Urbanization and human-nature relationships:

A comparison of urban and rural dwellers' perceptions of ecosystem services in the Solomon Islands

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To the women of the Solomon Islands, their kindness, openness, and resilience.

"Mankind has gone very far into an artificial world of his own creation. He has sought to insulate himself, in his cities of steel and concrete, from the realities of earth and water and the growing seed. Intoxicated with a sense of his own power, he seems to be going farther and farther into more experiments for the destruction of himself and his world. There is certainly no single remedy for this condition and I am offering no panacea. But it seems reasonable to believe — and I do believe — that the more clearly we can focus our attention on the wonders and realities of the universe about us the less taste we shall have for the destruction of our race. Wonder and humility are wholesome emotions, and they do not exist side by side with a lust for destruction."

~ Rachel Carson
Speech accepting the John Burroughs Medal (1952)
In Lost Woods: The Discovered Writing of Rachel Carson (1999)

"The city is a fact in nature, like a cave, a run of mackerel or an ant-heap. But it is also a conscious work of art, and it holds within its communal framework many simpler and more personal forms of art. Mind takes form in the city; and in turn, urban forms condition mind."

~ Lewis Mumford
The Culture of Cities (1938)

"Cities have the capability of providing something for everybody, only because, and only when, they are created by everybody."

~ Jane Jacobs
The Death and Life of Great American Cities (1961)

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Abstract

Urbanization deeply alters ecosystems, people's livelihoods, lifestyle, and their relationships with nature. However, the ways in which urbanization affects different aspects of human-nature relationships are not well understood. In this thesis, I explore how urbanization affects people's perceptions of ecosystem services in the Solomon Islands. Existing research on ecosystem services tends to focus on valuing supply in monetary or biophysical units. Valuing ecosystem services through people's perceptions (i.e., socio-cultural valuation) clarifies the perspective of the beneficiaries of the services. This in turn provides insights into how different people value and actually benefit from ecosystem services, wellbeing impacts, and ultimately, environmental behaviour.

I used a comparative case study approach, pairing two urban to two rural coastal sites in the Solomon Islands, a Small Island Developing State in the South Pacific. Only 20% of the population lives in urban areas, but urbanization is rapid. Using mixed methods, I conducted 50 semi-structured interviews per site (N=200). I analysed the data quantitatively and triangulated with qualitative data from focus group discussions and interviews with key informants. I focused on four interlocking themes.

First, I compared how urban and rural dwellers differed in their socio-cultural valuation of ecosystem services. I assessed the importance that people attributed to different ecosystem services for their wellbeing, as well as their satisfaction with these services. Although both urban and rural dwellers reported that ecosystem services were important for their wellbeing, urban dwellers' ratings were lower. Thus, urbanization appears to decrease nature's contributions to human wellbeing. Moreover, urban dwellers were less satisfied than rural dwellers with the benefits that they received from ecosystem services and would have preferred to benefit more. My findings demonstrate how urbanization affects human-nature relationships in the Solomon Islands. By including satisfaction in addition to importance, I provide a better understanding of people's needs and preferences towards nature.

Second, the effect of urbanization on wellbeing benefits derived from ecosystem services remains poorly understood. Drawing on the social wellbeing framework, I compared

perceived wellbeing benefits derived from ecosystem services in urban and rural areas. My analysis revealed complex and multidimensional associations between ecosystem services and wellbeing benefits, with all ecosystem services contributing to material, relational, and subjective wellbeing dimensions. Although ecosystem services contributed in similar ways to the wellbeing of urban and rural dwellers, urban dwellers reported fewer material, relational, and subjective wellbeing benefits, especially in terms of 'basic material needs', 'connection to nature', and 'feelings of happiness'. My findings highlight the multidimensional negative wellbeing impacts of altered human-nature relationships caused by urbanization. More broadly, by linking the ecosystem service and social wellbeing frameworks, I demonstrate the complexity and multidimensionality of ecosystem service-wellbeing relationships.

Third, as a driver of environmental change, urbanization rarely affects the provision of ecosystem services in isolation, but rather as bundles of spatially co-occurring services generated together through ecological and socio-economic processes. However, the effects of urbanization on the perceived distribution of ecosystem service bundles in the land- and seascape remain poorly understood. To address this gap, I compared urban and rural dwellers' perceptions of ecosystem service bundles associated with the different local ecosystems. Urbanization simplified ecosystem service bundles mainly through a reduction in the proportion of provisioning services in several bundles, but also culture and recreation services in a few bundles. My findings demonstrate where and how people's relationships with nature in the Solomon Islands were altered by urbanization. Analysing bundles from different angles, in terms of ecosystem service composition and number of people benefiting from them, can inform environmental management on how and where people benefit from ecosystem services in the land- and seascape.

Fourth, the mechanisms by which urbanization alters people's relationships with nature, for example in terms of ecosystem service availability and access, require further investigation. Ecosystem service availability in urban areas could be limited by highly transformed local ecosystems. However, according to the theory of access, the ability to derive benefits from a given ecosystem service supply determines the actual benefits to people. I compared perceived availability and access limitations to ecosystem service benefits in urban and rural areas. More urban dwellers reported being limited in both availability and access in the

benefits that they derived from ecosystem services. Availability factors were the most frequently perceived limitations, although access played an important role for both provisioning and cultural services. Therefore, reduced ecosystem service availability and access mechanisms related to urbanization were at least partly responsible for the altered human-nature relationships. By investigating perceived availability in conjunction with access issues, I fill an important research gap in the natural resources access literature.

In sum, I show in my thesis that urbanization in the Solomon Islands alters human-nature relationships by decreasing the contributions of provisioning, regulating, and cultural ecosystem services to human wellbeing. These changes affected primarily the material, but also the relational and subjective, wellbeing dimensions. Urbanization also simplified relationships with most ecosystems, losing direct connections through provisioning services, but also culture and recreation for some ecosystems. The effects of urbanization were due at least in part to decreased ecosystem service availability for all ecosystem services but also access mechanisms in the case of provisioning and cultural services.

Finally, more socio-cultural ecosystem service research focused on paired urban and rural comparisons, conducted in different contexts around the world and points along the rural-urban gradient, could lead to a better understanding of how urbanization transforms human-nature relationships. With more than half of the world's population lives in cities, urban dwellers' perceived relationships with ecosystem services could help urban planners and environmental managers identify opportunities to facilitate connections with nature, therefore improving human wellbeing and fostering pro-environmental behaviour, and, ultimately, helping ensure societies transition to more sustainable trajectories.

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List of acronyms

CICES	Common International Classification of Ecosystem Services
CLMM	Cumulative Links Mixed Model
EMM	Estimated Marginal Means
ESPA	Ecosystem Services for Poverty Alleviation
FGD	Focus Group Discussion
GDP	Gross Domestic Product
GLMM	Generalized Linear Mixed Model
IPBES	International Platform on Biodiversity and Ecosystem Services
IPCC	The Intergovernmental Panel on Climate Change
MA	Millennium Ecosystem Assessment
MSL	Material Style of Life
PCA	Principal Component Analysis
SD	Standard Deviation
SDG	Sustainable Developmental Goals
SIDS	Small Island Developing States
SPC	The Pacific Community
SPREP	Secretariat of the Pacific Regional Environment Programme
TEEB	The Economics of Ecosystems and Biodiversity
UN	United Nations

1. Introduction

1.1 Background

Urbanization transforms human-nature relationships and alters the contributions that ecosystems make to human wellbeing, via ecosystem services (MA 2005a, Elmqvist et al. 2013b). In this process, sparsely populated natural and rural environments are rapidly transformed into densely populated highly built urban environments, whose degraded ecosystems have less potential to provide ecosystem services (Seto et al. 2013). With the advent of urbanization, people's livelihoods also transition from being directly connected to nature in traditional rural societies, for example through agricultural production, to more indirect connections, in which most urban dwellers are employed in the industrial or service sectors (Elmqvist et al. 2013c, Cumming et al. 2014). These environmental and socio-economic changes can in turn affect how people experience, perceive, and value ecosystems and their services with consequences for environmental behaviour and wellbeing.

People living a modern lifestyle in built-up and degraded urban environments have fewer opportunities to experience nature compared to people living in more natural or rural environments. This phenomenon is referred to as 'nature-deficit disorder' in environmental psychology (Louv 2005, 2009) and 'extinction of experience' in ecology (Pyle 2003, Soga and Gaston 2016), and increases the risk of an array of health issues including diabetes, pulmonary diseases and anxiety (Dye 2008, Cox et al. 2018). This lack of connection with nature can decrease pro-environmental behavior and lead to unsustainable consumption patterns (Mackay and Schmitt 2019, Barrera-Hernández et al. 2020, Whitburn et al. 2020). Furthermore, these experiences of altered ecosystems shape people's conceptualizations of nature, which may differ between people and between generations, i.e., 'environmental generational amnesia' in psychology (Kahn Jr and Friedman 1995) and 'shifting baseline syndrome' in ecology (Pauly 1995, Papworth et al. 2009, Soga and Gaston 2018). A shift in nature baselines can generate feedback loops leading to further environmental degradation (Soga and Gaston 2018) by setting inadequate targets for environmental management that can maintain a system in a degraded state (Pauly 1995). Therefore, these transformed experiences and perceptions of nature can be detrimental to human wellbeing as well as environmental sustainability. Notwithstanding these general trends, the possibility to experience nature in cities and the impacts on wellbeing vary considerably according to availability and access of green and blue areas, which are mediated notably by geographic

location, culture, socio-economic characteristics, and preferences (e.g., Russell et al. 2013, Lin et al. 2014, Tan and Samsudin 2017).

However, little is known about how urbanization affects different facets of human-nature relationships. I contribute to addressing this research need by exploring through my thesis how people's perceptions of multiple ecosystem services are transformed by urbanization. Now that more than half of the world's population lives in cities (55%), a proportion that will reach two-thirds by 2050 (i.e., 6 billon people, United Nations 2019), solutions to improve both environmental sustainability and human wellbeing in the future must involve cities and their inhabitants, as acknowledged by the Sustainable Developmental Goal 11 to *Make cities and human settlements inclusive, safe, resilient and sustainable* (United Nations 2015).

1.2 The ecosystem service framework

Following the Second World War, humanity underwent the most rapid population growth, urbanization, and economic development in history, driven by an increased use of fossil fuels (Costanza et al. 2007, United Nations 2019). Urbanization can offer opportunities for sustainability by fostering innovation and allowing economies of scale in providing infrastructure and services at higher population densities (United Nations 2019). However, increased wealth and changes in lifestyle and consumption patterns, especially in affluent urban areas, came at a dire cost to the environment whose degradation was treated as an externality (Costanza et al. 1997, Kareiva et al. 2007). In reaction to the extensive environmental degradation experienced in the 20th century, ecologists and economists in the 1990s refined the concept of ecosystem services to show the importance of ecosystems to sustain human life, but also the threats that several ecosystem services face (Costanza et al. 1997, Daily 1997). By giving a monetary value to ecosystem services, this research aimed to raise societal awareness of humanity's dependence on ecosystems (MA 2005a, Daily et al. 2009).

At the turn of this century, the ecosystem service concept became more visible with the publication of the Millennium Ecosystem Assessment (MA 2005), a colossal research effort involving more than 1,360 experts from around the world. The MA showed that, at the time,

60% of ecosystem services had been degraded worldwide. By linking ecosystem services to human wellbeing, the MA showed the impact of environmental change on human wellbeing, highlighting that the poor and vulnerable were more negatively impacted. More recently, the International Platform on Biodiversity and Ecosystem Services (IPBES) has continued this endeavor, notably by showing the importance of pollinators, the threats that they are facing, and the resulting wellbeing impacts mainly on food production (Potts et al. 2016). This framework has been adopted by researchers from various disciplines, starting from its roots in ecology and economy to social, political and earth system sciences, and has resulted in over 17,000 publications during the two decades from 1997 to 2017 (Costanza et al. 2017). The concept has been integrated into practice by some governments, institutions, and corporations (Daily et al. 2009).

Although several ecosystem service classifications exist, I adopt here the Common International Classification of Ecosystem Services (CICES, Haines-Young and Potschin 2018). CICES was developed for ecosystem service accounting and assessing, as well as to translate other classifications into a common language (e.g., MA, The Economics of Ecosystems and Biodiversity (TEEB), or IPBES). CICES focuses on the elements and processes from ecosystems that allow us to derive wellbeing benefits, avoiding the confusion between ecosystem services and wellbeing benefits that can sometimes occur in other classifications. CICES recognizes three ecosystem service categories. First, provisioning services refer to the material goods that people derive from ecosystems, such as food, timber or medicine. Second, regulation and maintenance services (hereafter, regulating services) are the ecological processes that regulate water and air quality or local and global climatic conditions, for example to maintain healthy environmental conditions. Third, cultural services are the non-material benefits that people derive from nature, such as the elements of nature that present aesthetic or religious values for people.

The ecosystem service framework also offers an interesting perspective to investigate transformations in human-nature relationships associated with urbanization through the multiple services that people derive from nature. At local and regional scales, urbanization impacts the provision of the three ecosystem service categories differently and, thus, how urban dwellers can experience nature. First, local provisioning services that people

traditionally derive from their surrounding environment cannot meet the demand from the urban population; instead, provisioning services come from distant places through a globalized economy (Seto et al. 2012, Cumming et al. 2014). Provisioning services can also be replaced by non-ecosystem services such as manufactured goods that have complex and often obscure relationships with distant ecosystems (Cumming et al. 2014). Second, regulating services can be degraded in and around cities because of transformations to natural ecosystems, overexploitation of provisioning services, and pollution (MA 2005b). While some of the benefits derived from regulating services can be replaced by infrastructure such as water filtration plants, others such as air quality and climate regulation are harder to substitute by non-ecosystem services. Third, although some cultural services can be experienced in urban environments, for example urban parks provide places to recreate (Rall et al. 2017), their access might be unequal among social groups, with wealth shown to increase access to urban green areas (e.g., Dobbs et al. 2014, Tan and Samsudin 2017). However, less is known about the resulting impacts of these environmental changes associated with urbanization on people's perceptions of the ecosystem services.

Investigating people's perceptions of ecosystem services provides information on human-nature relationships from the viewpoint of the beneficiaries of these services. Perceptions refer to *the way an individual observes, understands, interprets, and evaluates*, in this case, their environment (Bennett 2016). As mental constructs, perceptions are influenced by the interaction between the object perceived, socio-cultural context, and personal values, norms, beliefs, knowledge, and experiences, among others (Bennett 2016). Approaches using perceptions as evidence to assign values to ecosystem services, i.e., socio-cultural valuation (Scholte et al. 2015), can help show who benefits from ecosystem services and how (Daw et al. 2011). Perceptions of ecosystem services can thus contribute to assessing the social impacts of environmental change and help manage the environment to mitigate these impacts (Bennett 2016). Furthermore, perceived values of ecosystem services can shed light on people's motivations and behaviours in relation to the environment (Braito et al. 2017, Muhar et al. 2017), which can inform environmental communication, conservation and sustainability initiatives. Therefore, in part through a better understanding of how people perceive their environment and the benefits that they derive from it, we can identify opportunities to

reconnect people with nature, improve human wellbeing, and lead societies into more sustainable trajectories.

1.3 Gaps in the ecosystem service literature

In this thesis I address eight broad research needs in the ecosystem service literature. More specific research gaps are discussed in the relevant chapters (Chapters 2 and 4 to 7).

1) Socio-cultural valuation

In the context of this thesis, ecosystem service valuation is understood as the assessment of the importance the ecosystem service contributions to human wellbeing. Three main approaches are used to value ecosystem services: (1) ecological or biophysical; (2) monetary or economic; and (3) non-monetary or socio-cultural valuations (MA 2005a, De Groot et al. 2010). Biophysical valuation quantifies the stock of certain ecosystem services, for example, in terms of carbon storage or sediment retention (Reyers et al. 2010) and is the most commonly used ecosystem service valuation approach (Lautenbach et al. 2019). However, ecosystem services measured in different units do not allow comparison of their relative importance for people, which is often needed in decision making. In contrast, both socio-cultural valuation and monetary valuation allow assessment of all categories of ecosystem services with the same methodology, in the same units (Granek et al. 2010, Hicks 2013). Economic valuation is often based on biophysical indicators that are then converted into monetary units (De Groot et al. 2010). However, monetary valuation is less suited to valuing intangible cultural ecosystem services (Scholte et al. 2015), such as sense of place or heritage values that may be harder to replace or substitute, than provisioning and regulating services (Plieninger et al. 2013). Furthermore, economic approaches might also be ill-suited in the case of ecosystem services that are not traded on the market, such as air purification (Granek et al. 2010), and for subsistence economies (Christie et al. 2012). In socio-cultural valuation, individuals or groups of people can attribute a value to ecosystem services according to the perceived importance of their contribution to human wellbeing, through rating or ranking exercises for example (Felipe-Lucia et al. 2015, Scholte et al. 2015). More research using a socio-cultural approach that involves ecosystem service beneficiaries is needed in the ecosystem service field in general (Lautenbach et al. 2019) and in the urban ecosystem service field in particular (Luederitz et al. 2015).

2) Socially-disaggregated analyses

Most ecosystem service studies rely on aggregate values, i.e., values for a whole population or for people in general (Daw et al. 2011). However, there have been calls for more individual-level data in the ecosystem service field as a whole (Daw et al. 2011) and in urban ecosystem services in particular (Haase et al. 2014, Luederitz et al. 2015). Changes in ecosystem service provision can impact people differently depending on their values, needs, and preferences (Daw et al. 2011, Robards et al. 2011). Therefore, understanding how and why people value ecosystem services differently, through socio-cultural valuation, can inform environmental management to avoid inequitable and detrimental social outcomes (Coulthard et al. 2011, Daw et al. 2011, Gurney et al. 2015). This type of valuation might be especially relevant in urban areas where social inequalities are high (e.g., Smets and Salman 2008, Østby 2016).

3) Human wellbeing

The ecosystem service perspective is used to demonstrate the importance of nature to people by highlighting its contributions to human wellbeing. However, the contributions of ecosystem services to the wellbeing of different people in a society are still not well understood, especially in the case of cultural and regulating services (Bennett et al. 2015, Daw et al. 2016). Furthermore, while there has been research on the impacts of nature or the lack of nature on physical and psychological health in urban environment (e.g., Harlan and Ruddell 2011, Hartig and Kahn 2016), there is a need to understand how ecosystems in and around cities contribute to other aspects and dimensions of wellbeing besides material wellbeing. For example, studies are needed that examine the relational and subjective dimensions of the social wellbeing framework (Gough and McGregor 2007).

4) Relational values

The IPBES framework has highlighted recently the importance of relational values (Díaz et al. 2015, Pascual et al. 2017), which have emerged as a blind spot in most ecosystem service research (Kadykalo et al. 2019). Relational values can be defined as "*preferences, principles, and virtues associated with relationships, both interpersonal and as articulated by policies and social norms"* (Chan et al. 2016) and signify "*the meaningfulness of relationships"* with nature (Pascual et al. 2017). Relational values are thought to be important because they can go beyond the intrinsic/instrumental values divide and may be more relevant to influence

people's behavior than instrumental or intrinsic values (Chan et al. 2016). Furthermore, how urbanization changes these relational nature values is not known.

5) Ecosystem service bundles

Ecosystem service bundles, or ecosystem services that frequently associate in space or time (Raudsepp-Hearne et al. 2010a), can provide important information in environmental management about the spatial distribution of ecosystem services, multifunctionality of landscapes and seascapes, and potential trade-offs between services (Saidi and Spray 2018). However, more social approaches in the ecosystem service bundle research field are needed to better integrate cultural services and to identify potential mismatches between ecosystem service supply and demand (Saidi and Spray 2018). The role of drivers of environmental change, such as urbanization, on ecosystem service distribution also needs to be better understood (Bennett et al. 2015, Spake et al. 2017).

6) Availability and access mechanisms

Research has focused more frequently on ecosystem service availability or supply (Burkhard et al. 2012) rather than differential access to ecosystem services across people or social groups (Bennett et al. 2015, Wieland et al. 2016). However, access to ecosystem services, defined as *the ability to derive benefits from* ecosystem services (Ribot and Peluso 2003), can mediate who actually benefits and how from a given supply of ecosystem services (Haines-Young and Potschin 2010, Daw et al. 2016). The need for research addressing questions of access was identified in the MA and again more recently by IPBES (Mastrángelo et al. 2019). In contrast, the access literature related to natural resources often omits the physical characteristic of the resource, such as its availability (Myers and Hansen 2019). How urbanization affects the relative roles of ecosystem service availability and access in limiting the benefits to people is not well understood.

7) Ecosystem disservices

Ecosystem disservices are ecosystem elements or functions that impact wellbeing negatively (Shackleton et al. 2016), but are rarely included in ecosystem service research (Lele et al. 2013, von Döhren and Haase 2015, Shackleton et al. 2016). Yet, in some instances, ecosystem disservices can influence people's behaviour towards nature even more than ecosystem

services (Blanco et al. 2019). For example in urban areas, ecosystem disservices can prevent people from experiencing nature because of feelings of insecurity in some urban green areas or health impacts due to allergies and vector-borne diseases (von Döhren and Haase 2015). Therefore, failing to address ecosystem disservices in environmental management could increase ecosystem disservice provision and lead to unintended detrimental impacts on human wellbeing for some people and even result in social conflicts (Lyytimäki and Sipilä 2009, Shackleton et al. 2016, Campagne et al. 2018). Using perceptions to assess disservices is especially relevant because disservices are, in some cases, highly subjective to the extent that some might even be considered services depending on the perspective (Jax et al. 2013).

8) The Global South

Most future urbanization will occur in countries of the Global South (United Nations 2019), potentially putting additional burdens on ecosystem services on which vulnerable populations have greater direct dependence (Daw et al. 2011, Fisher et al. 2013). However, most ecosystem service research (Lautenbach et al. 2019), as well as urban-focused research (Kremer et al. 2016), has emerged from countries of the Global North with the notable exception of China. However, urbanization may follow different trajectories in Global South countries. For instance, urbanization can occur without industrialization (Gollin et al. 2016); in which case it is associated to urban poverty and lack of adequate public services (Nagendra et al. 2018). Because urbanization can follow different paths in different places, it might affect people's relationships with nature in unique ways. Therefore, socio-cultural ecosystem service research in urbanizing regions of the Global South is timely.

1.4 Aim and objectives

In this thesis, I aim to contribute to a better understanding of how urbanization affects human-nature relationships in the Global South using an ecosystem service socio-cultural valuation approach. I suggest that there are two ways to address the question of how urbanization affects human-nature relationships using a socio-cultural approach. First, people's valuation of ecosystem services in an urbanizing region could be repeated through time. Second, comparing people's ecosystem service valuation in similar urban and rural sites could substitute the effect of time for space. For feasibility reasons, I use the latter in this thesis. I

address my aim and contribute to filling the research gaps that I identify through five objectives, each corresponding to a thesis chapter (note that chapter 3 describes my methodology):

1) Elucidate the research field comparing urban and rural ecosystem service preferences, describe the main trends in findings, and identify research gaps (Chapter 2).
2) Compare how urban and rural dwellers differ in their socio-cultural valuation of ecosystem services and disservices (Chapter 4).
3) Examine how people's perceptions of wellbeing benefits derived from ecosystem services differ between urban and rural areas, and how socio-demographic characteristics influence these wellbeing benefits (Chapter 5).
4) Explore how people's relationships with ecosystems differ between urban and rural dwellers by comparing their perceptions of ecosystem service and disservice bundles associated with different ecosystem types (Chapter 6).
5) Identify how perceived limitations to ecosystem service benefits differ between urban and rural dwellers in terms of availability and access mechanisms, and how these limitations differ according to socio-demographic characteristics (Chapter 7).

To illustrate the links between the main concepts that I address in my thesis, I adapt the ecosystem service cascade analogy (Haines-Young and Potschin 2010, Fisher et al. 2014, Daw et al. 2016) in which ecosystems produce benefits to people through a series of steps (Figure 1.1). Each step of the process is influenced by the preceding steps; in this case, wellbeing benefits depend not only on the type of ecosystem services, but also on their availability and access, and people's preferences. In this conceptualisation, people are embedded in their local ecosystems (although shown separately for simplicity), forming complex social-ecological systems. I use a socio-cultural approach to investigate the effects of urbanization on each step of the cascade. I do not directly investigate feedbacks from people to ecosystems and ecosystem services in this thesis. I will present a variation of this figure to illustrate the focus of each data-based chapter.

