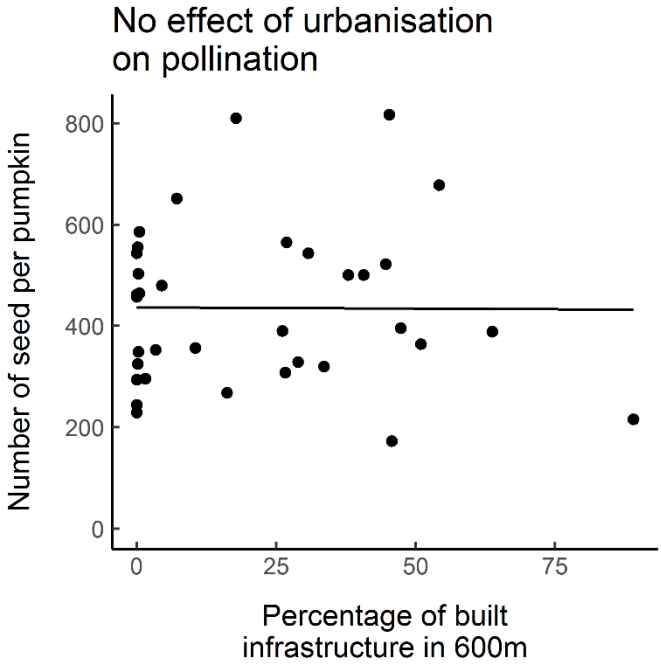

Figure G.1. Relationship between urbanisation gradient (built infrastructure) and pumpkin pollination success (seed per pumpkin). Each dot represents a sampling site (N = 35)

Table G.1. Parameter estimates, standard error, z-values and p-values for the averaged models (DeltaAICc≤2) for pumpkin seed counts.

		Estimate	Std. Error	Adjusted SE	z value	Pr(>|z|)
(Intercept)		6.189	0.275	0.281	22.032	<2e-16 ***
Altitude		-0.001	0.001	0.001	1.378	0.168
Variety	A-B	-0.036	0.207	0.215	0.167	0.868
	A-C	0.206	0.213	0.222	0.928	0.354

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Appendix H:
Greenspace visual preferences

H.1. Methods

Visual preferences for different greenspace management types were assessed before the Q-sort (Chapter 3). Participants were thus selected following the same procedure (Chapter 3.5.3) though excluded two visually impaired participants and included three participants who piloted the study, amounting to a total of 77 participants.

As part as the pre-sorting interview, participants were asked to rank, from the most preferred (1) to the least preferred (5), five pictures of urban greenspaces representing (i) an unmanaged urban greenspaces with relatively high vegetation, (ii) an urban farm, (iii) an open greenspace with short vegetation, (iv) a highly managed greenspace with lawns, hedges and trees and (v) rooftop vegetation comprised of trees (Figure H.1). All images were taken in Ghanaian cities. Images were presented to the participants in a random order. Participants were then asked to explain their classification.

Rankings were compared with a non-parametric Kruskall-Wallis test and a pair-wise Wilcoxon test was used for pair-wise comparisons.

Figure H.1. Pictures of greenspaces presented to the Q-study participants for ordering

H.2. Results

There were significant differences in how the different types of greenspaces were ranked (Kruskal-Wallis chi-squared=107.4, df=4, p<0.001). The greenspace picture representing a highly maintained lawn with hedges and trees (iv) was the significantly preferred as opposed to all other pictures (p<0.001, Figure H.2 and H.3, Table H.2). This was described as being *"very serene and […] well planned in the sense that it's like the parks around have been properly demarcated which makes it a bit permanent", "beautiful, orderly, serene environment"* or a place where *"people can sit outside and relax".*

The open greenspace with short vegetation (iii) was the one with the highest (least preferred) median, though the difference was only significant compared with the urban farm (p=0.035) and the highly maintained lawn (p<0.001). Its negative aspects were mainly that it had *"not been properly cared for, needs watering"* or *"not well kept".* It was however recognised to *"give space for social gatherings and in case of disasters"*.

As for the other types of urban greenspaces, they was no consensus on which of those were preferred or not, with their median score being of three (neither most nor least preferred) for the all three greenspace types (Figure H.2). The unmanaged greenspace (i) was described as being uncontrolled, with opinions ranging from *"this one is a bit wilder and I like that"* to *"we are not leaving it for*

the sake of the greenery, you should have visual elements". The urban farm (ii) was praised as being useful, offering a way to *"feed on it for a long time"* and complement income. However, it was also criticised for being badly maintained. As for the rooftop, it was said that *"here is a touch of modernity […] there is a feel of some creativity attached to it"* but also to lack space, having *"just a few trees"*. Some respondents also mentioned not seeing green roofs as a realistic option in smaller cities like Sunyani and Techiman.