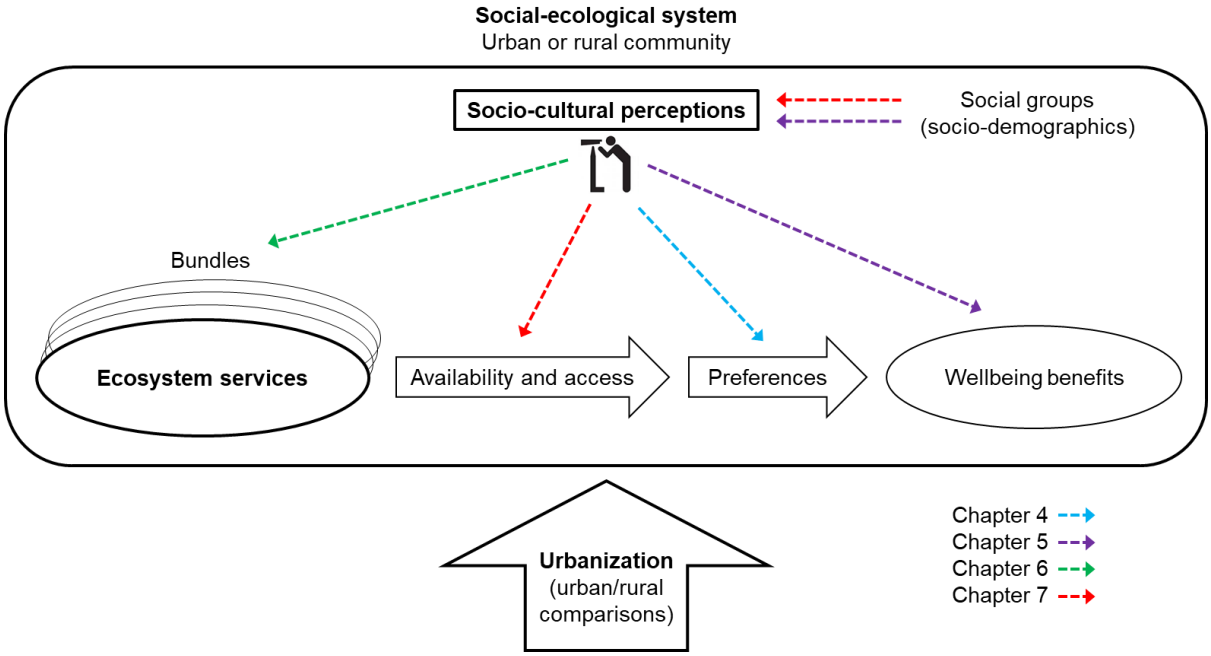


Figure 1.1 Diagram of the main concepts investigated in my thesis.
The elements in bold are the pillars on which my thesis is built, whereas the others are dealt with in specific chapters.

1.5 Study region

I chose to focus my research on a Small Island Developing State (SIDS), the Solomon Islands, for various reasons. People in SIDS, as in other areas of the Global South, rely heavily on local ecosystem services for their wellbeing (Suich et al. 2015, Marshall et al. 2018). However, the environmental vulnerability of SIDS is among the highest of all countries (Kaly et al. 2004), threatened notably by increased frequency and intensity of natural disasters, and sea level rise resulting from anthropogenic climate change (UN-Habitat 2015, IPCC 2019). The need for economic and social development, as well as limited land areas and fragile natural environments, mean that small Pacific islands present sustainability challenges (Dyball et al. 2013, Fernandes and Pinho 2017). For these reasons, SIDS are specifically mentioned in the Sustainable Developmental Goals (United Nations 2015). Urbanization could contribute to the development of SIDS and potentially improve people's wellbeing (UN-Habitat 2015, Marshall et al. 2018). However, urbanization can also be detrimental to fragile coastal ecosystems and the services that they provide to people (Brown et al. 2008, Seto et al. 2013).

I selected the Solomon Islands as a study region because of their high dependence on natural resources and recent, rapid urbanization rate. Solomon Islanders rely heavily on ecosystems

for their wellbeing (Coulthard et al. 2017, McCarter et al. 2018); for example, 90% of households countrywide use firewood for cooking and the same proportion tend a garden (Solomon Islands National Statistics Office 2015). As in most other Pacific Island nations, urbanization in the Solomon Islands is a relatively recent phenomenon, typically occurring after 1950 (Dyball et al. 2013) and resulting from rural outmigration to the national capital and the largest urban centre of the country, Honiara (McDougall 2017). Only about 20% of the 642,000 people of the country live in urban areas (Solomon Islands National Statistics Office 2015) compared to 60% in other Small Island Developing States (UN-Habitat 2015). Yet, the fast-growing urban population (4.7%/year), of which a third lives in informal settlements, faces many challenges including a lack of employment opportunities and deficient infrastructure, notably in terms of water and sanitation (UN-Habitat 2012).

1.6 Thesis outline

My thesis follows the following structure: I present my review of the literature, study sites and data collection methods, four data-based chapters, and a general discussion (Figure 1.2).

In **chapter 2**, I address my first objective to review the literature comparing urban and rural socio-cultural valuation of ecosystem services to draw a portrait of this emerging field. I uncover the general trends in findings about the difference in preferences for ecosystem service categories between urban and rural dwellers, and the main explanations for these trends from 17 peer-reviewed papers. I also identify future research priorities to advance the field and provide insight about the consequences that urbanization and living in cities have on people's perceived relationships with nature. I address these research gaps in my data-based chapters.

In **chapter 3**, I introduce my methodological approach, my study sites in the Solomon Islands, and the data collection methods common to my four data-based chapters. I also describe how I selected the different ecosystem services and disservices that I investigate. Further information on specific methods or data analysis is presented in the relevant chapters.

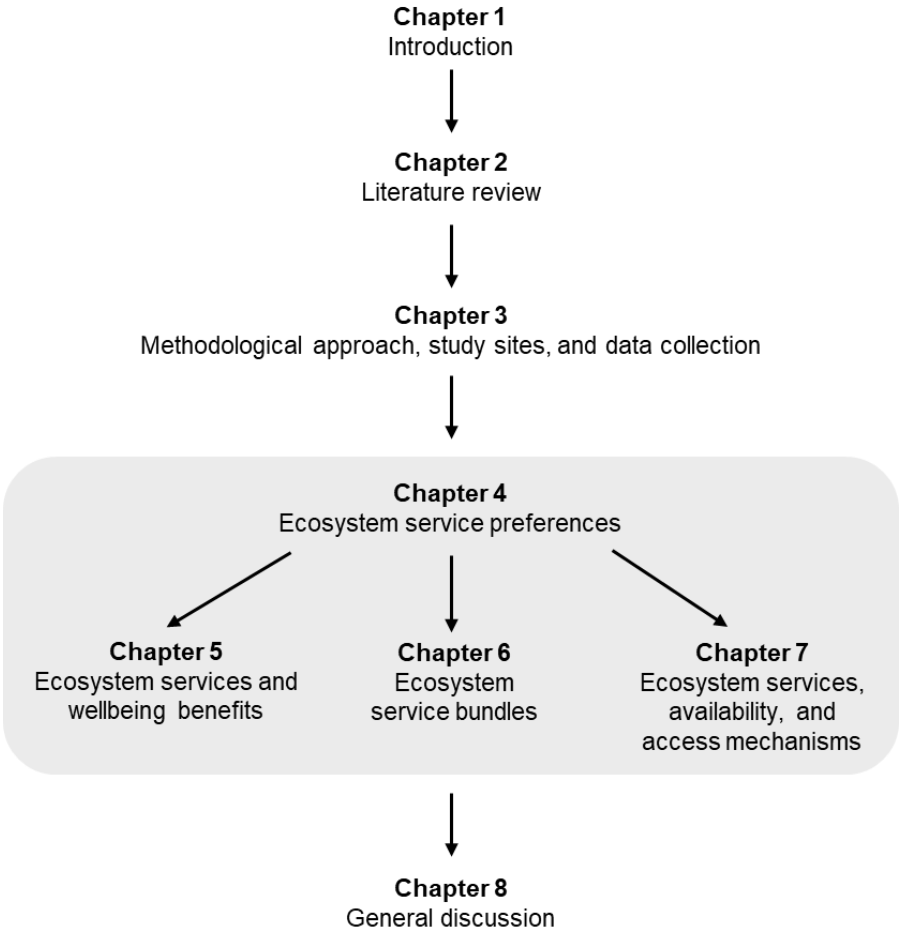


Figure 1.2 Thesis structure.

Chapter 4, the first data-based chapter, addresses my second objective comparing how urban and rural dwellers differ in their preferences for ecosystem services. More specifically, I use interview data on the importance and satisfaction that people in the Solomon Islands assign to ecosystem services and the importance of ecosystem disservices to compare urban and rural dwellers' preferences. By including satisfaction in addition to importance, I provide a better understanding of people's needs and preferences towards nature identified through a socio-cultural approach.

Chapter 4 shows how human-nature relationships differ between urban and rural areas. In **chapter 5**, I look into the consequences of these changes on multidimensional wellbeing. I address my third objective of understanding how living in cities affects people's perceptions of the wellbeing benefits derived from ecosystem services. I use interview and focus group discussion data to link ecosystems services to the wellbeing benefits that they provide to

people, using the social wellbeing framework (Gough and McGregor 2007). I further disaggregate findings according to various socio-demographic characteristics to determine if wellbeing benefits differ between different groups in society. By linking the ecosystem service framework and the social wellbeing framework, I demonstrate the complexity and the multidimensionality of the ecosystem service-wellbeing relationship. In addition, I discuss how my approach can help address the relational values that people have about nature.

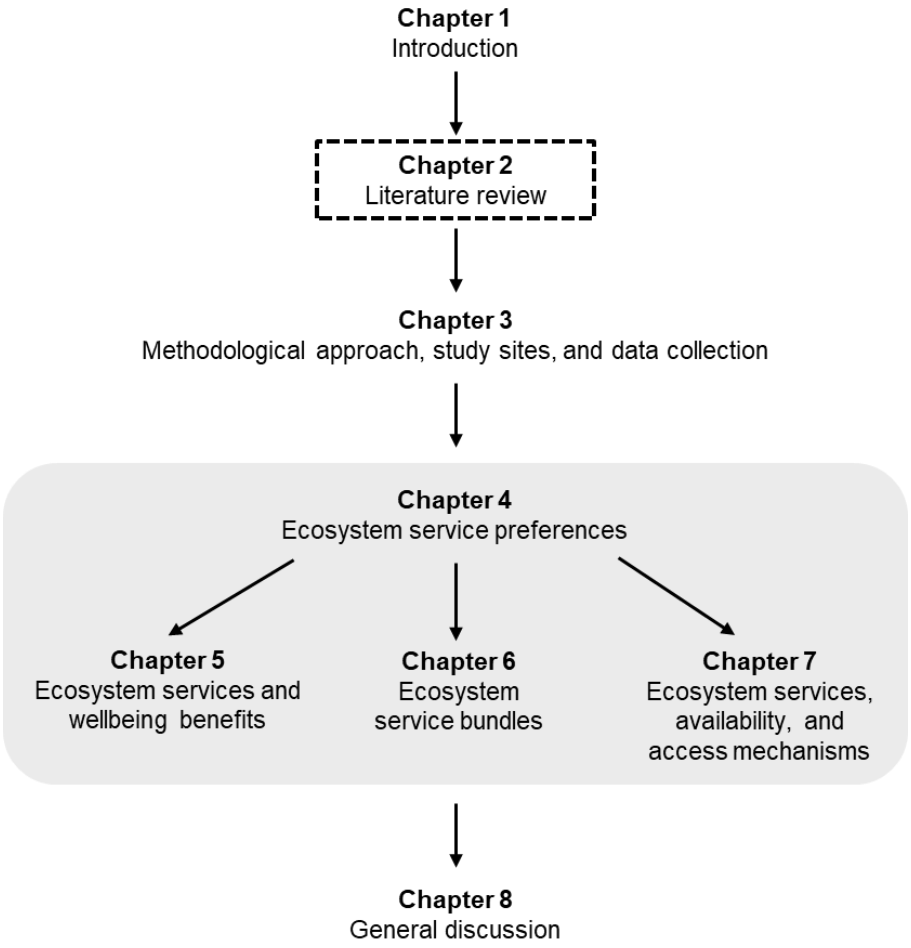
After comparing urban and rural dwellers' valuation of ecosystem services in chapter 4, I examine in **chapter 6** how urban and rural dwellers differ in the way that they derive the different ecosystem services in the land and seascapes. My fourth objective explores how people's relationships with ecosystems differ between urban and rural dwellers by comparing their perceptions of ecosystem services and disservices bundles. I use interview data about the ecosystem services and disservices associated with the different local ecosystem types (e.g., coral reefs and gardens) where these services and disservices are thought to originate in urban and rural areas. Therefore, I address this gap in socio-cultural research that usually does not differentiate between the different ecosystems in a study area (Scholte et al. 2015). I uncover how urbanization affects the number of people benefiting from different bundles and their ecosystem service composition, and thus how people relate to their local environment.

I explore in **chapter 7** some of the causal mechanisms of the altered human-nature relationships described in the previous chapters. More specifically, this chapter covers the fifth objective about how perceived limitations to ecosystem service benefits differ between urban and rural dwellers in terms of availability and access mechanisms, and how socio-demographic characteristics influence these perceptions. I use interview data of reported limitations that people in urban and rural areas associated with the various ecosystem services. These mechanisms are classified into availability limitations or access mechanisms according to the theory of access (Ribot and Peluso 2003). In this chapter as well, I disaggregate the findings according the various socio-demographic characteristics to determine if the limitations differ according to different groups in society. By investigating both perceived availability and access issues, I fill research gap in the natural resources access literature (Myers and Hansen 2019).

Finally, in my general discussion, **chapter 8**, I summarize my main findings in relation to my research objectives. I also explain how I have contributed to the ecosystem service research field. I point to the main limitations and caveats of my research, and to some needs for future research on ecosystem services and urbanization. I conclude by highlighting the potential contributions that this type of research could make to meeting the Sustainable Development Goal 11 to *make cities and human settlements inclusive, safe, resilient and sustainable* (United Nations 2015).

2. Literature review*

In this chapter I present my literature review of the research field on urban and rural ecosystem service preferences. I describe the main trends in findings, and identify research gaps that I subsequently address in my data-based chapters.



* Adapted from Lapointe, Cumming, and Gurney (2019) Comparing Ecosystem Service Preferences between Urban and Rural Dwellers. Bioscience

Contributions: I developed the research question, methodology, collected the data, performed the data analyses, and developed the figures and tables with the advice of G. Cumming and G. Gurney. I wrote the first draft of the paper which was revised with editorial input from G. Cumming and G. Gurney.

Comparing ecosystem service preferences between urban and rural dwellers

Abstract

Urbanization can profoundly alter social-ecological relationships, but its influence on people's perceptions and valuation of ecosystem services is poorly understood. I reviewed an emerging literature that compares socio-cultural valuation of ecosystem services by urban and rural dwellers. This research suggests that although regulating and cultural ecosystem services are highly valued by both rural and urban dwellers, urban dwellers tended to value provisioning ecosystem services less than rural dwellers. Differences in ecosystem service valuation could result from different experiences, uses, and needs for ecosystem services of urban and rural dwellers. I also identified two key gaps in the literature that relate to understanding (1) how diverse ecosystem services contribute differently to the wellbeing of rural and urban populations (and the relevance of these differences for environmental education and policy); and (2) the changing roles of ecosystem services in developing countries and vulnerable ecosystems, such as small islands, that face pressing environmental, social and economic challenges.

2.1 Introduction

Urban and rural populations ultimately depend both directly and indirectly on ecosystems for their wellbeing. However, the environmental, economic and social changes associated with urbanization can alter people's relationship with nature and the wellbeing benefits people obtain from ecosystems, i.e., ecosystem services (MA 2005a). Cities have the potential to affect global sustainability (Seto et al. 2017). Projections indicate that by 2050, the urban population will have grown from 3.5 to 6 billion people, accounting for two-thirds of the global population (United Nations 2014). In this context, it is important to understand the differences in how people in urban and rural areas respectively benefit from and value nature because it seems likely that future impacts on ecosystems will increasingly be dictated by urban dwellers.

Current conceptual models of the relationships between biophysical environments and human wellbeing regard ecosystem service provision as a sequence, or cascade, in which ecosystems create potential ecosystem services that are realized through benefits and use

values to influence human wellbeing (Spangenberg et al. 2014). Quantifying and modelling this cascade requires that the connections between different elements are understood and, ideally, connected empirically through statistical relationships and equations (Cumming and Maciejewski 2017). While the step from the biophysical elements of an ecosystem to potential ecosystem services is relatively well documented (Naeem et al. 2009), the more human-focused, value-related elements of the cascade are poorly understood and little information is available from which to model or simulate them for management, scenario planning, or vulnerability analyses (Rieb et al. 2017). To explore the current state of knowledge in this area, and to highlight areas in which understanding the human elements of ecosystem service provision will be critical as society navigates the transition to a dominantly urban world, I reviewed the literature comparing the people's perceptions and preferences for ecosystem services in urban and rural areas.

The valuation of ecosystem services using people's perceptions or preferences is called socio-cultural valuation or non-monetary valuation (Scholte et al. 2015). Valuing ecosystem services with a socio-cultural approach has three major advantages for managing ecosystem services sustainably and equitably. First, perceptions are essential to understanding actual ecosystem service contributions to individual wellbeing (for example, using the Millennium Ecosystem Assessment (MA 2005a) wellbeing constituents: security, basic material for a good life, health, and good social relations) that account for a person's own circumstances, needs and preferences towards the environment (Daw et al. 2011). This is why recent reviews on urban ecosystem services (Haase et al. 2014, Luederitz et al. 2015), and in the ecosystem service literature in general (Daw et al. 2011), identify a strong need for individual-level data. Further, heterogeneity between social sub-groups in perceptions, preferences and wellbeing contributions from ecosystems can provide insights into how they might be impacted differently by environmental change and how trade-offs can emerge between groups. Second, values and perceptions also influence motivation and ultimately behaviour towards the environment (Braito et al. 2017, Muhar et al. 2017). Third, socio-cultural valuation permits direct comparisons among all categories of ecosystem services (provisioning, regulating and cultural). Direct comparisons among ecosystem services can point to potential trade-offs between them (e.g., land clearing for food provisioning may reduce cultural values, such as aesthetic benefits or medicinal plants, provided by forests). Economic valuation methods, in

contrast, are less suited to measuring ecosystem services that are intangible (Scholte et al. 2015) and/or not traded on the market (Granek et al. 2010). However, intangible cultural ecosystem services, such as sense of place or heritage values, may be more challenging to replace or substitute than provisioning and regulating ecosystem services (Plieninger et al. 2013). Thus, socio-cultural valuation of ecosystem services can contribute to informed environmental management decision-making by clarifying the potential trade-offs between ecosystem services and social sub-groups.

Urban and rural environments differ in lifestyle, economic activities, and ecosystem service supply. These differences may influence the human-nature relationship and the perceptions of ecosystem services. First, an urban lifestyle may be associated with particular sets of needs or preferences. For example, a study in Italy has shown that people tend to value urban non-ecosystem services (e.g., communications technology, waste disposal, transport) over ecosystem services for their contributions to their quality of life (Antognelli and Vizzari 2017). Second, the specialized economies of cities imply that fewer people are involved in their own food production than in traditional rural societies. Instead, urbanized societies meet their needs by substituting some ecosystem services with infrastructure and manufactured goods, which have complex and obscure relationships to ecosystems (Cumming et al. 2014). Affluent societies transfer many of the environmental impacts of their consumption to less affluent nations through trade and pollution (Weinzettel et al. 2013). Third, ecosystem service supply has been shown to decrease in urban areas (e.g., Su et al. 2012, Qiu and Turner 2013, Radford and James 2013, Long et al. 2014). The most heavily impacted ecosystem services are often those that have a close relationship to land cover, including regulating ecosystem services (e.g., water filtration and regulation, soil retention, and climate regulation) and provisioning ecosystem services (e.g., food and material production). Rural areas are also affected by urban areas and urbanization. Urban areas often expand into natural areas and agricultural land (Bren d'Amour et al. 2017). Furthermore, to meet the needs of urban populations for food and materials, the production of provisioning ecosystem services (e.g., food, fibre, and fuel) may increase in rural areas. Increases in provisioning ecosystem services can lead to a decrease in regulating ecosystem services related to the functioning of ecosystems, potentially causing environmental degradation (MA 2005a, Lee and Lautenbach 2016). For example, the shift to high intensity agriculture in Europe has caused declines in rural

pollinators and natural pest regulators (Power 2010). Thus, because of their physical environment and socioeconomic context, people in urban areas experience nature and depend on it differently than people in rural areas; in turn, this could affect their perceptions and preferences of nature and the ecosystem services it provides.

Understanding how and why ecosystem service preferences differ between populations and social groups has important consequences for environmental management, notably in identifying conflicting values and the winners and losers from different outcomes. In addition, as the main consumers of ecosystem services worldwide, the consumption choices of urban dwellers can have important impacts on local and distant rural ecosystems (Kareiva et al. 2007, Seto et al. 2012).

In this review, I ask whether general trends in urban versus rural ecosystem service preferences emerge and what the main explanations are for these trends. I synthesized the findings of case studies that contrasted urban and rural ecosystem service socio-cultural valuation of a same culture or in a same region. This topic has not been previously addressed by either the literature on urban ecosystem services (e.g., Haase et al. 2014, Luederitz et al. 2015, Kremer et al. 2016) or that on ecosystem service socio-cultural valuation (e.g., Scholte et al. 2015). A rigorous understanding of the urban-rural divide depends on comparative case studies in which ecosystem service valuation has been done using the same approach in both urban and rural areas of the same region or country, thus controlling to some extent for the influences of culture and methodology. I sought to identify similarities and differences in ecosystem service valuation between the urban and rural populations; the main factors that might explain differences in ecosystem service valuation; and whether the authors considered wellbeing benefits associated with ecosystem services. My review highlights several important, emerging research priorities.

2.2 Methods

I collected data from peer-reviewed journal articles obtained from ISI Web of Science searches conducted between August and October 2017, and updated in August 2018. I used the following search terms in 'Topic': (ecosystem service* OR landscape service*) AND urban*

AND rural AND (perception* OR preference* OR stakeholder* OR user* OR beneficiar* OR cultural valuation OR soc* valuation OR demand OR use) for all years. I considered socio-cultural valuation in a broad sense, including research on ecosystem service preferences, as well as ecosystem service use and willingness to pay, given that they provided information on ecosystem service use or preferences. Included papers focused on ecosystem service beneficiaries and their perceptions or use of ecosystem services. Landscape services were also included in the search because this term is sometimes used similarly to ecosystem services (e.g., Fagerholm et al. 2012, Willemen et al. 2012). I did not consider the grey literature, and may have overlooked papers in which the rural-urban contrast was considered as a socio-demographic indicator (i.e., residential type) and/or was not mentioned in the title or abstract.

My approach initially identified a pool of 107 potential papers, from which I selected papers according to the following three criteria: (1) The search terms appeared in the title or the abstract, and the papers explicitly used the words 'ecosystem services' or 'landscape service' as well as 'urban' and 'rural'; (2) findings were drawn from field-based case studies; and (3) studies compared urban and rural dwellers' ecosystem service uses and preferences (the latter could be elicited using various methods). Focusing the review in this way, I identified a total of 17 focal papers (listed in Appendix A). For each focal paper, I considered a set of variables related to understanding differences in ecosystem service preferences between urban and rural areas and the current breadth of the field (Table A.1, in Appendix A): country of origin; context of the study; type of methodology; stakeholders involved; ecosystem services assessed; findings and interpretation of the urban-rural ecosystem service valuation; influence of socio-demographic indicators; differences between developed and developing countries; link between ecosystem services and wellbeing.

In order to make valid ecosystem services comparisons across studies, I translated assessed ecosystem services into the Common International Classification of Ecosystem Services at the class level (CICES, Haines-Young and Potschin 2018, see Table A.2 for the definitions of ecosystem service classes). The translation of ecosystem services into CICES version 5.1 (Haines-Young and Potschin 2018) sometimes proved challenging, because different definitions and classifications of ecosystem services were used. In general, I tried to respect the intent of the study when converting ecosystem services and therefore, keep a similar

number of ecosystem services. When several interpretations were possible, I made a few simplifications to ensure classification consistency. First, when two ecosystem services classes were assessed together (e.g., recreation and tourism), only the one most frequently mentioned or otherwise the first in order of appearance was recorded. Second, I classified non-timber forest products as wild plants for nutrition if no additional information was provided. Third, if recreation was mentioned without being specified as an active or passive interaction with the environment, it was placed in the active category.

2.3 Results

2.3.1 Portrait of the field: Countries and context in which the studies were conducted

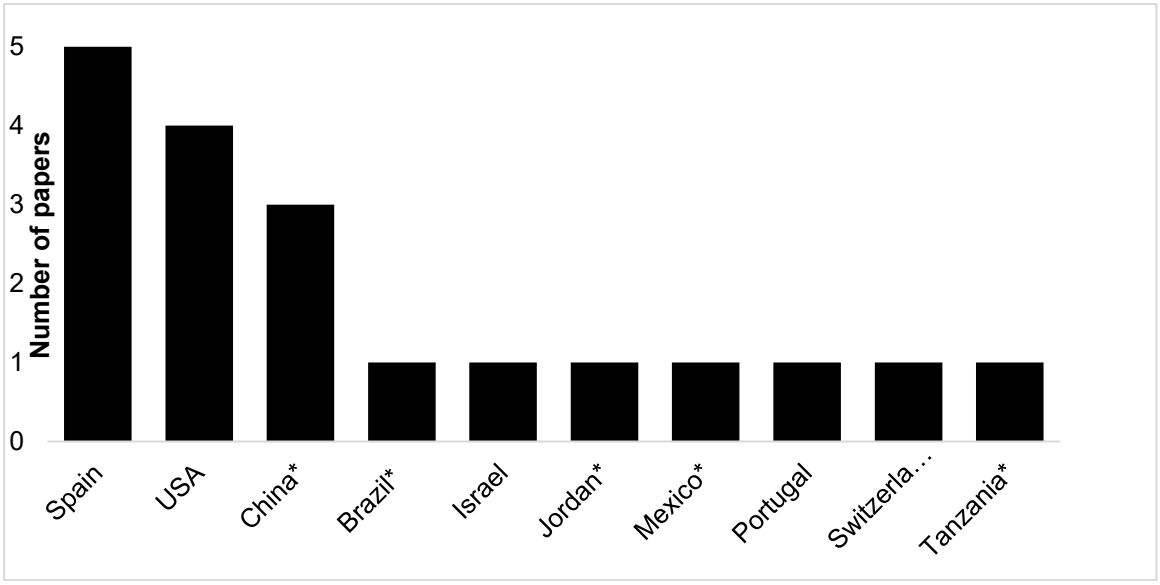


Figure 2.1 Frequency of publications considered in the review per country where the studies were conducted.
(N=17, two papers considered two countries each, (*) indicate developing countries)

All papers reviewed were published after 2006, more than 80% since 2012, in a diversity of journals. Only three journals had two articles each: *Ecosystem Services, Forest Policy and Economics,* and *Journal of Environmental Management*. Ten studies were conducted in developed countries and five in developing countries (Figure 2.1). Two studies compared a developing to a developed country (China/Switzerland and Jordan/Israel).

Papers either adopted an ecological (e.g., watershed, river basin, forest) or political boundary (e.g., municipality, region), or no boundary was specified. In the latter case, for example, one paper focused on archetypal forests from China and Switzerland (Lindemann-Matthies et al. 2013). Most papers used a combination of ecological and political boundaries, prioritizing one

or the other. For example, Shi et al. (2016) selected municipalities within the boundaries of a watershed. Sometimes, studies covered the extent of a protected area (e.g., Williams et al. 2017). Areas covered by the studies ranged from dozens to thousands of square kilometres.

To define urban and rural, authors used population size (five papers), population densities (one paper), percentage of built areas (one paper), or referred to a national law or a previous publication (four papers). In seven papers no definition was provided.

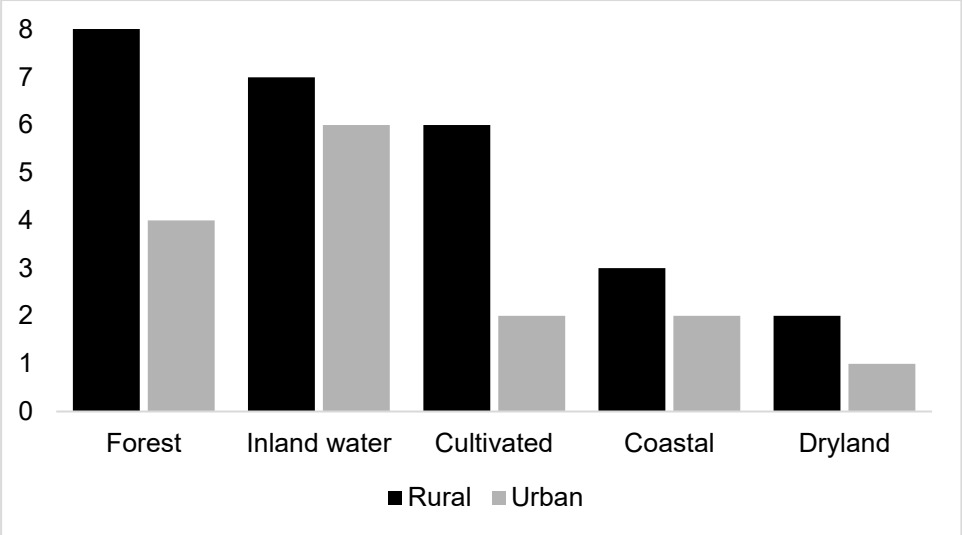


Figure 2.2 Frequency of main ecosystem types studied in the papers reviewed (N=17). Ecosystems were classified according the Millennium Ecosystem Assessment system and the context where they are located: urban (i.e., close to or in an urban/periurban area or directly provide ecosystem services to an urban area) or rural (i.e., in a rural or a natural area). A same ecosystem type in a paper can be considered both urban and rural if it covers the two contexts.

The ecosystems studied most frequently (as classified by the MA (2005)) were forests, inland water (especially rivers) and cultivated land (Figure 2.2). No study assessed marine or island ecosystems and one study assessed a mountain ecosystem. Only one paper surveying multiple ecosystems identified an 'urban' type in the Bilbao greenbelt, Spain (Martín-López et al. 2012). Nine out of 17 papers also considered ecosystem services that were delivered or obtained in urban or periurban areas. The other papers studied ecosystem services outside of urban areas, i.e., in natural or rural areas, that were visited by urban dwellers.

2.3.2 Data collection and valuation method

The papers that examined participants' perceptions of ecosystem services used a diversity of methods including ecosystem service presence (e.g., capacity of an ecosystem to generate

ecosystem services), ecosystem service importance or relative preference for ecosystem services (Table 2.1).

Table 2.1 Frequency of methods followed in the papers reviewed (N=17).

Type of method	Number of papers
Data collection	
Interview/surveys/self-administered surveys	16
Focus groups	3
Other (use of ecosystem services)	2
Multiple methods	5
Other tools used in data collection	
Used pictures to illustrate ES or ecosystems	7
Collected spatial data	1
Sampling of the population	
Random	15
Purposive (specific stakeholder group, e.g., landowners or experts)	6
Combination of random and purposive	4
Ecosystem service valuation method	
Perceptions	16
Use	10
Rating	9
Ranking	3
Willingness to pay or to give time	6
Ecosystem service classification method	
Millennium Ecosystem Assessment	4
Common International Classification of Ecosystem Services	1
Ad hoc classification	12

2.3.3 Ecosystem services assessed

On average, studies evaluated 9 ecosystem services from 32 classes (Table 2.2 and Figure 2.3). Ecosystem disservices were examined in three of the 17 papers reviewed; these included the impacts of deer browsing on forest plants, affecting tree regeneration and songbird populations (Racevskis and Lupi 2006); dislike of bugs and weeds (Kenwick et al. 2009); forest plagues and wildfires (Caro-Borrero et al. 2015); and negative landscape characteristics (e.g., dust and aridity (Orenstein and Groner 2014)).

Table 2.2 Average number of ecosystem services assessed per category and in total per paper.

Ecosystem services category	**Average number of ecosystem services per study** (N=17)	**Average number of ecosystem services per study in developing country** (N= 5)	**Average number of ecosystem services per study in developed country** (N= 10)
Provisioning	2.5	3.0	2.4
Regulating	3.1	2.4	3.4
Cultural	3.8	2.4	4.5
Total	9.5 (ranging from 4 to 15)	7.8	10.3

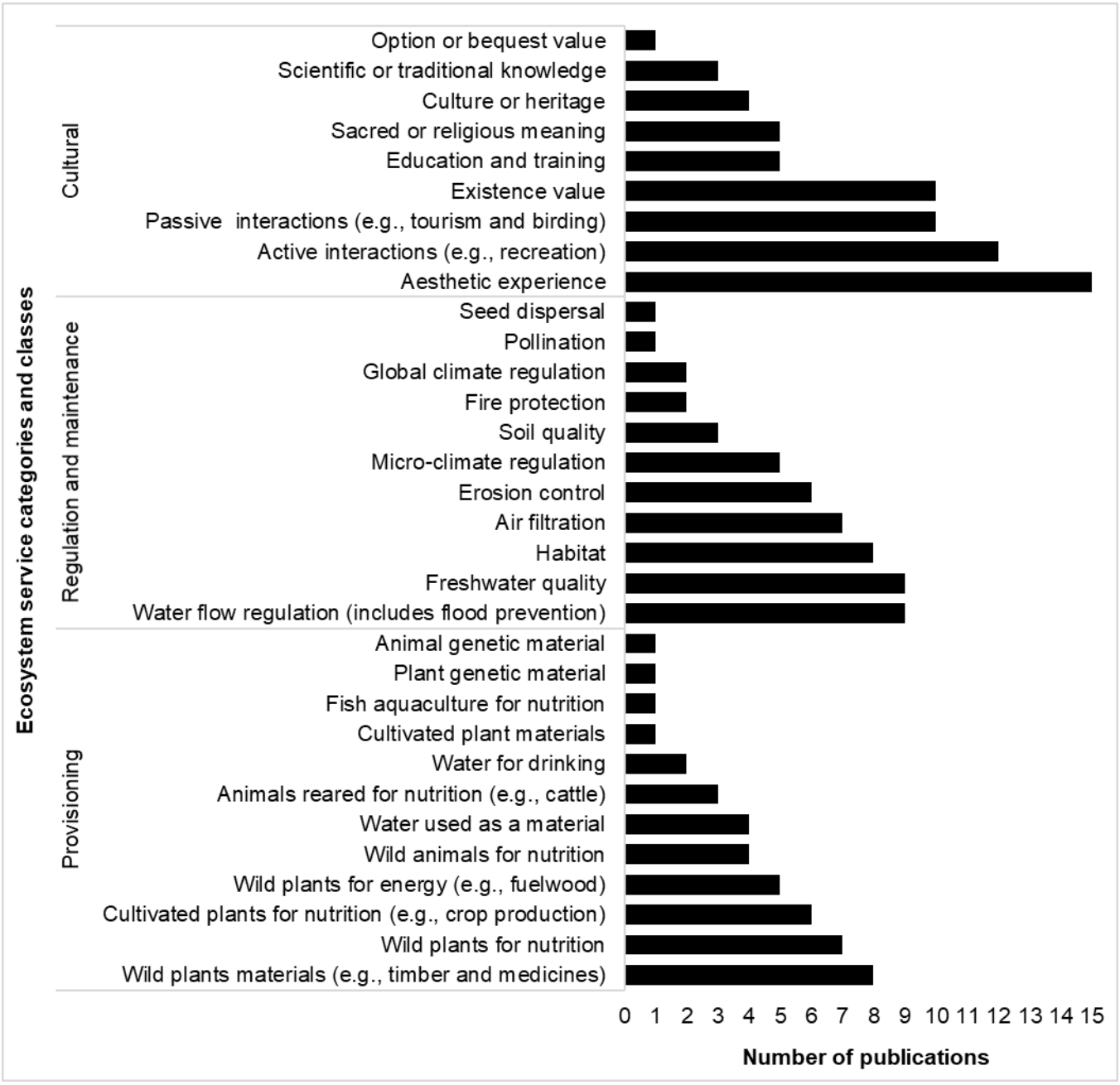


Figure 2.3 Frequency of ecosystem service classes and categories assessed in the papers reviewed.

2.3.4 Urban-rural comparisons

The ecosystem service categories that were found to be the most important in the papers reviewed (without contrasting urban and rural dwellers) were, in order, regulating, cultural, and provisioning services (Table 2.3). However, for urban dwellers, provisioning ecosystem services were the most important type only in one study (da Cunha Ávila et al. (2017) on home gardens in Brazil); whereas preferences were more equally divided across ecosystem service categories for rural dwellers. Relative differences between urban and rural dwellers' ecosystem service preferences were found in 16 of the 17 papers reviewed. Only one paper

from the USA did not find differences between suburban and rural ecosystem service preferences for riparian buffer types (Kenwick et al. 2009). About half of the studies found that provisioning ecosystem services (e.g. food production, timber) were relatively more important for rural than urban people (Table 2.3). Regulating (in particular, air filtration and micro-climate regulation) and cultural ecosystem services (e.g., recreation and aesthetic experience) were found to be most important to urban dwellers more often than for rural people. Direct contrasts between developing and developed countries in urban-rural comparisons of ecosystem service valuation cannot be undertaken because only three papers conducted solely in developing countries compared the three ecosystem service categories directly.

Table 2.3 Comparative valuation of ecosystem service categories by rural and urban dwellers.

Ecosystem service category	Ecosystem service preferences: most valued by population (N=13)[a]		Differences in valuation between populations: valued more by one population than the other (N=16)	
	Rural	Urban	Rural	Urban
Provisioning	4	1	8	0
Regulating	6	7	3	5
Cultural	3	5	2	7

[a] Thirteen of the 17 papers reviewed specified the most important ecosystem service category for rural and urban dwellers, whereas 16 pointed to differences between rural and urban dwellers (but not all ecosystem service categories were compared in every study and sometimes differences were found in only one ecosystem service category). All of the 17 papers appear in one or both of the comparisons.

2.3.5 Explanation of the urban-rural differences in ecosystem service valuation

To explain differences in ecosystem service valuation, authors often hypothesized and/or measured associations between ecosystem service valuation and socio-demographic characteristics (Figure 2.4). Education, sex and age were most frequently found to have an influence. Income, ethnicity, and occupation were also thought to be influential, but in fewer papers (in 6, 3 and 1 papers, respectively). The other factors were classified into seven categories (described in Table A.3) derived from two frameworks: Determinants of socio-cultural values of ecosystem services (Scholte et al. 2015) and Elasticity in ecosystem services (Daw et al. 2016).

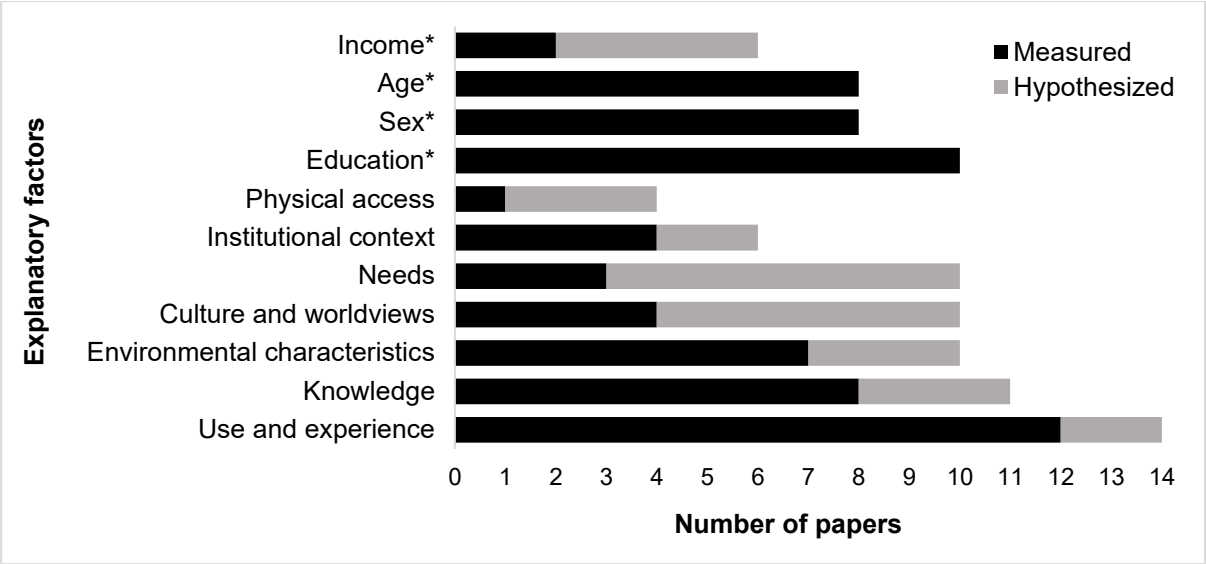


Figure 2.4 Frequency of the main explanatory factors measured or hypothesized to influence people's ecosystem service valuation cited in the papers reviewed.
(* indicate socio-demographic characteristics).

An explanation for the rural-urban contrast in ecosystem service valuation based on the factors mentioned above was provided in 13 of the 17 papers reviewed. Differing needs and use or experience were the main explanations for differences between populations (Figure 2.5). The main socio-demographic characteristics that explained differences in urban vs. rural ecosystem service valuation were education as well as income and affluence; all were generally higher in urban areas (Martín-López et al. 2012, García-Llorente et al. 2016). Education was positively associated with the perception of a larger range of ecosystem services and environmental knowledge (Martín-López et al. 2012, Pan et al. 2016, Soy-Massoni et al. 2016) and regulating ecosystem services (Caro-Borrero et al. 2015), and negatively with the importance of ecosystem services for rural areas (Martín-López et al. 2012, García-Llorente et al. 2016). Income and affluence appeared positively related to ecosystem service valuation (Orenstein and Groner 2014), to the willingness to pay for ecosystem services (Shi et al. 2016), and to the positive perception of payments for ecosystem services (Caro-Borrero et al. 2015). Older people were associated to rural perceptions (or younger people to urban areas) in three papers and females to urban perceptions (or males to rural ones) in two papers.

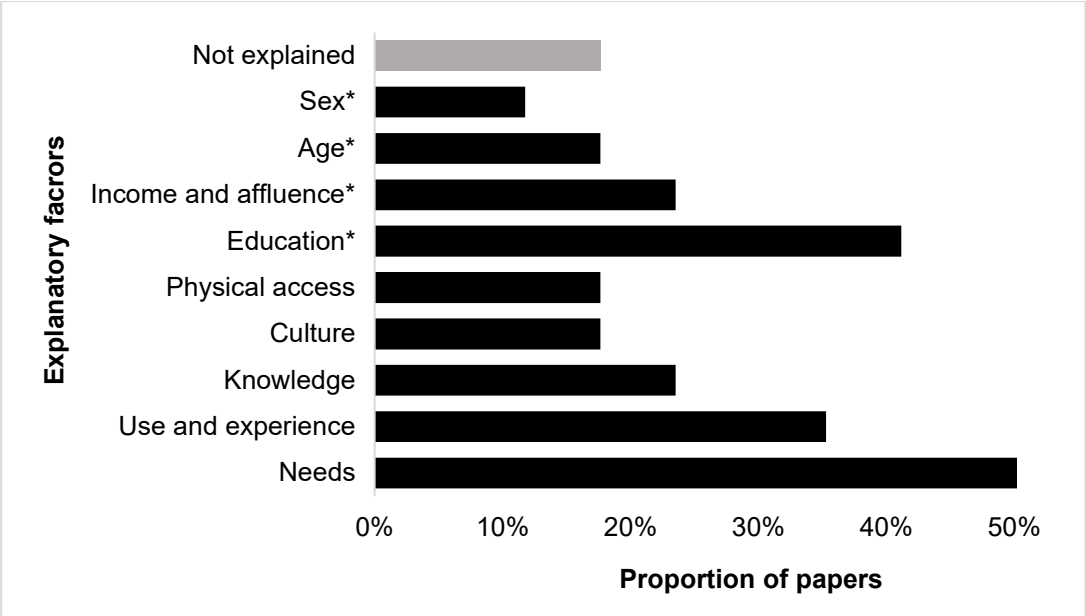


Figure 2.5 The main explanatory factors of the urban and rural contrast in ecosystem service valuation expressed as a proportion of the papers reviewed.
(* indicate socio-demographic characteristics, the number of papers not providing an explanation is in grey).

2.3.6 Link between ecosystem services and wellbeing

Wellbeing was mentioned in 13 of the 17 papers, most often when defining ecosystem services. However, fewer studies (seven) made actual links between ecosystem services and the constituents of wellbeing (as classified in the MA (2005): security, basic material for a good life, health and good social relations). Links between ecosystem services and wellbeing were made more frequently with the basic material for a good life constituent of the MA wellbeing definition, with income and occupation being most common, especially for rural inhabitants (e.g., Orenstein and Groner 2014). Health was mentioned as an ecosystem service in one paper (Soy-Massoni et al. 2016). Finally, Pan et al. (2016) mentioned the importance of social interactions for rural dwellers using a river.

2.4 Discussion

My review showed that urban and rural dwellers present similarities in their valuation of ecosystem services but also important differences. The main difference in ecosystem service valuation between urban and rural dwellers was that the importance of provisioning ecosystem services was rarely perceived by urban dwellers. Urban and rural populations highly valued regulating and cultural ecosystem services, although the actual ecosystem

services preferred differed. Differences between urban and rural dwellers could be mediated by differences in socio-demographic characteristics; education, income and affluence are higher in urban areas. These characteristics, combined with different lifestyles and livelihoods, are likely to lead to differences in needs between urban and rural populations as well as in their experience and use of nature.

The supply and the demand of provisioning ecosystem services differs at three levels in urban compared to rural areas. First, the supply of provisioning ecosystem services (e.g. agricultural production) is usually low in urban areas and could result in a lack of direct experience with these services by urban dwellers. Second, infrastructure and manufactured goods can substitute part of the demand for provisioning ecosystem services (e.g., processed food and synthetic building materials) (Cumming et al. 2014). Casado-Arzuaga et al. (2013), for example, found that urban dwellers knew that the food they ate tended not to come from local ecosystems. Third, the ability of people to afford alternatives to provisioning ecosystem services is likely to increase in urban areas where incomes are generally higher than in rural areas (Henderson 2010). Conversely, the fact that rural dwellers valued provisioning ecosystem services more highly than did urban dwellers could be attributed to the higher supply of some provisioning ecosystem services in rural areas and their importance for the livelihoods of the people living in rural areas, i.e., by providing food and material either directly, or through occupations that depend on these services.

My findings point to somewhat different human-nature relationships in rural and urban areas. Some papers qualified the urban dwellers' relationship to ecosystem services and nature as indirect (Pan et al. 2016), disconnected (Martín-López et al. 2012, García-Llorente et al. 2016), more theoretical (Martín-López et al. 2012, Pan et al. 2016), or more bucolic (López-Santiago et al. 2014, Soy-Massoni et al. 2016). In contrast, rural dwellers were said to have a more direct, more connected (Racevskis and Lupi 2006, Martín-López et al. 2012), or more production-oriented relationship to nature (López-Santiago et al. 2014, Soy-Massoni et al. 2016). This gap between nature and people in urban areas is sometimes referred to as "nature deficit" (Louv 2005).

Socio-cultural valuation of ecosystem services has practical implications for decision-makers, in at least two areas. First, policies and management practices can use ecosystem service valuation to identify and meet the preferences and needs of different groups (e.g., Kenwick et al. 2009), and to point out shared values (e.g., Williams et al. 2017) and potential conflicts between these groups (e.g., Martín-López et al. 2012). My review shows that these social groups might differ not only in where they live, but also in socio-demographic characteristics including education level, age, and sex. Second, environmental education programs can be targeted to specific groups to highlight the importance of under-recognized ecosystem services to their wellbeing (Racevskis and Lupi 2006, Carvalho-Ribeiro and Lovett 2011, Lindemann-Matthies et al. 2013, Mombo et al. 2014). In fact, Casado-Arzuaga et al. (2013) have shown that the information communicated can transform ecosystem service preferences. This might compensate in part for the knowledge traditionally gained through direct experience of nature.