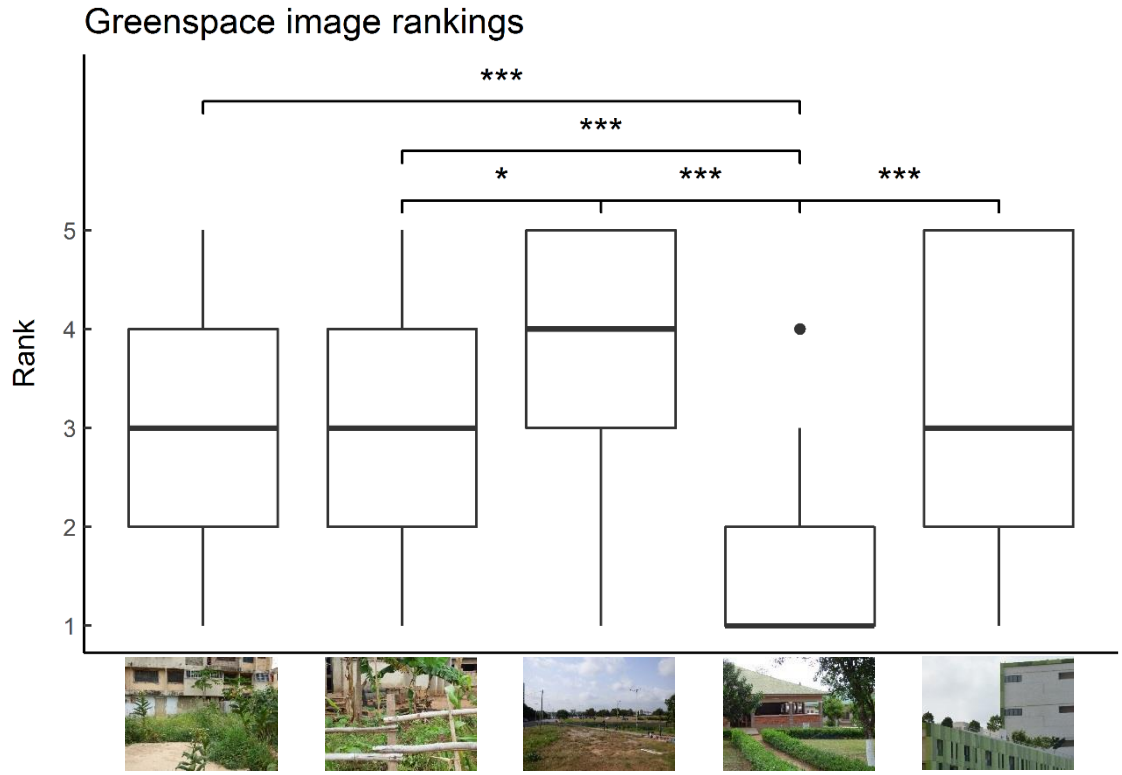

Figure H.2. Differences in ranking for the five different types of greenspaces. Pictures were ranked from the most preferred (1) to the least preferred (5). N=77. Boxes show median and interquartile ranges, with the whiskers extending to 1.5 of the interquartile range. Significance levels are indicated by *$p < 0.05$, **$p < 0.01$ and ***$p < 0.001$.

Table H.1. P-values of the pair-wise comparisons rankings of the different types of urban greenspaces.

				
	0.618	-	-	-
	0.173	0.035	-	-
	3e-15	3e-15	<2e-16	-
	0.729	0.431	0.293	3e-15

Glossary

Biodiversity	The variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems (United Nations, 1992).
Biodiversity hotspot	See hotspot
City	See urban areas
Ecosystem services	The contributions that ecosystems make to human well-being (Haines-Young and Potschin, 2013). Those contributions are defined by a clause describing the biophysical output and a clause describing the contribution it makes to an eventual use or benefit, and are classified in three categories: (i) provisioning, (ii) regulation and maintenance and (iii) cultural (Haines-Young and Potschin, 2018).
Ecosystem disservices	Functions of ecosystems that are perceived as negative for human well-being (Lyytimäki and Sipilä, 2009).
Global North	As opposed to Global South (next entry), includes all nations classified by the World Bank as high-income country as well as European countries (including the Russian Federation) classified as low- or middle-income countries (Mitlin and Satterthwaite, 2013).
Global South	Includes all nations classified by the World Bank as low- and middle- income countries that are in Africa, Asia and Latin America (Mitlin and Satterthwaite, 2013).

Governance	Structures and processes by which collective action among a diversity of social actors (state, private, and civil society) is coordinated towards upholding certain publicly held values and resources (Ernstson et al., 2010).
Greenspaces	All vegetated areas within the urban environment, including blue spaces such as lakes and rivers and their adjacent green (Taylor and Hochuli, 2017; Cvejić et al., 2015).
Hotspot	Area that (a) features exceptional concentrations of species with exceptional levels of endemism, and that (b) face exceptional degree of threats (Myers, 1988).
Non-native species	A species, subspecies or lower taxon, introduced outside its natural past or present distribution; includes any part, gametes, seeds, eggs, or propagules of such species that might survive and subsequently reproduce (CBD, 2002).
Urban areas	Abutting areas with high density of human population, quantified with a proportion of built infrastructure equal or greater than 15% (McKinney, 2008; McIntyre et al., 2000).
Payment for ecosystem services	A voluntary transaction where a well-defined environmental service or a land use likely to secure that service is being ‘bought’ by a service buyer from a service provider if and only if the service provider secures service provision (Engel et al., 2008).
Social networks	The set of relationships enabling the movement of ideas and information or influencing the beliefs and behaviours of the individual stakeholders (Groce et al., 2019).
Values	The importance of something for itself or for others, now or in the future, close by or at a distance. It is subjective and may be based on experience (IPBES, 2015).

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