Finally, my review supports the argument that a socio-cultural approach can be used to value a diversity of ecosystem services across all ecosystem service categories (Granek et al. 2010, Hicks 2011). It has been suggested that because regulating ecosystem services might be harder to perceive, their value is not captured as effectively by socio-cultural valuation as other ecosystem services (Asah et al. 2014, Scholte et al. 2015). My findings indicate that this is not true for regulating ecosystem services in general. However, when regulating ecosystem services were not specifically mentioned to the research participants, they were not as readily perceived and valued (Casado-Arzuaga et al. 2013, Soy-Massoni et al. 2016). Furthermore, more than two-third of papers also considered cultural ecosystem service classes other than recreation and aesthetic value, such as spiritual or existence values, that are rarely considered in ecosystem service research (Chan et al. 2012, Daniel et al. 2012, Scholte et al. 2015). Surprisingly, although the importance of cultural ecosystem services for urban dwellers of the Western world has been demonstrated (Kremer et al. 2016), a recent literature review on urban ecosystem services has shown that cultural ecosystem services are lacking in urban ecosystem service assessments (Ziter 2016). Socio-cultural valuation can help bridge that gap.

Research priorities

My review highlights the many needs for further research in this emerging field. The gaps that I have identified reflect the limited number of papers available for review, rather than providing a critique of the papers themselves. Three research areas appear to be of particular importance for future research on how ecosystem service valuation differs between urban and rural dwellers: (1) assessment of human wellbeing benefits; (2) ecosystem diversity; and (3) research in developing countries.

The wellbeing benefits of ecosystem services in both rural and urban environments are poorly understood, as has been highlighted for the ecosystem service literature in general (Bennett et al. 2015, Dawson and Martin 2015, Daw et al. 2016). Of the few papers that I reviewed that considered the link between ecosystem services and wellbeing, most examined links with economic benefits (Mombo et al. 2014, Orenstein and Groner 2014). However, I often encountered a conflation of ecosystem services and wellbeing benefits. For example, wellbeing benefits were mentioned as an ecosystem service, for example health (Soy-Massoni et al. 2016) and occupation (Racevskis and Lupi 2006). Ecosystem services' wellbeing benefits can be examined using the MA framework or other wellbeing frameworks (for a review of different frameworks that can be used to study the wellbeing impacts of ecosystem services, see Agarwala et al. (2014)).

Future research on socio-cultural valuation of urban and rural ecosystem services would benefit from the inclusion of a greater diversity of ecosystem types. About half of the studies assessed only ecosystem services that were remote from urban communities. Urban-rural comparisons in ecosystem service preferences could also include ecosystem services that are located in or close to urban areas and can contribute to the wellbeing of urban dwellers in their everyday life. There is also a need to study marine and island ecosystems.

Lastly, more research contrasting ecosystem service preferences of rural-urban dwellers is needed in developing countries, especially since most urbanization will occur in these countries in the future (United Nations 2014). Most of the social-ecological research on urbanization has been conducted in developed countries (McHale et al. 2013). However, urbanization processes may differ between developed and developing countries; for example,

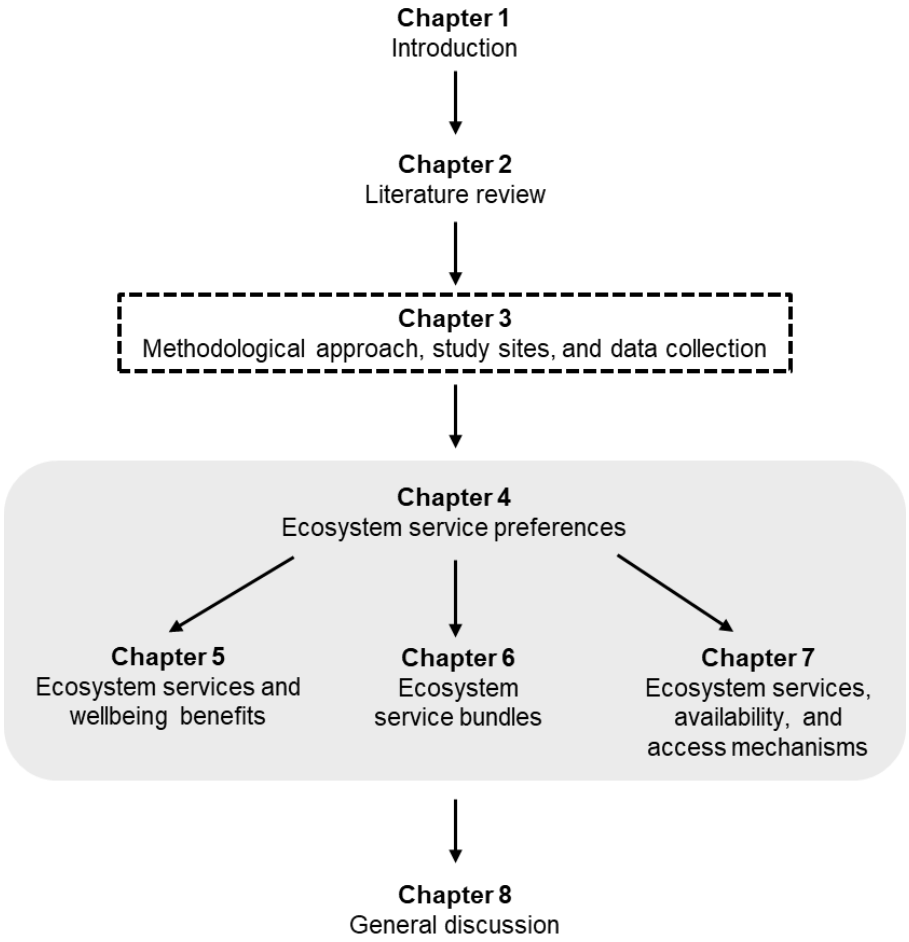
in developing countries, urbanization is not always linked to industrialization and an improved quality of life (Gollin et al. 2016).

2.5 Conclusion

I reviewed the literature comparing people's preferences for ecosystem services in urban and rural areas to understand the ways in which living in cities affects how people value the benefits they obtain from nature. Research on ecosystem service socio-cultural valuation of rural vs urban dwellers is an emergent field, as illustrated by the low number of peer-reviewed journal articles currently considering this topic. My review showed that the socio-cultural valuation of ecosystem services differs between urban and rural dwellers. While both populations highly valued regulating and cultural ecosystem services, urban dwellers rarely found provisioning ecosystem services to be important for their wellbeing. These differences could be due to differences in affluence and education between the populations as well as different needs, uses and experiences of nature in urban and rural contexts. My analysis identifies two key future directions for this nascent literature. First, assessing wellbeing contributions derived from ecosystem services would help better understand the importance of nature in the life of rural and urban dwellers. Second, broadening research horizons in terms of the diversity of ecosystem types and countries is also needed to better understand the potential impacts of urbanization on the most vulnerable people and ecosystems. In particular, future research on changes in ecosystem service preferences associated with urbanization is needed in developing countries facing social, economic and environmental challenges that may follow different development trajectories from those of Western countries (Cumming and von Cramon-Taubadel 2018).

3. Methodological approach, study sites, and data collection

In this chapter I describe the methodological approach that I follow in my four data-based chapters. I describe my four study sites, how I selected the ecosystem services and disservices that I examined in this research, and my sampling design and data collection methods.



3.1 Approach

To explore the effect of urbanization on human-nature relationships, I employ a case study approach because this research method is well suited to explore 'how' research questions related to contemporary events (Yin 2014) and to examine interactions between complex social and ecological systems (Poteete et al. 2010). Moreover, comparative case studies can uncover contrasts and similarities across cases to provide a better understanding of a phenomenon (Campbell 2010). In this case, to study the effect of urbanization, I compared case studies that are located as far apart as possible along the urban-rural gradient in the Solomon Islands. I used a repeated paired design with two pairs of urban and rural sites; the sites were paired to minimize unwanted variation within a pair not due to urbanization and the pairing was replicated to capture more of the variability associated with urbanization.

I used both qualitative and quantitative social science methods to explore people's perceptions of ecosystem services. With the qualitative methods, I explored certain concepts to better understand their significance in the Solomon Islands' context. More precisely, I conducted expert interviews and focus group discussions, to gain a better understanding of the relevant ecosystem services and wellbeing constituents in the context of the Solomon Islands. I also interviewed key informants to draw community profiles of each of my study sites. The qualitative data helped me to build my quantitative data collection tool and interpret my findings. I used quantitative methods to address my research objectives and to test hypotheses. I used semi-structured household surveys to compare urban and rural dwellers socio-cultural valuation of ecosystem services, their perceptions of ecosystem services bundles, wellbeing benefits, and availability and access limitations.

3.2 Study sites

The Solomon Islands are a collection of about 990 islands in the South Pacific. The islands are of volcanic origin or formed by raised coral reefs, with an ocean-equatorial climate, and host an impressive biodiversity with high levels of endemism (Ministry of Environment Conservation and Meteorology 2008). The population of 642,000 people is mostly of Melanesian ancestry, sharing cultural traditions common to Melanesian people such as customary land and sea ownership (Solomon Islands National Statistics Office 2015).

Customary land in the Solomon Islands represents 83% of the land (Corrin 2012). Customary land is legally governed by customary law that guides land ownership and inheritance for indigenous citizens (Corrin 2012) and restricts the rights of use and access without permission for non-owners (Foukona 2017). Similarly, the coastline, lagoons, nearshore and outer reefs are customarily owned (Hviding 1998). Customary lands provide a cultural identity, the means for subsistence, and a source of wealth that contribute directly to the wellbeing of a family, a tribe or a village that collectively own the land (Malvatumauri National Council of Chiefs 2012). Public land, for example on which Honiara is located, had been expropriated from customary land by colonial power preceding the country's independence in 1978 (Williams 2011).

Although the country is well endowed in natural resources (e.g., fisheries and logging), the Solomon islands have one of the lowest per capita GDPs of the Pacific islands (1,643 UDS, SPC 2015) and a low human development index (UNDP 2018). Country-wide, the main livelihood activities of the population are reported to be the production of goods for household consumption (28%) and studying (28%), the latter stemming from the high proportion of youth (52% of the population is less than 20 years old)(Solomon Islands National Statistics Office 2015). Other activities include the production of goods to sell (8%) and unpaid domestic work (8%). Only 12% of the population receive wages, although it jumps to 30% in urban areas. The country's economy is also dependent on natural resources, with exports of timber, fish, copra, palm oil, cocoa, and coconut oil representing about 25% of GDP and directed mainly to China (CIA 2019). Imports represent the equivalent of about 50% of GDP and include food, manufactured goods, and fuels, which come mainly from China and Australia (CIA 2019).

Box 3.1 How to define an urban area

There are several definitions of what constitutes an urban area that are dependent on the country and relative to the comparison with rural areas in a given country (MA 2005a, United Nations 2019). In relative terms, an urban area is more populous and more densely populated than a rural area in the same country. There are also more built-up areas, institutions, and political and economic headquarters located in urban than in rural areas. Urban dwellers are more likely to work in the industrial or service sectors of the economy than in agriculture.

In my thesis, I refer to the definition proposed by the Solomon Islands government which recognizes 10 urban areas in the country based on population density and diversity of economic activities, including the capital, Honiara, and most provincial administrative centres (Solomon Islands National Statistics Office 2015).

I collected data in two pairs of coastal urban-rural sites in two provinces (Table 3.1 and Figure 3.1). I selected the two urban sites based on feasibility and the availability of a suitable paired rural site of at least 50 households. Each site within a pair had similar environmental characteristics, such as ecosystem types, distance from the coast, and were located on the same island. In Guadalcanal province, the first urban site was a collection of neighbourhoods differing in socio-economic characteristics (formal and informal settlements) in the centre of Honiara. I paired Honiara with a village called Tamboko, located 20 km west on the same coast of Guadalcanal. The second urban site was Noro, a fast-growing industrial town in the Western province. I paired Noro with a village, Nusa Hope, situated in the Roviana lagoon and 30 km from Noro as the crow flies. Both sites in Western province were located off the coast of New Georgia Island.

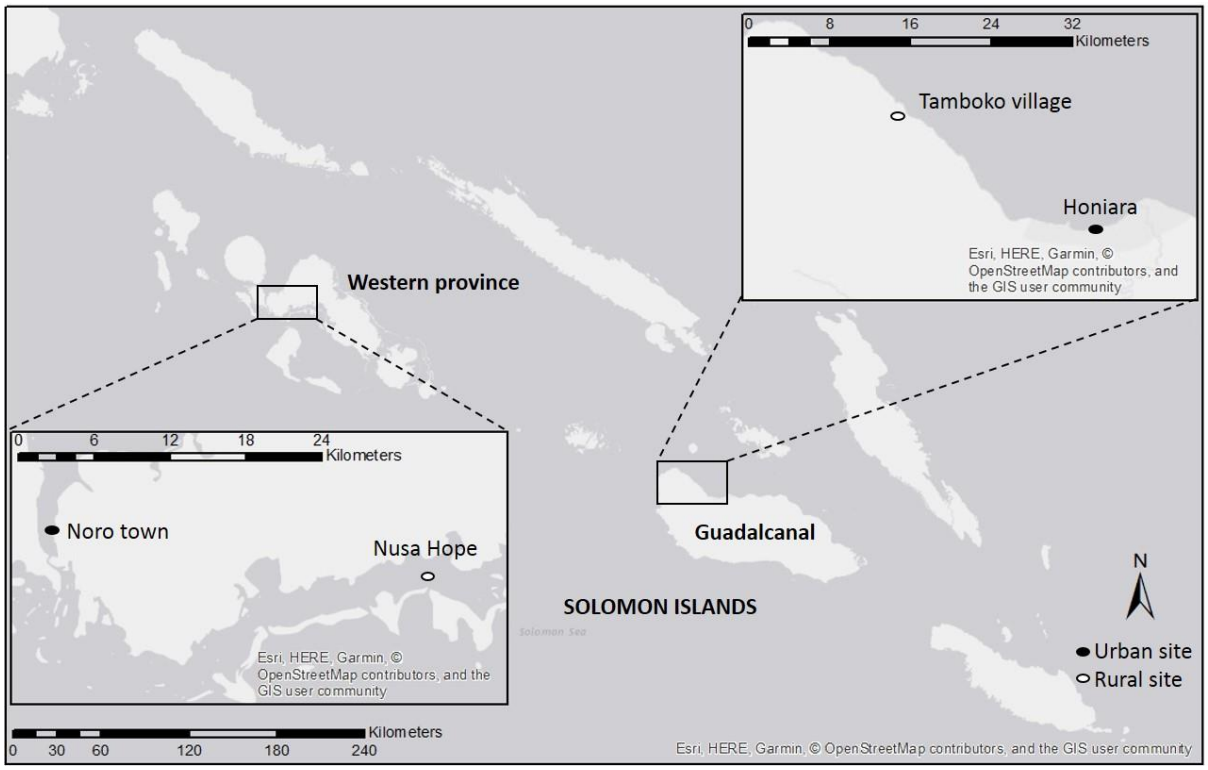


Figure 3.1 Map of the study sites.

Table 3.1 Comparison of population, infrastructure and services, and ecosystem indicators of the four study sites.

Indicator	Guadalcanal **Honiara** (Urban 1)	**Tamboko** (Rural 1)	Western province **Noro** (Urban 2)	**Nusa Hope** (Rural 2)
Population size	68000[a]	N/A[b]	6000[c]	N/A[b]
Main livelihood/ occupation[d]	Paid work, home-production to sell, student	Gardening and selling at market	Paid work, home-production to sell	Fishing, gardening and fundraising for church
Infrastructure and services[e]				
Distance to closest market	In town	40 min by motorized land transportation	In town	6h by canoe, 2h motor-boat
Time to closest hospital	In town	1h by motorized land transportation	20 min by motorized land transportation	6h by canoe, 2h motor-boat
Elementary school	Yes	Yes	Yes	No
Electricity	Yes, in formal settlements	No	Yes, in formal settlements	No
Sewage system	Yes, in formal settlements	No	Yes, in formal settlements	No
Piped water	Yes, in formal settlements	Communal pipes	Yes, in formal settlements	No
Trash disposal	Burnt, collected, dumped in river and ocean	Burnt, buried and dumped in river	Collected mainly	Thrown in ocean, burnt
Main ecosystems[f]				
Terrestrial ecosystems	Forest, grassland	Forest, grassland	Forest	Forest
Marine ecosystems	Ocean, coral	Ocean, coral	Ocean, coral mangrove, seagrass	Ocean, coral mangrove, seagrass
Freshwater ecosystems	River	River	River, wetland	River, wetland

[a] Solomon Islands population census 2012-2013 (Solomon Islands National Statistics Office 2015).

[b] Data was not available for these sites.

[c] Town survey conducted in 2016 (Noro Town Council 2017).

[d] Socio-demographic data collected in the interviews.

[e] Data obtained from key informant interviews (community leaders) and UN-Habitat (2012).

[f] Data obtained from focus group discussions and aerial photographs.

3.3 Ecosystem services and disservices selection

I defined ecosystem services according to the Common International Classification of Ecosystem Services at the class level (CICES, Haines-Young and Potschin 2018, version 5.1). CICES was developed for the System of Environmental-Economic Accounting (SEEA) led by the United Nations Statistical Division (UNSD) for ecosystem service accounting and assessing. It provides a means to translate other ecosystem service classifications into a common language (e.g., MA, The Economics of Ecosystems and Biodiversity (TEEB), or Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES)). Supporting ecosystem services are not considered as a separate ecosystem service category, but rather as the underlying ecosystem functions that generate ecosystem services (e.g., primary productivity). Some supporting ecosystem services from the MA are included in the regulation and maintenance category (e.g., soil formation).

I drew on local expertise and knowledge to select ecosystem services and disservices to ensure that the services were important to the beneficiaries and relevant in the context of the Solomon Islands (Martín-López et al. 2014). I reduced the list of about 65 ecosystem services proposed at the class level by CICES to 23 ecosystem services, keeping those that appeared relevant in the Solomon Islands context for expert interviews and focus group discussions. This first selection resulted from literature searches and discussions with researchers familiar with the Solomon Islands. I considered both focus groups discussions and expert interviews to select the three most important services from each category for a total of nine ecosystem services (Table 3.2). Furthermore, I grouped a few ecosystem services into one; for example, I combined several categories of food into one. Ecosystem disservice were classified into three categories from the information obtained from the focus group discussions (Table 3.3).

Table 3.2 Description of the ecosystem services selected.

Ecosystem service	Corresponding CICES names at the class level	Description given to interview participants
Provisioning services		
Food	(1) Cultivated terrestrial plants (including fungi, algae), (2) plants cultivated by in-situ aquaculture, (3) animals reared, (4) animals reared by in-situ aquaculture, (5) wild plants (terrestrial and aquatic, including fungi, algae), and (6) wild animals (terrestrial and aquatic) used for nutritional purposes.	Food from plants and animals (including fish) that are grown/reared or harvested in nature.
Materials	(1) Fibres and other materials from cultivated plants, fungi, algae and bacteria, (2) fibres and other materials from wild plants for direct use or processing.	Materials from plants and animals, e.g. building materials and medicine that are grown or harvested in nature.
Firewood	(1) Cultivated plants (including fungi, algae), (2) wild plants (terrestrial and aquatic, including fungi, algae) used as a source of energy.	Fuel from plants for cooking or lighting that are grown or harvested in nature.
Regulating services		
Clean air	Filtration/sequestration/storage/accumulation by micro-organisms, algae, plants, and animals	Plants that clean the air, e.g. by removing dusts and pollutants.
Clean water	Filtration/sequestration/storage/accumulation by micro-organisms, algae, plants, and animals	Plants and animals that clean the water (filtrate wastes).
Soil protection	Control of erosion rates	Plants and animals that prevent soil erosion (e.g., plant roots that stabilise the soil) and protect the coast (e.g., by reducing waves).
Cultural services		
Recreation	(1) Characteristics of living systems that that enable activities promoting health, recuperation or enjoyment through active or immersive interactions, or (2) through passive or observational interactions.	Places in nature for activities or to relax and have an enjoyable time (e.g., activities to come together, swimming, walking).
Culture	(1) Characteristics of living systems that are resonant in terms of culture or heritage, (2) elements of living systems that have symbolic meaning, or (3) sacred or religious meaning	Culture, heritage and traditional knowledge associated with nature including stories, tambu plants and animals.
Stewardship	(1) Characteristics or features of living systems that have an existence value, or (2) have an option or bequest value.	Protect or conserve plants, animals and nature for their own value or for future generations.

Table 3.3 Description of the ecosystem disservices selected.

Ecosystem disservice	Description given to interview participants
Dangerous organisms	Dangerous plants and animals (including insects) that can harm you (directly or by carrying diseases).
Pests and diseases	Pests (animals and insects) and diseases that affect the food or materials (plants or animals) that are grown/reared or harvested in nature.
Natural disasters	Natural disasters (e.g., cyclones, tsunamis, floods, landslides).

3.4 Data collection and sampling design

I present in this section the different data collection methods that I used in my research: expert interviews, key informant interviews, focus group discussions, and household interviews. More specific information is given in the relevant chapters.

The focus group discussions and household interviews were conducted by research assistants from the Solomon Islands. I trained the research assistants over a 2-4 day period. I participated in all focus group discussions. I alternated between research assistants to accompany them during the household interviews. I interviewed the experts and key informants myself.

3.4.1 Expert interviews to select ecosystem services

To contribute to the selection of ecosystem services and disservices, I interviewed eight people regarded as experts in the field of ecosystem services or human wellbeing with practical experience in the Solomon Islands (seven face-to-face and one by email) in May and June 2018 (Table 3.4). The goal of the semi-structured interview was to understand their perspective on the relevance of the initial ecosystem service list in the Solomon Islands. The experts were recommended by organizations, other experts or found through internet searches. All but one were Solomon Islanders.

Table 3.4 Description of the experts interviewed.

Organization	Occupation	Gender
Ministry of Environment, Climate Change, Disaster Management & Meteorology	Conservation officer	Female
Pacific Regional Environment Programme (SPREP)	Project manager	Male
Food and Agriculture Organization of the United Nations (FAO)	Project manager	Male
Solomon Islands National University (SINU)	Lecturer	Female
Solomon Islands National University (SINU)	Lecturer	Female
Ministry of Fisheries and Marine Resources	Higher management	Female
Ministry of Health and Medical Services	Nutrition and food security officer	Female
World Fish	Nutrition expert	Female

3.4.2 Key informant interviews and community profiling

To establish a community profile and help interpret my findings, I conducted two semi-structured interviews per site with key informants (Table 3.5). The themes were based on existing community profiling questionnaires (Coulthard et al. 2015, Gurney and Darling 2017). People selected were recognized by others as leaders or elders with extensive knowledge of the community.

Table 3.5 Description of the key informants interviewed.

Site	Role	Gender
Honiara	Church leader	Female
Honiara	Director of Environment division, City Council	Male
Tamboko	Chief	Male
Tamboko	Female leader	Female
Noro	Town clerk	Male
Noro	School principal	Female
Nusa Hope	Elder	Female
Nusa Hope	Elder	Male

The discussion themes were related to:

1) Community demographics such as number of households, people per household, religions, ethnic groups, main occupation of people.
2) Community institutions, for example, churches, community groups, governmental organisations, NGOs and their role in the community.
3) Access to services and infrastructure such as healthcare, education, transport, water, sewage, garbage collection, electricity, security, commerce (market, bank, general store, etc.), and communications (phone and Internet).
4) Shocks and historical events (natural or anthropogenic) of the past decades that could influence how people use and benefit from nature.
5) The main challenges facing the community, possible futures, etc.

3.4.3 Focus group discussions

For ecosystem service selection

The research assistants and I held six focus group discussions in June 2018 (four in Honiara and two in Tamboko, Table 3.6), with separate male and female discussions. In Honiara, participants were recruited in public places in the centre of the city and discussions were held at the Holy Cross Cathedral. In Tamboko, the village chief selected participants and discussions took place in the community hall. Two pilot discussions had taken place previously with students of the Solomon Islands National University. Discussions were conducted in Solomon Islands Pijin with one research assistant acting as a facilitator and one as a note-taker.

Table 3.6 Summary of the focus group discussion participants to select ecosystem services.

Site	Urbanization level	Males	Females	Total
Honiara	Urban	8	8	16
Tamboko	Rural	9	9	18
Total		17	17	34

The discussions consisted of three main parts:

1) After all ecosystem services from the initial list had been described, participants were asked a) if each ecosystem service was important to their household's wellbeing (participants could select as many important ecosystem services as desired in this first stage), b) if so, how, and c) in which ecosystems they derived the service from. There were pictures of different ecosystems (including human-modified ecosystems) to guide them for the last question.
2) Participants were asked to vote individually and anonymously on a piece of paper for the 10 (more or less) ecosystem services that were the most important for them and their family to live well in their community.
3) To identify ecosystem disservices, participants were asked to discuss things in nature that were bad for them and their household.

To identify locally relevant wellbeing elements

To understand which wellbeing aspects were considered important in each community, the research assistants and I held eight focus group discussions: one with men and one with women in each of the four sites from September to December 2018 (with 3 to 6 participants

per discussion, Table 3.7). Participants in villages were mainly proposed by the village leaders. In urban locations, we recruited people in public areas. Discussions were held in churches or in community halls in Solomon Islands Pijin and were led by two research assistants. I designed the discussion based on the questions presented in the handbook Exploring wellbeing in fishing communities (Coulthard et al. 2015). Further details are provided in Chapter 6.

Table 3.7 Summary of the wellbeing focus group discussion participants.

Site	Urbanization level	Males	Females	Total
Honiara	Urban	3	5	8
Noro	Urban	4	6	10
Tamboko	Rural	4	4	8
Nusa Hope	Rural	4	4	8
Total		15	19	34

3.4.4 Household interviews

I used semi-structured interviews to collect data at the household scale to perform quantitative analyses (questionnaire presented in Appendix B). The questionnaire was inspired by previous socio-cultural valuation studies that used a rating method (e.g., Lindemann-Matthies et al. 2013, Oteros-Rozas et al. 2014). The sociodemographic and material assets section were adapted from *A Global Social-Ecological Systems Monitoring Framework* (Gurney and Darling 2017, Gurney et al. 2019) according to the data presented in the 2012-2013 Solomon Islands population census (Solomon Islands National Statistics Office 2015). The interviews consisted of six main sections that will be discussed further in the relevant chapters:

1) Sociodemographic characteristics and subjective wellbeing evaluation (more details are given in chapters 6 and 7).
2) Ecosystem services' associations with ecosystem types (more details are given in chapter 5).
3) Ecosystem services' importance rating and the associated wellbeing benefits (more details are given in chapters 4 and 6).
4) Ecosystem services' satisfaction rating and the availability and access limitations (more details are given in chapters 4 and 7).
5) Ecosystem disservices' importance rating and association with ecosystem types (more details are given in chapters 4 and 5).

6) Material assets to derive a measure of wealth (further details are given in chapters 6 and 7).

The research assistants and I piloted the interview questionnaire in Honiara with 50 households in June and July 2018 to adjust the wording of the questions and the length of the interview. We then conducted 50 face-to-face semi-structured interviews in each of the four sites (N=200, Table 3.8) from September to December 2018. I chose this number of interviews per site to have a balanced design and equal sampling at all sites as well as for feasibility reasons; 50 interviews would be on the higher range of what could be achievable in large villages of the Solomon Islands and would be sufficient to conduct statistical analyses (for examples of sample sizes in similar contexts, see Gurney et al. 2014, Gurney et al. 2016, Lau et al. 2019). Interviews were conducted by the research assistants in Solomon Islands Pijin (except in Nusa Hope where the interview had to be translated in Roviana for most people). Respondents were selected using systematic random sampling, whereby every second household encountered was selected. We interviewed only one person per household, preferentially the head of the household or their spouse. Respondents were 49% male and 51% female, and 97% of Melanesian ancestry compared to a population of 51% male 49% female, and 96% Melanesian in the national census (Solomon Islands National Statistics Office 2015).

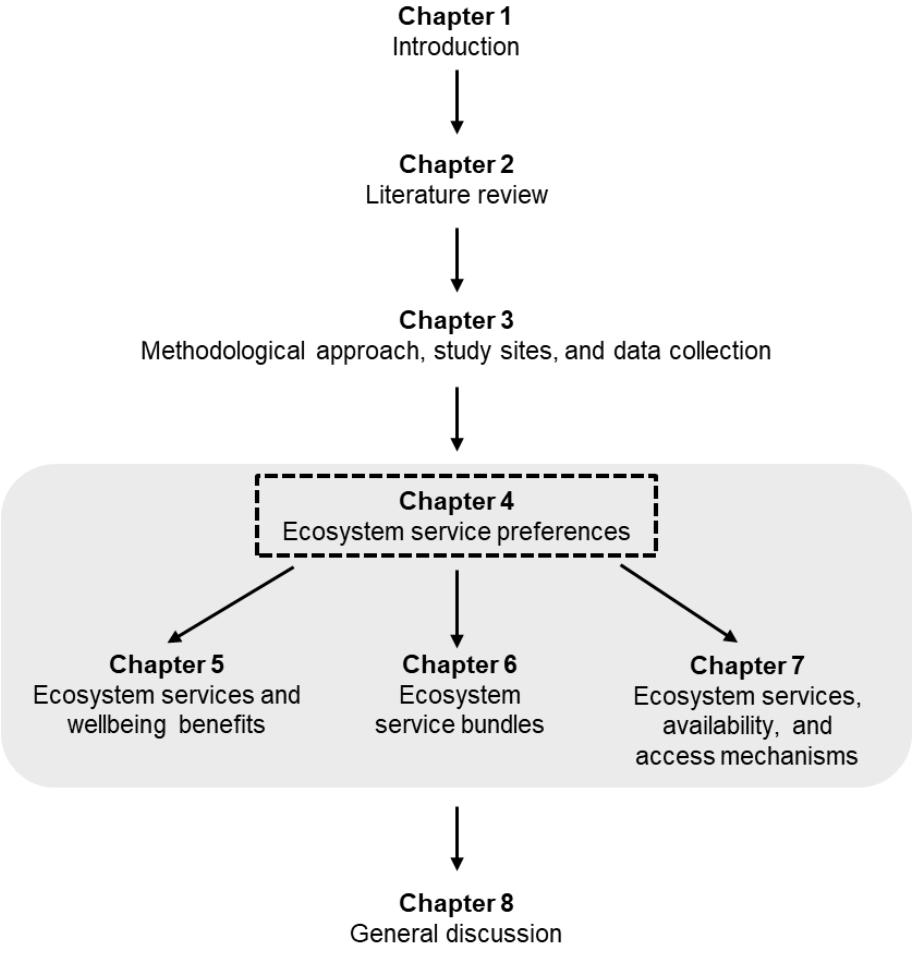
Table 3.8 Summary of household interview participants' socio-demographic characteristics and interview duration.

Site	Urbanization level	Males	Females	Mean age (SD[a])	Mean number of years living in community (SD)	Mean duration in minutes (SD[a])
Honiara	Urban	25	25	35.9 (14.0)	16.2 (13.8)	80.2 (18.7)
Noro	Urban	26	24	39.4 (10.0)	11.7 (9.2)	76.7 (21.5)
Tamboko	Rural	22	28	41.9 (13.2)	33.0 (19.1)	93.7 (22.6)
Nusa Hope	Rural	25	25	46.3 (16.8)	35.6 (21.0)	68.4 (25.5)
Total		98	102	40.3 (14.2)	24.1 (19.3)	266 hours

[a] Standard deviation

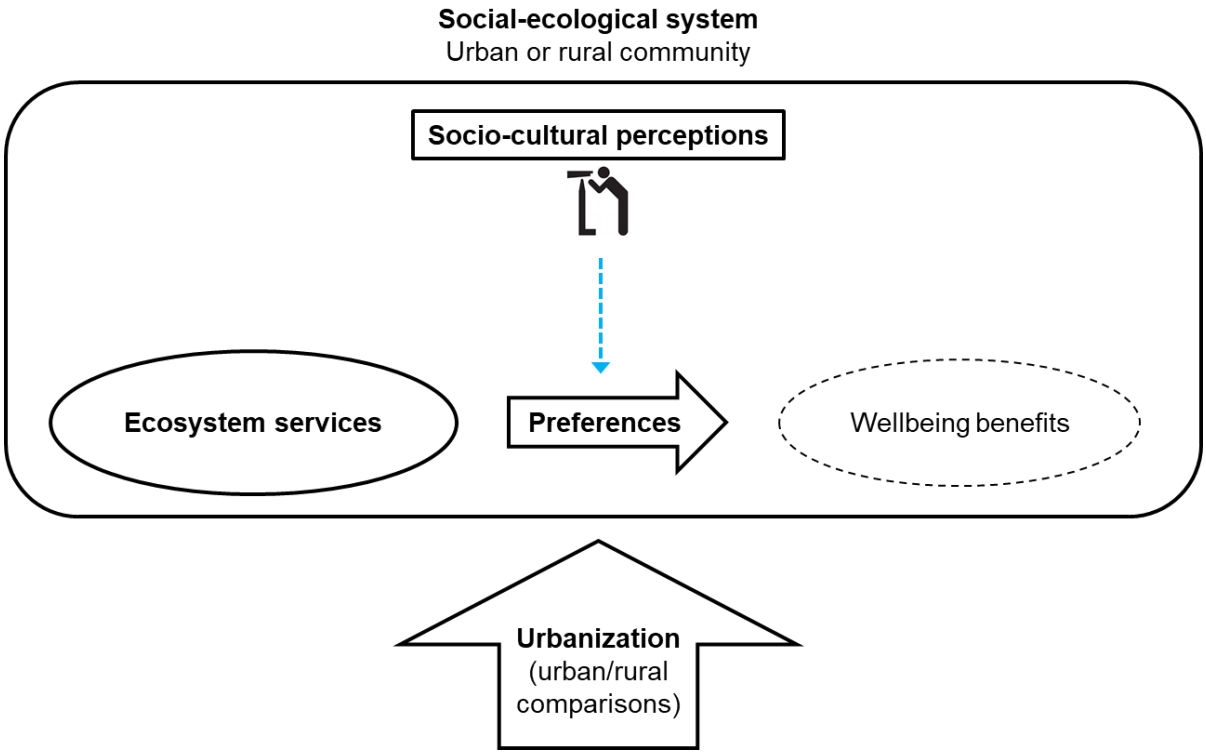
4. Ecosystem service preferences*

In my first data-based chapter, I use socio-cultural valuation to examine urban and rural dwellers' preferences for ecosystem services. The next three data chapters build on these findings.



* Adapted from Lapointe M., Gurney G.G., and Cumming G.S. (2020) Urbanization alters ecosystem service preferences in a Small Island Developing State. Ecosystem Services

Contributions: I developed the research question, methodology, collected the data, performed the data analyses, and developed the figures and tables with the advice of G. Cumming and G. Gurney. I wrote the first draft of the paper which was revised with editorial input from G. Cumming and G. Gurney.


Social-ecological system
Urban or rural community
Socio-cultural perceptions
Ecosystem services
Preferences
Wellbeing benefits
Urbanization
(urban/rural
comparisons)

Urbanization alters ecosystem service preferences in a Small Island Developing State

Abstract

Urbanization entails social, economic and environmental changes that can transform how people relate to nature and disconnect them from it, with consequences for their wellbeing. The impacts of urbanization on human-nature relationships viewed through people's ecosystem service preferences are, however, poorly understood, especially in the rapidly urbanizing Global South. I tested the hypothesis that, although both urban and rural people depend on ecosystem services, people in cities would value ecosystem services less because they are less directly connected to ecosystems. Using a paired urban–rural study design, I conducted 200 interviews with urban and rural dwellers along the coast of the Solomon Islands, a Small Island Developing State (SIDS), to compare the importance they attributed to different ecosystem services and disservices for wellbeing, as well as their satisfaction with ecosystem services. Although urban and rural dwellers reported that ecosystem services were very important for their wellbeing, urban dwellers' ratings were lower, thereby supporting my hypothesis. Urban dwellers were less satisfied than rural dwellers with the benefits that they received from ecosystem services and would have preferred to benefit more, showing that they were less connected to nature, although maybe not voluntarily. Both urban and rural dwellers perceived important negative impacts from ecosystem disservices. Thus, even a relatively recent urbanization process can alter people's relationships with nature, reducing significantly the benefits that people derive from ecosystems. Urban planning and environmental management can help reconnect people to nature by addressing people's needs and preferences towards nature, as revealed through ecosystem service and disservice socio-cultural valuation.

4.1 Introduction

Urbanization has been instrumental in improving human wellbeing, and it presents opportunities for sustainability (United Nations 2014). Yet, the consumption patterns of urban populations are also one of the main drivers of environmental change worldwide (Seto et al. 2013). With more than half of the world's population now living in cities (United Nations 2014), the pressing need for sustainable cities that offer a high quality of life is acknowledged

in its own Sustainable Development Goal (Goal 11, United Nations 2017). In societies of the Global North, environmental degradation in and around cities can lead to a gap between nature and people (nature deficit; e.g., Louv 2005, 2009). People experiencing only highly transformed or degraded ecosystems may change their norms, shifting their baseline for what constitutes nature (Soga and Gaston 2018). This altered baseline could in turn affect people's behaviour towards and governance of the environment, resulting in further environmental change. Since urbanization is ongoing, in particular in countries of the Global South (United Nations 2014), it is important to understand how living in cities affects the role of nature in people's wellbeing and its implications for urban planning, biodiversity conservation, and sustainability initiatives.

The ecosystem service framework provides a lens to investigate possible changes in human-nature relationships. Moreover, people's needs and attitudes towards ecosystem services can be investigated through socio-cultural valuation, for example, by eliciting perceived importance of ecosystem services (Scholte et al. 2015). Indeed, the actual benefits derived from ecosystem services depend on people's perceptions, which remain largely unexplored by research on urban ecosystem services (Luederitz et al. 2015). Furthermore, the impact of urbanization on how people value ecosystems and their services is still poorly understood, especially in the Global South (Elmqvist et al. 2013a, Kremer et al. 2016, Lapointe et al. 2019, Chapter 2). Thus, in this chapter, I compare urban and rural dwellers' socio-cultural valuation of ecosystem services in a Small Island Developing State (SIDS).

Urbanization influences the supply of many ecosystem services. The demand from cities exceeds local ecosystem productivity, meaning that local provisioning services must be substituted by ecosystem services that are supplied from further away, and non-ecosystem services such as manufactured goods and technologies (e.g., piped water and synthetic fabrics; Cumming et al. 2014). Regulating services are often degraded in and around urban areas; for example, air and water quality may be poor. Some regulating services can be replaced to some extent by infrastructure (e.g., water filtration plants, walls to prevent erosion). The case of cultural services is more complex because non-material benefits can sometimes be produced by smaller areas that can generate important flows to people (e.g., Rall et al. 2017). However, cultural services, with the exception of recreation, have received

less attention from researchers (Haase et al. 2014). Ecosystem elements that affect wellbeing negatively, 'ecosystem disservices', are marginally studied in a 'services' framework compared to ecosystem services, but have mostly been considered in environments heavily modified by humans, such as urban areas (Shackleton et al. 2016). Ecosystem disservices help provide a more complete picture of human-nature relationships. Urban ecosystem disservices include studies of plants causing pollen allergies, pathogens and their vectors, and plants and animals that damage infrastructures (von Döhren and Haase 2015). Given that existing research on urban ecosystem services has tended to focus on the availability or supply of ecosystem services (especially regulating services), understanding of the demand-side of the urban ecosystem services equation remains limited (Haase et al. 2014). Nonetheless, understanding people's needs for and preferences towards ecosystem services is essential to manage the environment in a way that maintains or improves the benefits that people derive from nature.

While the impacts of human activities, such as urbanization, on ecosystem service delivery are now better understood (e.g., MA 2005), we still lack an understanding of how human behaviours and underlying values, worldviews and beliefs contribute to environmental changes, as well as how human wellbeing is impacted by these changes (Duraiappah and Rogers 2011). A socio-cultural approach to ecosystem service valuation can help meet these research needs by investigating how people perceive and value the environment (Scholte et al. 2015). The few published comparative socio-cultural assessments of urban and rural ecosystem services point to differences in ecosystem service preferences by level of urbanization (Lapointe et al. 2019, Chapter 2). Previous research suggests that both urban and rural dwellers highly value regulating and cultural services, but the importance of provisioning services is perceived mostly by rural people (Lapointe et al. 2019, Chapter 2). These findings could indicate a more indirect or disconnected human-nature relationship in urban areas compared to rural areas (Martín-López et al. 2012, García-Llorente et al. 2016, Pan et al. 2016). However, more research is needed to confirm these trends, especially in the Global South, where very few studies have been conducted. Moreover, half of the papers reviewed in Lapointe et al. (2019, Chapter 2) focused on ecosystem services distant from urban dwellers (e.g., a national park) rather than their immediate environment. Urban planning and environmental management in and around cities would benefit from a better understanding

of the impacts of urbanization on the benefits and negative impacts that people derive from nature and their consequences for wellbeing.

Socio-cultural assessments often measure perceived ecosystem service importance, but rarely ecosystem service satisfaction (although see Cumming and Maciejewski 2017). Ecosystem service satisfaction refers to the perceived adequacy of the benefits received according to people's needs and expectations. The Expectancy Disconfirmation Model (Oliver 1977) from consumer research relates satisfaction to expectations, performance and disconfirmation, i.e., the difference between expectations and perceived performance. Thus, ecosystem service satisfaction provides information on the perceived state of an ecosystem service and someone's expectations for it, and on the difference between them. It can provide complementary information to ecosystem service importance, especially in contexts where ecosystem services are degraded or less available, as in many urban environments.

I addressed these gaps by asking how people living in cities and villages differed in their valuation of ecosystem services in their local environment in the Solomon Islands, a Small Island Developing State. Most people in the Solomon Islands live in villages, but urbanization is occurring at a rapid pace (4.7%/year, UN-Habitat 2012). The Solomon Islands offer an interesting case study because people live mainly along the coast, spanning terrestrial, marine, and freshwater ecosystems. I hypothesized that (H1) urbanization will affect people's perceived ecosystem service and disservice valuation, with urban people placing a lower value on ecosystem services because of their less direct connections to ecosystems. The contrasting null hypothesis (H2) suggests that values for ecosystem services are independent of a person's surroundings and hence, that there would be no difference in the perceived values of ecosystem services and disservices between urban and rural dwellers. It is also possible (H3) that urban dwellers, with higher formal education levels, might rate certain ecosystem services such as regulating or cultural services higher than rural dwellers (e.g., Martín-López et al. 2012). To test these hypotheses, I compared the perceived importance and satisfaction associated with nine ecosystem services (in provisioning, regulating, and cultural categories), and the perceived importance of three ecosystem disservices between paired urban and rural sites.

4.2 Methods

4.2.1 Ecosystem service and disservice valuation

The perceived importance (i.e., the perceived contribution that an ecosystem service made to a household's wellbeing) of nine ecosystem services and three disservices for the respondents' household was rated using a five-point Likert-type scale where a score of 1 indicated that the ecosystem service had no importance at all to the household and 5 indicated that it was absolutely essential. Respondents' satisfaction with the benefits that they obtained from each ecosystem service was also elicited using a five-point Likert-type scale. Although the use of Likert scale is contested by some (e.g., Dolnicar et al. 2011), they are commonly used in quantitative analyses similar to mine (e.g., Iniesta-Arandia et al. 2014, Ament et al. 2016, Gurney et al. 2019). We asked people to think of nature and ecosystem services that they could access in their daily lives. For provisioning services, I only considered that a household was benefiting if people were directly involved in obtaining the ecosystem service from nature (e.g., fruits and vegetables bought at the market would not be considered an ecosystem service in this case).

4.2.2 Statistical analyses

I compared ecosystem services and disservices ratings for urban and rural areas using Cumulative Links Mixed Models (CLMM) implemented using the *ordinal* package (Christensen 2019b). The rating distributions, especially of importance, were left-skewed (see Figure 4.1). I thus had to group the five-point ratings into three groups: ratings of 1, 2 and 3 were qualified as low values, a rating of 4 as medium, and 5 as high. For consistency, I kept this grouping for all analyses. I ran the CLMM on these new rating variables with urbanization level and ecosystem service type or category, and ecosystem disservices as fixed effects. I included households as a random effect to account for the fact that one person per household rated all ecosystem services and disservices resulting in ratings that cannot be considered independent from one another. Household was in turn nested in the site where the data was collected (see Table C.1 for model descriptions). The assumption of proportional odds was tested and met for most models (six out of eight models). The assumption could not be met in two cases for ecosystem service categories, while the same models with ecosystem service types did meet the assumption. However, according to the author of the ordinal package: " (…) in the author's experience almost all CLMs on real data show some evidence of non-proportional odds for

one or more variables while the most useful representation of the data is often a model that simply assumes proportional odds" (Christensen 2019a). I conducted an analysis of deviance for each model with the function *Anova* in the *car* package (Fox et al. 2019) to test for the significance of the fixed effects variables on ratings by producing a Wald chi-square test. Following a significant interaction between urbanization level and ecosystem services, a post-hoc multiple comparison test with a Tukey correction was performed with the *emmeans* package (Lenth et al. 2019) to compute Estimated Marginal Means (EMM). To look into the effect of study site, I conducted similar analyses, but with site replacing urbanization level as a fixed effect and only household as a random effect. Similarly, the relative importance of different ecosystem services within urban and rural areas was assessed with a CLMM with only ecosystem services as the fixed effect and household as a random effect. All analyses were conducted in R (R Core Team 2018).

4.3 Results

Ecosystem service importance ratings were very high in both urban and rural locations (Figure 4.1), but strikingly higher in rural areas. For example, ratings of 1 (Not important at all) or 2 (Not very important) were absent in rural areas with the exception of culture. The differences between urban and rural sites were significant for ecosystem service types as well as categories (Table C.2). I was therefore able the reject the null hypothesis of no difference between the importance ratings of urban and rural dwellers. Rural dwellers rated all ecosystem service types and categories significantly higher than urban dwellers (Table C.3). Within each urban and rural areas taken separately, the relative importance of the different ecosystem services was not easily teased apart, but regulating services were the most important category for urban dwellers, while provisioning and regulating services were the most important for rural dwellers (Figure C.1).

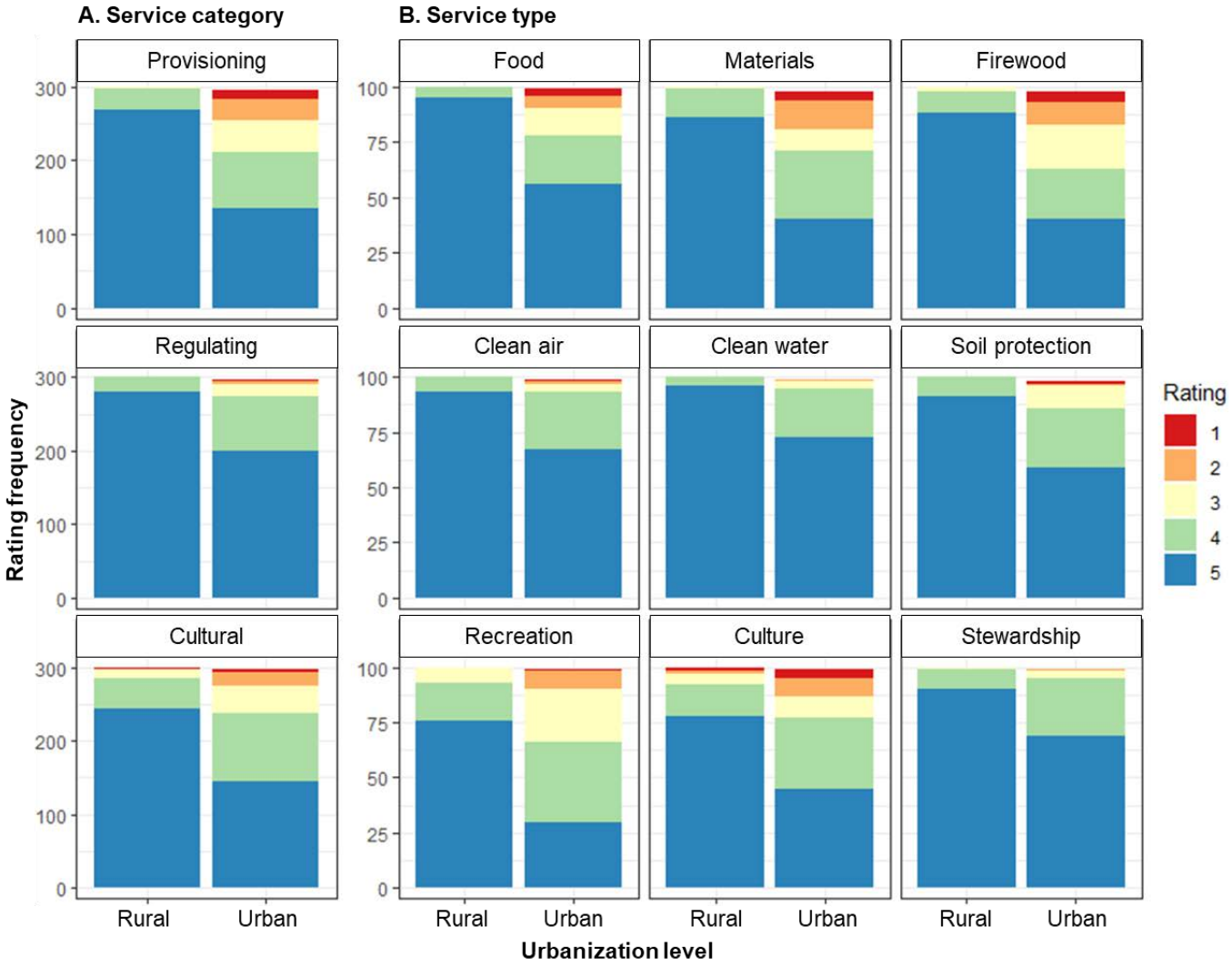


Figure 4.1 Importance rating frequency for ecosystem service categories (A) and types (B) according to urbanization level.
Ratings: (1) Not important at all; (2) Not very important; (3) Somewhat important; (4) Very important; (5) Absolutely essential.

Satisfaction rating frequency for ecosystem service categories and types (Figure 4.2) also differed between urban and rural areas with, for example, the majority of rural dwellers rating 5 (very satisfied) for all ecosystem service type and category, whereas ratings of 5 rarely exceeded 25% of people in urban areas. Ecosystem service satisfaction ratings were significantly lower in urban compared to rural areas for ecosystem service types as well as categories (Tables C.4 and C.5). Once again I rejected the null hypothesis of no difference between urban and rural dwellers satisfaction rating. Differences among ecosystem services within urban and rural areas were not very pronounced (Figure C.2). Still, when looking at ecosystem service categories, urban dwellers were least satisfied with provisioning services.

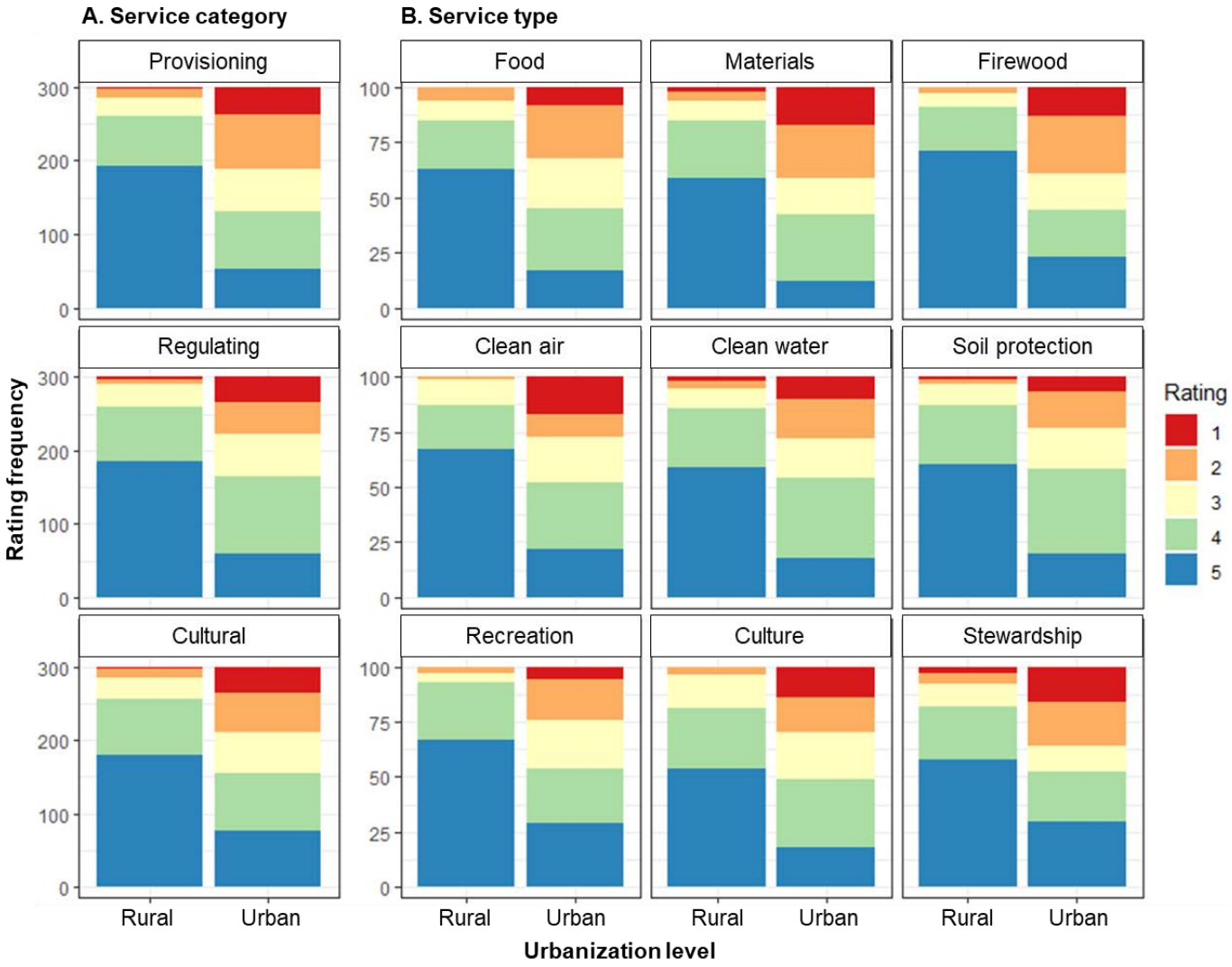


Figure 4.2 Satisfaction rating frequency for ecosystem service categories (A) and types (B) according to urbanization level.
Ratings: (1) Very unsatisfied; (2) Unsatisfied; (3) Neutral; (4) Satisfied; (5) Very satisfied.

Ecosystem disservices importance rating frequencies (Figure 4.3) did not differ significantly between urban and rural areas (Table C.6). Thus, I failed to reject the null hypothesis of no difference between rural and urban ecosystem disservice importance ratings. However, there were significant differences among ecosystem disservices (Table C.6, Figure C.3).

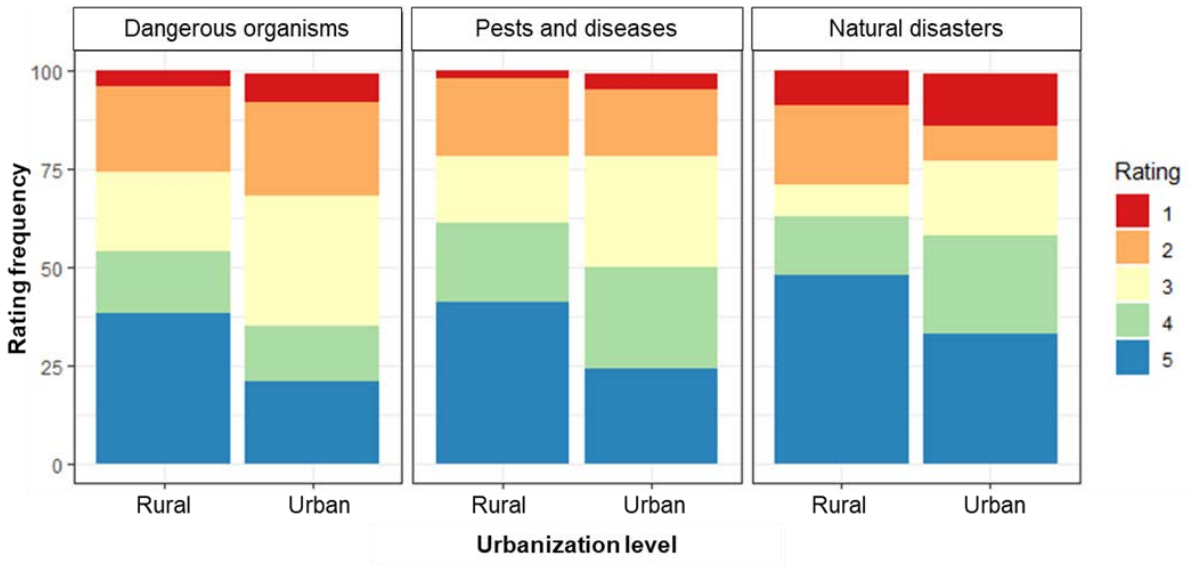


Figure 4.3 Ecosystem disservice importance rating frequency according to urbanization level.
Rating: (1) Not important at all; (2) Not very important; (3) Somewhat important; (4) Very important; (5) Extremely important.

There were significant differences among the four sites for ecosystem service and disservice importance, and ecosystem service satisfaction (Figure 4.4). Ecosystem service importance and satisfaction ratings for the two rural sites were always higher than for the two urban sites, although the difference was not significant in the case of cultural services between Noro town (Urban 2) and Tamboko village (Rural 1). For ecosystem disservice ratings, Tamboko village (Rural 1) showed higher ratings than the other sites.

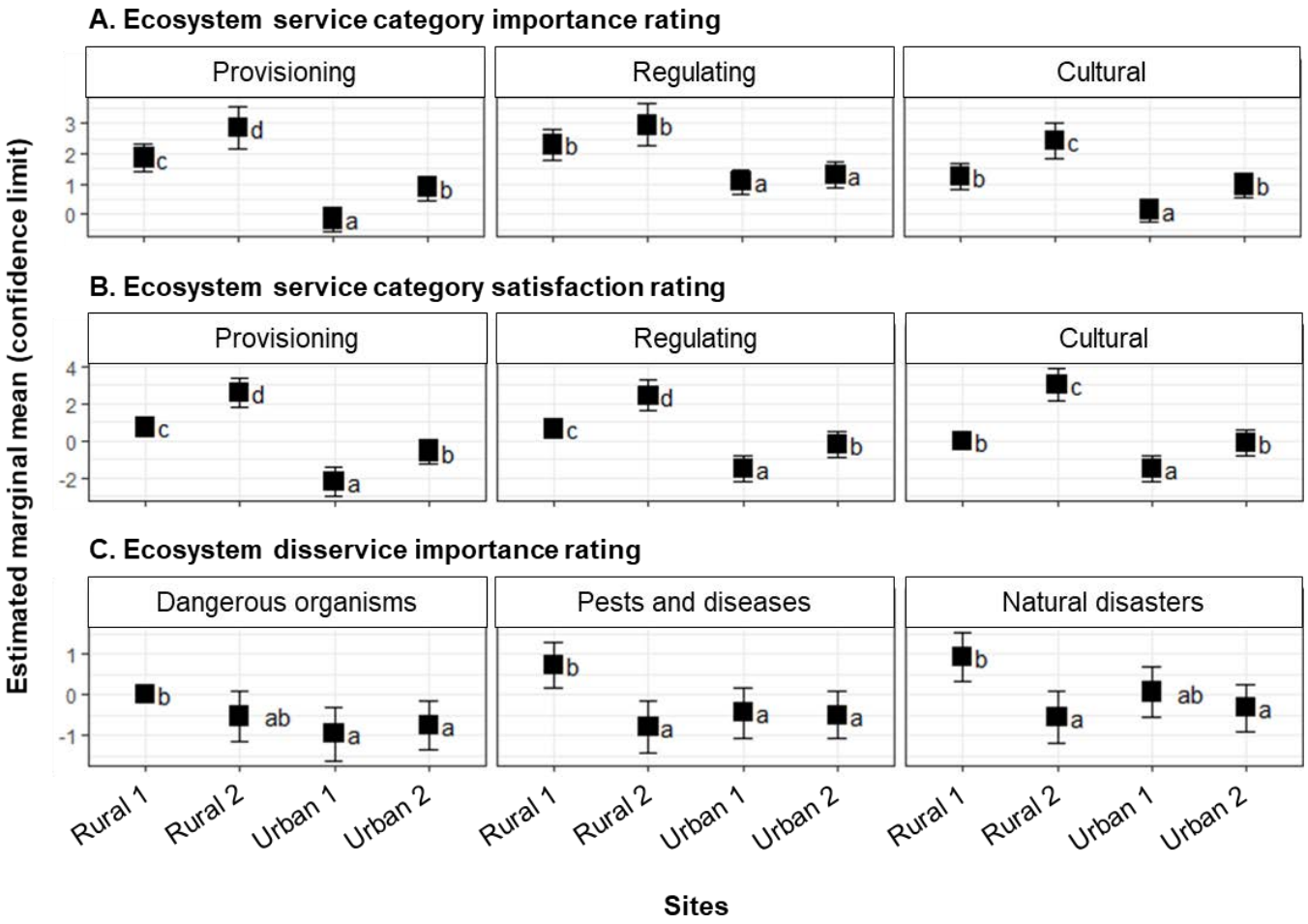


Figure 4.4 Coefficient plots from the Cumulative Links Mixed Models comparing ecosystem service importance (A.), satisfaction (B.), and ecosystem disservice importance ratings (C.) by site.

Sites sharing a letter in the same panel are not significantly different from one another. Sites are: Rural 1: Tamboko; Rural 2: Nusa Hope; Urban 1: Honiara; Urban 2: Noro.

4.4 Discussion

4.4.1 Provisioning, regulating, and cultural services, and disservices valuation

My results derived from paired urban and rural sites strongly supported the hypothesis that urbanization affects people's preferences for ecosystem services. I found that perceived importance and reported satisfaction for ecosystem services were significantly lower for urban than rural dwellers. However, ecosystem disservice perceived importance was not significantly related to urbanization level, although there were significant differences between the four sites. The perceived importance of and satisfaction for ecosystem services also differed among sites. Considered together, these results indicate lower perceived wellbeing benefits received from ecosystem services in urban areas, but as many perceived negative

impacts. I did not assess whether this wellbeing loss in urban areas could be compensated by non-ecosystem services, but a study in Italy that compared ecosystem services with human-made services found that 46% of liveability was associated with ecosystem services (Antognelli and Vizzari 2016). I can therefore assume that the loss in wellbeing of urban dwellers in the Solomon Islands, a low-income country highly dependent on natural resources, could not be fully compensated by alternatives.

The greater importance of provisioning services that I found in rural compared to urban areas aligns with previous research conducted in very different parts of the world (e.g., Martín-López et al. 2012, Pan et al. 2016, Aguado et al. 2018). These differences in ecosystem service importance between urban and rural dwellers could be explained by, among other factors, the reduced availability or access to ecosystem services in built-up areas, the presence of alternatives, and main livelihood activity (Cumming et al. 2014, Lapointe et al. 2019, Chapter 2). In the Solomon Islands, city dwellers have more non-ecosystem service alternatives than their rural counterparts for food, materials, and firewood, although not as much as in wealthier urban areas.

Regulating services were the most important ecosystem service category for urban dwellers, as is the case in high-income countries (Lapointe et al. 2019, Chapter 2). While in wealthier nations regulating services can be replaced in part by infrastructure (Cumming et al. 2014), these alternatives are fewer in low-income countries that might have deficient infrastructure. For example, only about 60% urban settlers in the Solomon Islands have access to piped water (Solomon Islands National Statistics Office 2015).

Cultural services were highly valued in absolute terms by both urban and rural dwellers, but relatively less so than provisioning and regulating services, with the exception of stewardship. Cultural services are usually considered to be among the most important services in urban settings, allowing humans to connect with nature (Kremer et al. 2016). However, most of this research emanates from the Global North and China (Luederitz et al. 2015), with a few exceptions (Caballero-Serrano et al. 2016, Elbakidze et al. 2018). The three cultural services that I assessed were very different from one another. First, stewardship was highly valued by both urban and rural dwellers, potentially because it is necessary to continue benefiting from

other ecosystem services. Second, culture, heritage, and traditional knowledge related to nature are mostly associated to villages, and the mix of different cultures in urban centres could render traditional cultures harder to access. In addition, culture, heritage, and traditional knowledge permeate all provisioning services because these ecosystem services are all related to traditional uses (traditional gardening and fishing practices, building traditional houses, using traditional medicines, and using firewood for traditional *motu* cooking). Indeed, a study conducted in rural Melanesia also obtained lower valuation of cultural services compared to other services, although their qualitative analysis revealed strong links between cultural and provisioning services (Lau et al. 2019). Third, recreation was rated the lowest service in both urban and rural locations but is often one of the most important ecosystem services in the Global North (Gómez-Baggethun et al. 2013). The higher availability of natural areas in rural sites could explain the relative higher ratings when compared to urban areas, and it is possible that recreation might not be as important in relative terms as other ecosystem services for people of the Global South.

The lower satisfaction from ecosystem services for urban dwellers means, according to the Expectancy Disconfirmation Model (Oliver 1977), that expectations for ecosystem services benefits were not fully met. This could be due to a mismatch between the demand and the local supply of ecosystem services, as well as the inadequacy of alternatives. Thus, people's expectations for ecosystem services in urban areas of the Solomon Islands did not completely shift to the urban profile typical of wealthier cities, especially in their valuation of provisioning services. The fact that rural people were also not fully satisfied with the benefits received from ecosystem services could be the result of the relatively recent environmental and population changes that limit the availability and quality of ecosystem services. For example, logging by foreign companies was often mentioned to explain limitations in some provisioning services, as well as promoting soil erosion, and reducing water quality through run-off. In addition, population growth in villages also means that some people have to travel further to access their garden, to go fishing or harvest timber.

I found no significant differences between urban and rural dwellers related to the impacts that ecosystem disservices have on wellbeing. People in rural and urban areas felt negatively impacted by ecosystem disservices with a median rating of 'Very important' (with the

exception of dangerous plants and animals that had a median rating of 'Somewhat important'). Indeed, ecosystem disservices can have important negative impacts in cities, notably in health and economic terms, but also in rural areas, for example with exotic pests and diseases that affect agriculture (von Döhren and Haase 2015). Overall, the fact that urban dwellers in the Solomon Islands reported receiving less benefits from ecosystems but as many detrimental impacts as rural people indicates a degraded relationship with nature that is probably impacting their overall wellbeing.

4.4.2 A gradient of urbanization levels among sites

I observed large differences in ratings between sites for ecosystem service and disservice importance and ecosystem service satisfaction, pointing to a rural–urban gradient rather than a clear dichotomy. Differences between the two urban sites could potentially be explained in part by ecosystem service availability due to socioeconomic context. The capital Honiara is the largest city and economic hub of the Solomon Islands. Its physical expansion is limited by customary land ownership and is very densely populated (UN-Habitat 2012). In contrast, Noro has about a tenth of Honiara's population and most areas are less densely populated. Compared to Honiara, Noro has more garden space, forested areas, fishing grounds, cleaner rivers and oceans, and better air quality. As a result, satisfaction for all ecosystem service categories, as well as the importance of provisioning and cultural services, was significantly lower in Honiara than in Noro. Urban dwellers reported high negative impacts from ecosystem disservices. Both urban sites have experienced important natural disasters (cyclone, floods, and a tsunami in Noro). In addition, these towns have important ports, potential entry points for exotic pests and diseases. Urban dwellers might be less vulnerable to the crocodile or shark attacks feared in villages, but urban populations of wild dogs can be aggressive, and mosquitoes can transmit malaria and dengue.

The two villages studied also differed from one another, probably because of their environmental and economic contexts. Nusa Hope could be considered more rural than Tamboko, notably in terms of the presence of infrastructure and access to markets. Tamboko is connected by a road to Honiara, the largest market in the country, while Nusa Hope is a remote village accessible only by boat. The satisfaction for all ecosystem service categories was higher in Nusa Hope than in Tamboko. Tamboko was the site most affected by ecosystem

disservices. It experienced recent destructive flash floods, which were attributed by some to logging in the watershed. Gardens and plantations were also invaded by exotic pests, mainly the coconut beetle and African snail. In brief, ecosystem service availability and access in relation to population size, and distance to markets could be driving the urbanization gradient observed in ecosystem service valuation in the Solomon Islands.

4.4.3 Implications for the Solomon Islands

Since urbanization is a recent phenomenon in the Solomon Islands, I would expect urban–rural differences to become more rather than less pronounced in the future when compared to those that I found, as well as in societies that have been urbanized for a longer time (e.g., Martín-López et al. 2012). The differences between the two urban sites point in that direction. I cannot conclude that urban dwellers in the Solomon Islands have shifted their norms or baselines for nature because of ecosystem service importance ratings were still high and people were not satisfied with the current state of benefits and would have preferred benefiting more. It remains to be seen if further alienation of nature will happen in the future for urban populations, as has been reported in Westernized societies (Soga and Gaston 2018).

The Solomon Islands have one of the fastest population growth rates of all Pacific islands (SPC 2015), and an even greater urban growth rate (UN-Habitat 2012). Urbanization, together with population growth, climate change and sea level rise, resource exploitation, and pollution, has been identified as one of the main threats to already deteriorating marine, coral reef, and forest ecosystems (Toki et al. 2017). Thus, planning for more sustainable urban areas in the Solomon Islands that takes into account people's wellbeing should aim to maintain regulating services, provide access to some provisioning services that do not require extensive land areas (e.g., horticultural gardens), and offer opportunities for cultural services, while proposing adequate alternatives to some provisioning and regulating services.

4.4.4 Limitations and caveats

Importance and satisfaction ratings were both very high in urban and rural areas, and could result in part from the ecosystem service selection process in which we asked participants to choose the ecosystem services most important for their wellbeing. I kept the highest-ranking ecosystem services in both urban and rural contexts for the subsequent data collection.

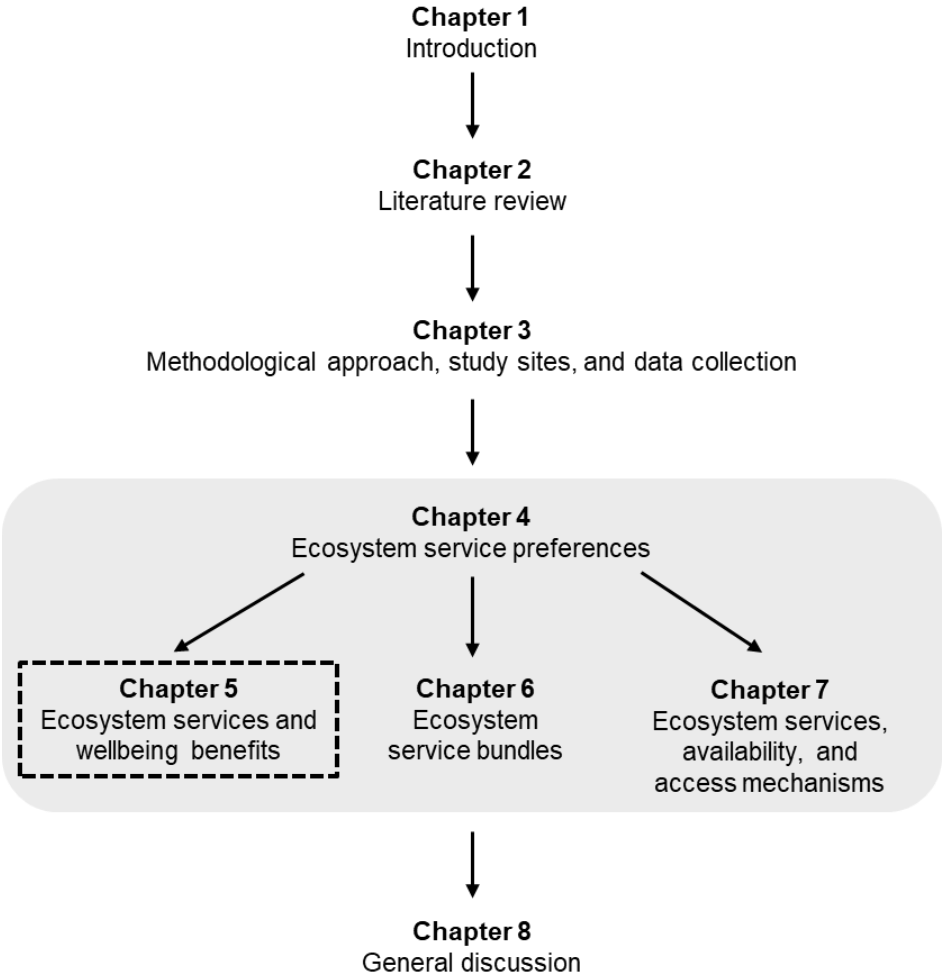
Furthermore, some urban respondents may not have been thinking of their current living environment (even if instructed to do so), but rather of their village when answering questions about nature. Many people in the Solomon Islands, including urban dwellers, are very attached to their rural roots and still call their family village home, even if they have been living away for a long time (McDougall 2017). As a result, ecosystem service importance and satisfaction ratings might have been overrated in urban areas. These biases were, however, not large enough to override the difference between urban and rural dwellers.

4.5 Conclusion

Urbanization has changed social-ecological systems extensively over time and will continue to do so in the future, especially in countries of the Global South where most of future urbanization will take place. However, the impact of urbanization on how people value ecosystems and their services is still poorly understood. I addressed this key research gap by comparing urban to rural dwellers' valuation of ecosystem services in the Solomon Islands. I have shown that urbanization did affect how people benefited from nature. More precisely, the perceived contribution of ecosystem services to wellbeing was reduced in urban areas compared to rural areas, and urban dwellers were not as satisfied with the benefits derived from ecosystem services. In addition, ecosystem disservices were not perceived to be lower in towns and cities compared to rural areas, although there were differences among the four study sites. My results show that nature's contributions to wellbeing are fewer in urban areas, and these lost benefits can probably not be fully replaced by currently available alternatives in this low-income country. In an era of urbanization, ecosystem service research must focus on ways to meet people's needs to improve their wellbeing, while addressing pressing environmental challenges.

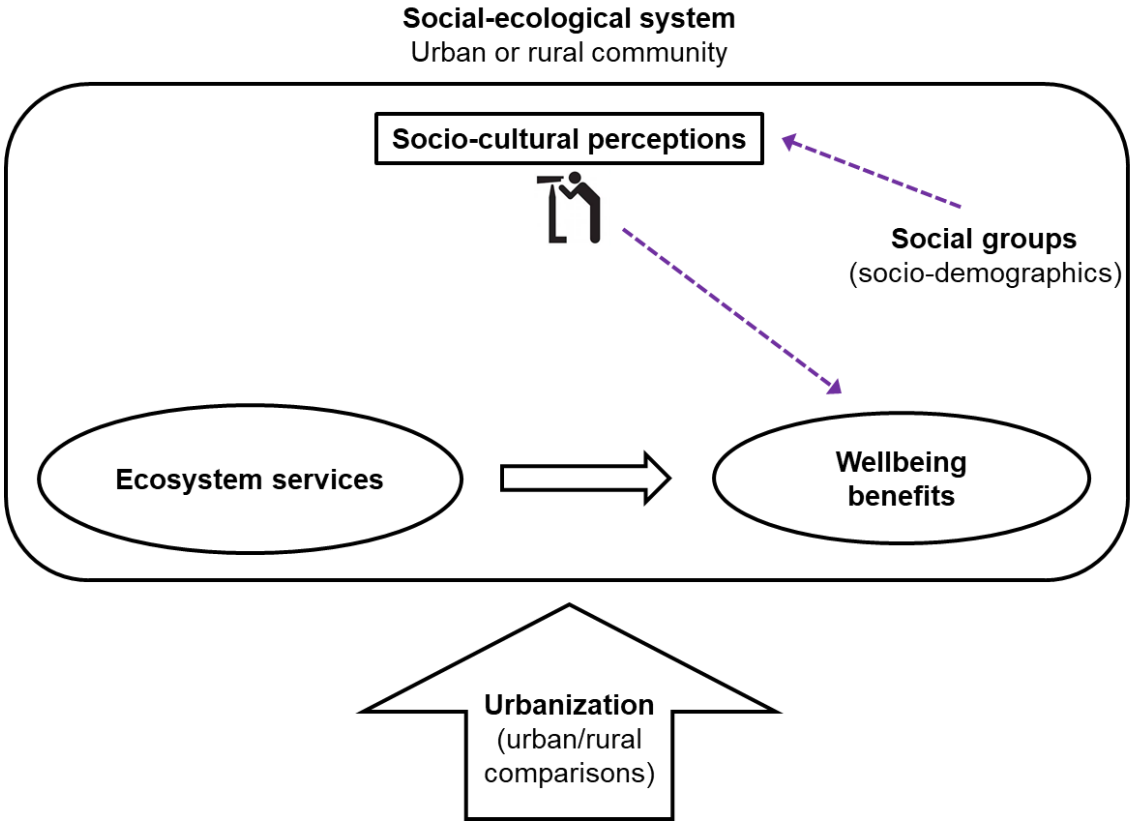
5. Ecosystem services and wellbeing benefits*

Following my examination of how ecosystem service preferences differ between urban and rural dwellers in the Solomon Islands (Chapter 4), in this chapter I investigate the implications for multidimensional wellbeing.



* Adapted from Lapointe M., Gurney G.G., Coulthard S., and Cumming G.S. (2021) Ecosystem services, wellbeing benefits, and urbanization associations in a Small Island Developing State. People and Nature

Contributions: I developed the research question, methodology, collected the data, performed the data analyses, and developed the figures and tables with the advice of G. Cumming and G. Gurney. I wrote the first draft of the paper which was revised with editorial input from G. Cumming, G. Gurney, and S. Coulthard.


Social-ecological system
Urban or rural community
Socio-cultural perceptions
Social groups
(socio-demographics)
Ecosystem services
Wellbeing
benefits
Urbanization
(urban/rural
comparisons)

Ecosystem services, wellbeing benefits, and urbanization associations in a Small Island Developing State

Abstract

Urbanization is a key driver of social and environmental change worldwide. However, our understanding of its impacts on the multidimensional wellbeing benefits that people obtain from ecosystems remains limited. I explored how the wellbeing contributions from land- and seascapes varied with urbanization level in the Solomon Islands, a fast-urbanizing Small Island Developing State. Drawing on the social wellbeing framework, I compared perceived wellbeing benefits derived from ecosystem services in paired urban and rural sites. My analysis of 200 semi-structured interviews revealed complex associations between provisioning, regulating, and cultural services and wellbeing benefits, with all ecosystem services contributing to material, relational, and subjective wellbeing dimensions. Although patterns of associations between ecosystem services and wellbeing benefits were similar between urban and rural dwellers, urban dwellers reported significantly fewer material, relational, and subjective wellbeing benefits. The most important differences between urban and rural dwellers were in terms of meeting basic material needs (e.g., income and material comfort), feeling connected to nature, and feeling happy and satisfied. With urbanization, livelihood activities transition from being subsistence-based to income generating, which is also associated with increased wealth in urban areas. Similarly to the relationship between ecosystem service wellbeing benefits and urbanization, material wealth was negatively associated with perceptions of wellbeing benefits. People with less material wealth appeared more reliant on nature for their multidimensional wellbeing. My findings demonstrate that the altered human-nature relationships in urban areas are associated with decreases in multidimensional wellbeing that people derive from nature. Improving access to particular ecosystem services, which make clear contributions to multidimensional wellbeing, could be a focus for urban planners and environmental management where enhanced human-nature relationships and poverty alleviation are central goals.

5.1 Introduction

Urbanization transforms rural and natural environments to highly built urban environments, which results in a decrease in the supply of several local ecosystem services (Seto et al. 2017, United Nations 2019). In the process, people's livelihoods transition from a direct reliance on nature, through agriculture or fisheries for example, to a more indirect one, through employment in the industrial or service sectors of the economy (Cumming et al. 2014). Cities contribute to improving human wellbeing by offering employment opportunities and access to social and non-ecosystem services such as education, waste disposal, and health care (United Nations 2019). However, living mostly disconnected from nature, in predominantly human-made environments that often experience air and water pollution, can be detrimental for urban dwellers' physical and psychological health (e.g., Harlan and Ruddell 2011, Hartig and Kahn 2016). Now that more than half of the world's population lives in cities, it is timely to understand better how living in cities and urbanization affect the wellbeing benefits that people derive from nature, especially in the Global South where most future urbanization will occur (United Nations 2019).

Since the mid-20th century, rapid urbanization, population growth, and industrialization have been associated with increased human wellbeing according to various indicators (e.g., DGP, health, literacy rates), but also extensive environmental degradation (MA 2005a). The fact that human wellbeing could increase while environmental quality had been deteriorating has been referred to as the Environmentalist's Paradox (Raudsepp-Hearne et al. 2010b). In fact, because humans depend on nature, as shown notably by the ecosystem service or Nature's Contributions to People (Pascual et al. 2017) approaches, it seems paradoxical that trends in human wellbeing and natural capital could be decoupled.

Three interlinked knowledge gaps in ecosystem service research might obscure the relationships between environmental change and wellbeing. First, unidimensional indicators such as monetary-based values do not address multiple dimensions of wellbeing that could be affected by environmental change (Agarwala et al. 2014, Daw et al. 2016). In fact, the need to employ a multi-dimensional human wellbeing lens to measure social progress or development rather than relying on reductionist economic measures (e.g., GDP) is increasingly recognised (e.g., Stiglitz et al. 2009, Costanza et al. 2014). Multi-dimensional wellbeing assessments

should include both objective and subjective components, as well as indicators covering aspects such as wealth, health, and education, but also security, social relationships, life satisfaction, and ecosystems' quality (Stiglitz et al. 2009).

Second, while ecosystem services are defined as "the contributions that ecosystems make to human wellbeing" (Haines-Young and Potschin 2018), most ecosystem service research since the ground-breaking Millennium Ecosystem Assessment (MA 2005a) has focused on the ecosystem-side of the equation and assumed that ecosystem services provided wellbeing benefits to people (Daw et al. 2016). Moreover, research on the relationships between ecosystem services and wellbeing has focused especially on provisioning services, consequently, the contributions of regulating and cultural services to multidimensional wellbeing are poorly understood (Bennett et al. 2015, Guerry et al. 2015, Daw et al. 2016).

Third, most studies have used aggregate measures of wellbeing benefits derived from ecosystem services, which hinders assessment of whether impacts of environmental change can differ between people within a society, creating winners and losers of environmental change (Daw et al. 2011, Fisher et al. 2013). This information is relevant to manage the environment equitably in the perspective of maintaining or improving the wellbeing of different social groups (Coulthard et al. 2011, Daw et al. 2011, Gurney et al. 2015). Disaggregated analyses might be especially relevant in urban areas where social inequalities can be high (e.g., Smets and Salman 2008, Østby 2016).

Wellbeing research is represented by a diversity of theoretical frameworks and is considered to have reached a certain maturity in its conceptualization (Adler and Seligman 2016). The contributions of ecosystems and their services to human wellbeing was first demonstrated by the pioneer work of the MA, which also proposed a framework to study the association of ecosystem services to five components of wellbeing: material needs, health, social relations, security, and freedom of choice and action (MA 2005a). The use of wellbeing within the MA framework has helped to promote understanding of how ecosystem services relate to multiple dimensions of wellbeing, and has stimulated the adoption of multi-dimensional assessment of human-environment relationships (see for example the Ecosystem Services for Poverty Alleviation programme, ESPA 2018). Nevertheless, the MA framework has also been

criticized for being insufficiently complete to fully address wellbeing, notably because of its aggregated scale (Summers et al. 2012, Lele 2013). To deepen the understanding of wellbeing provided by the MA, the social wellbeing framework (Gough and McGregor 2007) is gaining traction, and has been applied to investigate the relationship between ecosystem services and wellbeing (Agarwala et al. 2014, King et al. 2014, Chaigneau et al. 2019). According to this framework, wellbeing can be conceptualised and measured in three dimensions: a material dimension addressing income, health and education for example; a relational dimension including relationships that influence what can be achieved with given components of the material dimension; and a subjective dimension relating to a person's evaluation of their own wellbeing (McGregor 2007). All three dimensions must be taken into account to provide a complete understanding of a person's wellbeing in the social context in which they live (McGregor 2007).

Research on wellbeing benefits derived from urban ecosystem services has focused mainly on urban green areas in the Global North and regulating (e.g., air and water quality) and cultural services (mainly recreation) (e.g., Harlan and Ruddell 2011, Coutts and Hahn 2015) having positive impacts on physical and mental health (Coutts and Hahn 2015, Bratman et al. 2019). Conversely, environmental degradation and the lack of nature exposure in cities has been shown to impact health negatively (Harlan and Ruddell 2011, Cox et al. 2018). A few comparative case studies of urban versus rural communities have addressed differences in ecosystem services and wellbeing (Aguado et al. 2018, Song et al. 2018, Yang et al. 2019), which could help to shed light on the effect of urbanization on the wellbeing benefits derived from ecosystem services. However, these studies either assessed wellbeing independently of ecosystem services (Aguado et al. 2018, Yang et al. 2019) or assumed that ecosystem services produced certain wellbeing benefits without measuring them (Song et al. 2018). Therefore, the contributions of ecosystems services to multi-dimensional wellbeing in relation to urbanization and living in cities remain unclear.

To explore how urbanization and living in cities is associated with people's perceptions of multidimensional wellbeing benefits derived from provisioning, regulating, and cultural ecosystem services, I compared two paired urban and rural sites in a Small Island Developing State. I used the social wellbeing framework to investigate locally relevant wellbeing benefits

derived from ecosystem services (Gough and McGregor 2007, Coulthard et al. 2014). I selected the Solomon Islands because of their rapid urban population growth (4.7% annually, UN-Habitat 2012) and because Solomon Islanders' wellbeing is highly dependent on ecosystems (Coulthard et al. 2017, McCarter et al. 2018). Furthermore, coastal and island ecosystems have received less research attention in studies related to ecosystem services and poverty (Suich et al. 2015). I focused on four questions: (1) How do Solomon Islanders in urban and rural areas conceive wellbeing?; (2) How do ecosystem services contribute to the wellbeing of Solomon Islanders?; (3) How do the wellbeing benefits derived from ecosystem services differ between urban and rural dwellers?; and (4) How are socio-demographic characteristics associated with perceived wellbeing benefits derived from ecosystem services? Furthermore, for question (3), I tested the hypothesis that urban dwellers would report benefiting less from provisioning, regulating, and cultural services than rural dwellers because of the disconnect between people and nature caused by environmental and lifestyle changes associated with urbanization. Alternatively, living in an urban environment might not influence perceived benefits derived from nature or urban dwellers could perceive even more benefits (perhaps due to higher levels of formal education).

5.2 Methods

5.2.1 Study sites and sampling design

I used mixed methods to investigate the relationship between ecosystem services and wellbeing. The goal of the qualitative component was to understand which wellbeing aspects were considered important in each community. The research assistants and I held eight focus group discussions: one with men and one with women in each of the four sites. Participants in villages were mostly suggested by the village leaders. In urban locations, we recruited people in public areas. Discussions were held in churches or in community halls.

For the quantitative component, the research assistants conducted 50 semi-structured interviews in each of the four sites to assess the relationship between ecosystem services and wellbeing benefits (N=200). Respondents were selected using systematic random sampling, whereby every second household was selected. We interviewed only one person per household, preferentially the head of the household (this includes the head's spouse if the

head was male). We maintained a gender balance in each site (respondents were 49% male and 51% female) and we collected other key socio-demographic characteristics that were likely to be related to perceptions of ecosystem services and their benefits (Table 5.1).

5.2.2 Wellbeing benefits identification

To identify the important wellbeing elements in each study site, we asked focus group discussion participants to describe someone who was doing well in their community and someone who was not (e.g., Coulthard et al. 2015). Then, to assess the relationship of wellbeing elements and ecosystem services, we asked household interview participants to describe in open-ended questions all the ways each ecosystem service contributed to their household's wellbeing. I analysed the answers written in full from 50 pilot interviews to identify the main wellbeing benefits reported according to the social wellbeing framework (White 2008). In the final interviews, the research assistants classified answers into these pre-determined categories (Table D.1). Wellbeing benefits that represented less than 1% of potential answers or that were reported by 5% or less people per ecosystem service were removed from the analyses.

Table 5.1 Socio-demographic characteristics elicited in household interviews.

Variable	Justification	Description	Variable type
Age	Related to differences in ecosystem service valuation (e.g., Maestre-Andrés et al. 2016) and between urban and rural areas (e.g., Martín-López et al. 2012).	Recorded in years.	Continuous
Education level	Related to differences in ecosystem service valuation (Aguado et al. 2018) and between urban and rural areas (e.g., Martín-López et al. 2012).	Level of formal education: 1) None to elementary; 2) junior secondary and professional, e.g., carpentry; 3) senior secondary; and 4) tertiary.	Ordinal (4 levels)
Main livelihood	An indicator of occupation and reliance on provisioning services associated with differences in ecosystem service valuation (Plieninger et al. 2013, Paudyal et al. 2015).	1) Food production; 2) Food production and home production to generate income; 3) Food production and paid work; 4) Wages are most important, but some food production; 5) Wages only.	Categorical (5 categories)
Material style of life (MSL)	An indicator of wealth. Wealth is related to differences in ecosystem service valuation (Dawson and Martin 2015, Horcea-Milcu et al. 2016).	A material assets index constructed using a principal components analysis (Table D.2).	Continuous

Time living in the community	Urban areas are destinations for migrants (United Nations 2019).	Number of years living in the community divided by the person's age.	Continuous

5.2.3 Statistical analyses

Urban-rural comparisons

To test my hypothesis that urban dwellers would report fewer wellbeing benefits associated with ecosystem services than rural dwellers, I used generalized linear mixed models for each of the 15 wellbeing benefits. These models were fitted with a binomial distribution (presence-absence of each benefit) with the *lme4* package (Bates et al. 2019). The response variable was the presence of a wellbeing benefit per household (see Table D.3 for model descriptions). Urbanization level (urban versus rural), ecosystem services, and the interaction between the two variables were the fixed effects. In all cases, I added household as random factor to control for the non-independence of multiple responses per respondent. I did not include the study site in the random structure because it has only four levels; I would have included it as a fixed effect, but it was not possible in this case because each site is nested within an urbanization level. I tested whether the fixed effects contributed significantly to the models with an analysis of deviance using the *Anova* function of the *car* package (Fox et al. 2019). In the case of a significant interaction between urbanization level and ecosystem services, I performed post-hoc multiple comparisons with the *emmeans* package (Lenth et al. 2019) with a Tukey correction for multiple testing. Assumptions of dispersion, linearity, and uniformity of the residuals were tested with the *Dharma* package (Hartig 2019).

Disaggregation by socio-demographic characteristics

To understand how socio-demographic characteristics were related to differences in perceptions of wellbeing benefits derived from ecosystem services and their association with urbanization level, I first investigated how the different socio-demographic characteristics measured differed between urban and rural areas with Chi2 or Student-t tests. I then assessed the association of the different socio-demographic characteristics among themselves and with urbanization using either Pearson's correlation coefficient, multiple correlation coefficient, or Cramer's V depending on the type of variable (i.e., numeric or categorical). Finally, I used generalized linear mixed models for each of the 15 wellbeing benefits as above, but replacing urbanization level by socio-demographic characteristics (see Table D.4 for model

descriptions). Again, I could not include the study site as a fixed effect because it was strongly associated to MSL and moderately associated with both livelihood and time living in the community (0.75, 0.51, 0.54, respectively; Figure D.1). Because MSL and livelihood activities were moderately associated (0.66; Figure D.1), I analysed them separately. All of the remaining socio-demographic characteristics were checked form multicollinearity using variance inflation factors. All analyses were undertaken in R (R Core Team 2019).

5.3 Results

5.3.1 Important wellbeing elements in the study sites

When asked to describe people in the community who were doing well and those who were not, several elements of wellbeing were identified in the focus groups undertaken with men and women at all of the study sites (Table 5.2). I classified wellbeing elements in the three dimensions of the social wellbeing framework, although some elements could have belonged to more than one dimension. In fact, the social wellbeing framework acknowledges that the three dimensions are related and overlap; the interpretation of a given wellbeing element therefore depends on how it affects a person (White 2010). I classified elements that could belong to different wellbeing dimensions into the one that appeared to capture the principal signifier of the wellbeing element. In the material dimension, these elements were meeting basic household material needs and providing for children, having income generating activities, good food, and a home. In the relational dimension, the most universally recognized elements were participating in community activities as well as sharing and helping others. Rules and religion were mentioned in seven of the eight focus group discussions. In relation to the subjective dimension of wellbeing, being happy and satisfied with life was also mentioned in seven of the eight discussions.

Other aspects were perceived differently among urbanization levels and/or study sites. The importance of education was only mentioned in urban areas. The importance of fishing and gardening was mainly mentioned in rural sites (and in Noro town by men). The importance of the natural environment was not directly mentioned, although four groups mentioned the importance of maintaining clean surroundings (mostly in urban settings).

Table 5.2 Important wellbeing elements derived from focus groups discussions (FGD, N=8) conducted in urban and rural study sites. The benefits presented were mentioned by at least 50% of the focus groups.

Wellbeing dimensions	Wellbeing elements	Number of FGD mentions		
		Urban	Rural	Total
Material	Meeting household material needs (e.g., school fees, clothing, transportation)	4	4	8
	Income generating activities	4	4	8
	Fishing and gardening activities	3	4	7
	Good and permanent house	4	3	7
	Education	4	0	4
	Health	2	2	4
Relational	Participating in community activities	4	4	8
	Helping others and sharing	4	4	8
	Following laws, religion, traditions	4	3	7
	Being kind to people	3	2	5
	Caring for the land and surroundings	3	1	4
Subjective	Satisfaction and happiness	4	3	7
	Being hard working	3	3	6
	Being humble	4	1	5
	Having life objectives	2	2	4

5.3.2 Association between ecosystem services and wellbeing benefits

In the household interviews, each ecosystem service was associated with multiple wellbeing benefits and *vice-versa* (Figure 5.1). For example, health benefits were more or less strongly associated with all ecosystem services. Stewardship was the ecosystem service with the most different benefits associated with it; and clean air, the least. The most widely recognized wellbeing benefits were, in order of importance, nutrition, health, material comfort, income and feeling happy. Education was the least mentioned of the main 15 benefits kept in the analyses.

5.3.3 Urban and rural comparisons of wellbeing benefits derived from ecosystem services

I predicted that urban dwellers would derive fewer wellbeing benefits from ecosystem services than rural dwellers. Overall, the patterns of associations between the different wellbeing benefits and ecosystem services were similar between urban and rural dwellers (Figure 5.2). However, for 11 of the 15 wellbeing benefits, across all dimensions of wellbeing, significantly fewer urban than rural dwellers reported deriving wellbeing benefits from at least one ecosystem service (Figure 5.2). Furthermore, some urban dwellers reported not benefiting at all from certain ecosystem services (7% for food, 14% for firewood, 10% for

material, 5% for clean air, and 10% for culture). Therefore, I rejected the null hypothesis of no differences in the perceived benefits that urban and rural dwellers derive from ecosystem services.

For the material wellbeing dimension, most differences between urban and rural dwellers were found in nutrition, health, income, and material comfort benefits. For example, 70% of rural dwellers compared to 52% of urban dwellers associated health benefits to materials such as medicinal plants. Moreover, in terms of income, 86% of households in rural areas derived income from food (by selling mainly fresh root crops, vegetables, and fruits) and 66% from firewood, whereas it was about half that number (44% and 32%, respectively) in urban areas.

For relational wellbeing benefits, most differences were encountered for connection to nature and traditional knowledge. For example, 46% people in rural areas associated the ecosystem service recreation to feeling connected to nature compared to 30% in urban areas. Clean air also mediated the feeling of connectedness to nature for 24% of rural dwellers, but only 6% of urban dwellers. Traditional knowledge was associated mainly with the ecosystem service culture for 81% of rural dwellers and 67% of urban dwellers.

Finally, within the subjective wellbeing dimension, feeling happy was reported significantly less by urban than rural dwellers for all ecosystem services with the exception of stewardship. Feeling happy was mostly associated with recreation in nature for 83% of rural dwellers and 66% of urban dwellers. Having access to clean air also brought happiness to 66% of rural dwellers, but only 38% of urban dwellers.

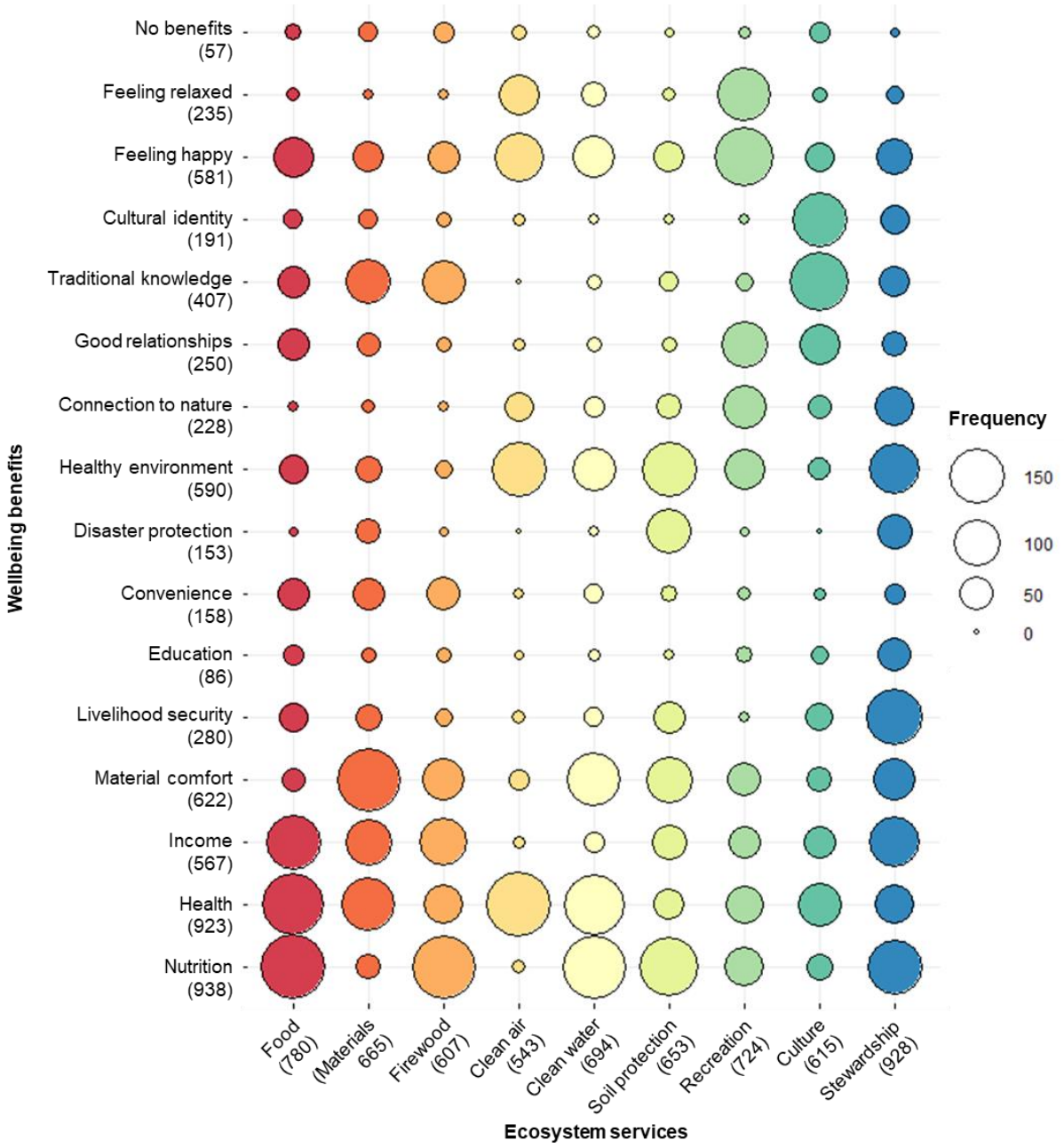


Figure 5.1 Bubble plot illustrating the frequency of wellbeing benefits associated with ecosystem services for both rural and urban dwellers.

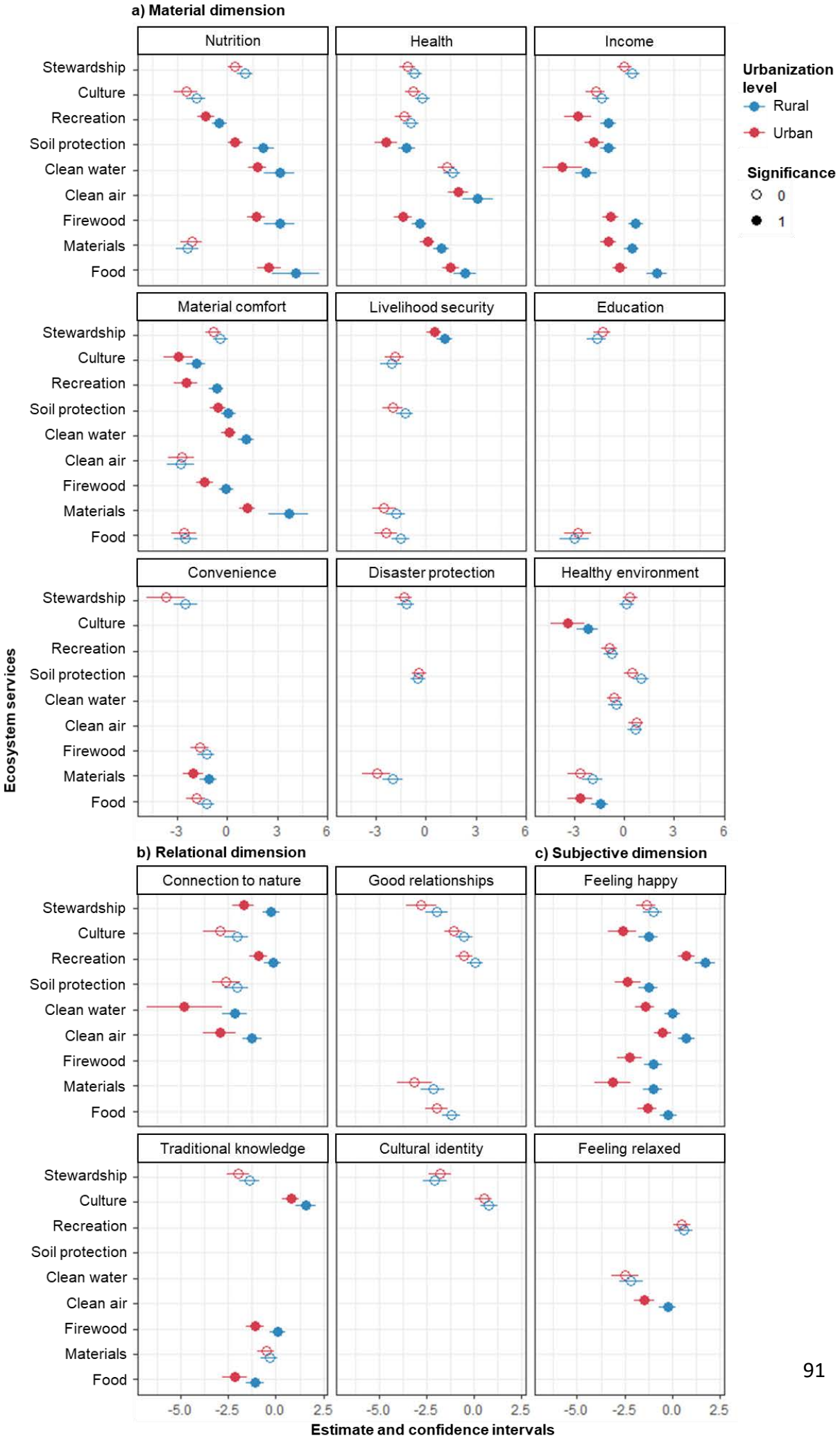

a) Material dimension
Nutrition
Health
Income
Material comfort
Livelihood security
Education
Convenience
Disaster protection
Healthy environment
b) Relational dimension
Connection to nature
Good relationships
c) Subjective dimension
Feeling happy
Traditional knowledge
Cultural identity
Feeling relaxed
Stewardship
Culture
Recreation
Soil protection
Clean water
Clean air
Firewood
Materials
Food
Ecosystem services
-3
0
3
6
-5.0
-2.5
0.0
2.5
Estimate and confidence intervals
Urbanization level
Rural
Urban
Significance
0
1

Figure 5.2 Comparison between urban (in red) and rural dwellers (in blue) of the probability of identifying a wellbeing benefit obtained from a logistic regression according to urbanization level, ecosystem services, and wellbeing benefits. For a) material, b) relational, and c) subjective wellbeing dimensions. Full circles indicate a significant difference between urban and rural dwellers (P ≤ 0.05).

5.3.4 Disaggregation of wellbeing benefits reported per socio-demographic characteristics

Respondents from urban and rural areas differed in terms of age, education level, main livelihood activities, time living in community, and wealth (Table 5.3). Compared to the average urban dweller, the average rural dweller was older, had been living for a longer time on average in the study site, had fewer material assets, and had lower educational attainment (fewer senior secondary and tertiary levels). Livelihoods were more based on cash economy in urban areas and on home production in rural areas. Livelihoods and wealth were strongly associated with urbanization level, and between themselves (Figure D.1).

The logistic regression relating wellbeing benefits to socio-demographic characteristics (but without urbanization level; Figure 5.3) revealed that the reported benefits varied mainly according to wealth. In fact, wealth was associated with lower probabilities of identifying benefits derived from ecosystem services for 12 of the 15 wellbeing benefits. Similarly, as livelihoods transition from subsistence-based to wages, the probabilities of reporting wellbeing benefits derived from ecosystem services decreased for eight of the 15 benefits (Figure D.2). In the case of the other socio-demographic characteristics, education varied significantly for four wellbeing benefits, age and time living in the community for two benefits, and gender for one benefit.

Table 5.3 Comparison of socio-demographic characteristics between urban and rural dwellers.

Sociodemographic characteristics		Urban and rural comparison				
		Urbanization level		Test statistic	df	p-value
Variable	Category	Urban	Rural			
Age (years)	Mean	36.4	44.1	t = 3.9419	188.75	0.0001
	SD[c]	12.1	15.2			
Education level[a]	1	26%	50%	X^2=20.968	3	0.0001
	2	17%	24%			
	3	32%	12%			
	4	25%	14%			
Main livelihood[b]	1	0%	8%	X^2 =147.35	4	<0.0001
	2	0%	45%			
	3	3%	35%			
	4	78%	12%			
	5	19%	0%			
Time living in the community (years)	Mean	14.0	34.3	t =8.7524	160.68	<0.0001
	SD	11.9	20.0			
Material style of life (MSL)	Mean	0.73	-0.73	t =-15.269	161.15	<0.0001
	SD	0.83	0.49			

[a](1) None to elementary; (2) Junior secondary and professional; (3) Senior secondary; (4) Tertiary.

[b](1) Food production; (2) Food production and home production to generate income; (3) Food production and wages; (4) Wages are most important, but some food production; (5) Wages only.

[c] SD = Standard deviation

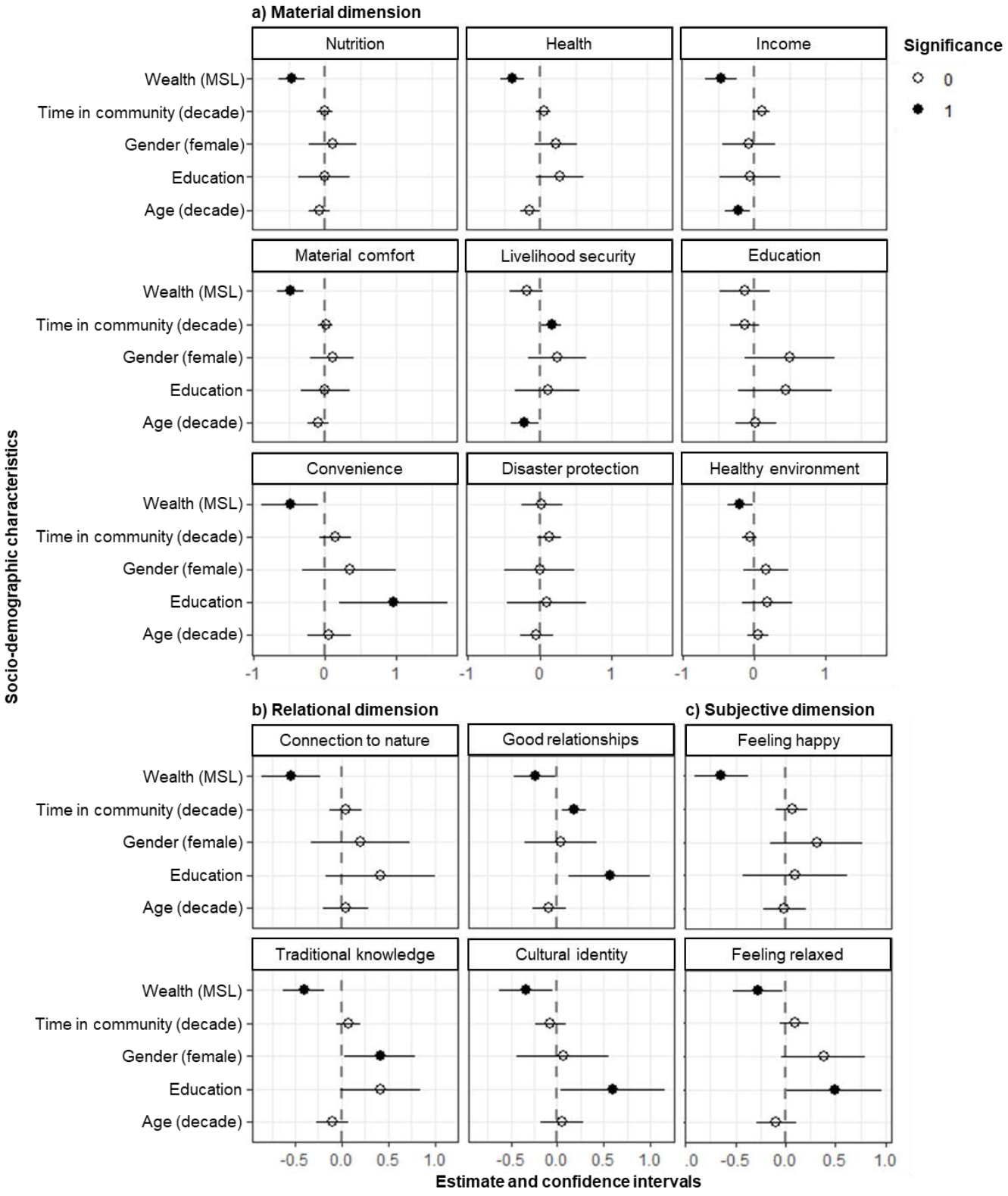


Figure 5.3 Probability of identifying a wellbeing benefit obtained from a logistic regression according to socio-demographic characteristics, the type of ecosystem service (not shown on the graph), and wellbeing benefits for a) material, b) relational, and c) subjective dimensions of wellbeing. Full circles indicate a significant effect of socio-demographic characteristics ($P \leq 0.05$).

5.4 Discussion

People in both urban and rural areas of the Solomon Islands mentioned wellbeing elements pertaining to all dimensions of the social wellbeing framework when stating what was important to live well in their community. I found that each ecosystem service contributed to several of these wellbeing elements, especially to the material dimension. My results demonstrate that, although ecosystem services contributed to urban and rural dwellers' wellbeing in similar ways, urban dwellers reported fewer wellbeing benefits derived from ecosystem services compared to rural dwellers, which supports my hypothesis. In other words, increased urbanization was associated to decreased nature's contributions to multidimensional human wellbeing in the Solomon Islands. Furthermore, I found that increased material wealth and, to a lower degree, livelihood activities mainly based on wages rather than food production were also associated with lower probabilities of identifying wellbeing benefits derived from ecosystem services. Associations between urbanization and wealth and livelihood activities suggest potential mechanisms by which urbanization affects the wellbeing derived from nature.

5.4.1 Important aspects of wellbeing in the Solomon Islands

Several of the locally relevant wellbeing elements identified in the focus group discussions were shared among study sites and genders. In all communities, people mentioned wellbeing elements from the three wellbeing dimensions. First, for the material dimension, basic material needs such as good food, income, and shelter, were identified by men and women in urban and rural areas. Other material benefits, such as health, were not identified in all groups; and education was mentioned only in urban areas, maybe because of the limited access in rural areas. Second, relational wellbeing benefits arise from the relationship between people, society (White 2010), and in this case, nature. They include aspects such as social relations, culture, institutions, and identity. This dimension of customary obligations is very important in Melanesian cultures (e.g., Malvatumauri National Council of Chiefs 2012, Coulthard et al. 2017, Lau et al. 2020), and community participation and sharing were mentioned by all focus groups. Third, with respect to the subjective wellbeing dimension, which also incorporates a person's values (Coulthard et al. 2017), focus group participants identified life satisfaction and happiness, but also desirable personality attributes or attitudes such as being hard working and humble.

The wellbeing elements reported here are similar to those identified in other studies of wellbeing in the Global South (Abunge et al. 2013, Dawson and Martin 2015, Beauchamp et al. 2018). For example, the importance of community and sharing with others appears in all studies. There were some unique elements in the conceptualization of wellbeing in the Solomon Islands, for example in the importance of certain personal attributes (e.g., being hard working and being nice to people). Furthermore, self-determination elements such as 'freedom of action and choices' identified in the MA were rarely mentioned in the discussions. This wellbeing constituent might depend on the fulfilment of other wellbeing elements, as portrayed in the MA, such as health, education or income, which may be harder to achieve in the Solomon Islands context.

5.4.2 Ecosystem service contributions to multidimensional wellbeing

The patterns of association between ecosystem services and wellbeing benefits that I found were complex; all ecosystem services contributed to each of the three wellbeing dimensions. First, material wellbeing benefits derived from ecosystem services were most often identified, illustrating the importance of nature to meet basic needs (e.g., nutrition, health, and shelter). Material benefits were derived mainly from provisioning and regulating services. In addition, I found that benefits associated with nature stewardship, which give insights into why people want to conserve nature, were also strongly related to the material dimension. My results align with previous research conducted in countries of the Global South that shows the importance of ecosystem services, especially provisioning services, to meet basic material needs (e.g., Suich et al. 2015).

Second, I found that relational benefits were mainly derived from cultural, but also provisioning and regulating services. Good relationships were mediated through recreation as well as through culture that guides social behaviour, for example in relation to taboo places. Furthermore, the sharing of food (and of money derived from food production) is essential to fulfil customary obligations in the Solomon Islands (Martin 2007). Traditional knowledge was not only related to cultural services, but also to all provisioning services that represent traditional practices such as gardening and cooking with firewood. Therefore, my approach linking ecosystem services to wellbeing benefits allowed me to highlight how culture

permeates ecosystem services that are not classified as cultural; addressing a limitation of the ecosystem service approach reported in previous studies in which cultural services appeared undervalued (Dawson and Martin 2015, Lau et al. 2019).

Third, while my evaluation of wellbeing benefits was subjective (given it was based on perception data), some benefits were especially related to how a person felt emotionally and were therefore classified as subjective (e.g., feeling happy and satisfied, and feeling relaxed and stress-free). To my knowledge, this wellbeing dimension has been little studied in ecosystem service research (although, see Britton and Coulthard 2013, Coulthard et al. 2017).

While the MA distinguished wellbeing benefits from the ecosystem services providing them, a distinction that is also present in the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES, Díaz et al. 2015), most research has focused on ecosystem service valuation without addressing human wellbeing impacts. These studies have focused on ecosystem service stocks, using unidimensional wellbeing indicators such as money, or conflating ecosystem services and wellbeing benefits (Bennett et al. 2015, Daw et al. 2016). My findings reflect to a great extent the results from the MA (2005), obtained on a large, aggregated scale, in how the different categories of ecosystem services contribute to multiple dimensions or constituents of wellbeing. However, the social wellbeing framework helped me identify additional relationships between ecosystem services and wellbeing, in the subjective and relational dimensions. I found that feeling of happiness in the subjective well-being dimension, which could not be covered by the MA (2005) because of its scale of analysis, was among the five most cited benefits and associated with provisioning, regulating and cultural services. Lastly, the social wellbeing framework appears to be especially relevant to consider these relational values of nature that depart from the intrinsic/instrumental divide and that are now thought to be key in valuing nature (Chan et al. 2016).

5.4.3 Urban and rural comparisons in wellbeing benefits derived from ecosystem services

Urban and rural dwellers associated similar wellbeing benefits to ecosystem services. However, significantly fewer urban dwellers derived benefits from 11 of the 15 benefits spanning all wellbeing dimensions. Therefore, increased urbanization was associated with decreased nature's contributions to multidimensional human wellbeing in the Solomon

Islands. The most important differences were in terms of meeting basic material needs (e.g., income and material comfort), feeling connected to nature, and feeling happy and satisfied; these wellbeing benefits were reported respectively 54%, 66%, 43%, and 54% less in urban compared to rural areas. Apart from connection to nature, basic material needs and feeling happy were identified as universally important wellbeing elements in the Solomon Islands.

The decreased contributions of ecosystem services to material wellbeing in urban areas might be at least partially replaced by non-ecosystem services in the Solomon Islands. For example, urban areas offer options to purchase both fresh and processed food, employment opportunities, health care services, although they are often inadequate or too costly to be equitably accessed in the Solomon Islands (Mecartney and Connell 2017).

In contrast to material wellbeing benefits, the relational wellbeing benefit, connectedness to nature, cannot be substituted as easily by non-ecosystem service alternatives, and might have detrimental impacts on overall wellbeing and pro-environmental behaviour. In fact, connectedness to nature has been shown to be associated to psychological and physical health benefits in the Global North (Russell et al. 2013, Zelenski and Nisbet 2014, Shanahan et al. 2016). In addition, feeling connected to nature predicts pro-environmental behaviour (Zylstra et al. 2014).

Feeling happy and satisfied emerged as one of the main wellbeing benefits related to ecosystem services, but was mentioned 46% less in urban than in rural areas. Interestingly, overall individual subjective wellbeing was also higher in rural than in urban areas: rural dwellers stating being satisfied or very satisfied with their life more than urban dwellers (82% and 56%, respectively). Similarly, a study conducted in the neighbouring country of Vanuatu reported that rural people had higher subjective wellbeing levels than urban dwellers (Malvatumauri National Council of Chiefs 2012). The lower subjective wellbeing of urban dwellers could be due in part to the decreased satisfaction derived from nature, but also to decreases in other ecosystem service benefits associated to all wellbeing dimensions. For example, happiness in Melanesia has been shown to be linked to residing on customary land with which people have strong cultural ties and derive their livelihoods (Feeny et al. 2014). Furthermore, the link between mental health benefits and spending time in nature is also well

known (Bratman et al. 2019). However, I cannot attribute the lower subjective wellbeing in urban areas solely to transformed human-nature relationships. For example, social fabric, among other things, could also impact wellbeing, considering the importance of community in Melanesian conception of wellbeing, as well as shifting baselines in wellbeing conceptualisation. Finally, by showing a decrease in all dimensions of wellbeing derived from nature in urban areas, my results might provide some evidence that the Environmentalist's Paradox (Raudsepp-Hearne et al. 2010a) stems in part from the narrow definition of wellbeing in large scale, aggregated analyses focusing on the material dimension of wellbeing.

5.4.4 Disaggregation of wellbeing benefits reported per socio-demographic characteristics

Among the socio-demographic characteristics considered, I found the strongest associations between material wealth and livelihood activities and perceived wellbeing benefits derived from ecosystem services. With urbanization, livelihood activities transitioned from being subsistence-based to income generating, which is also associated with increased wealth in urban areas. Other socio-demographic characteristics (age, education, and time living in the community), which also differed between urban and rural dwellers, did not have significant associations with most wellbeing benefits derived from ecosystem services in the Solomon Islands. As wealth increased, I found a significant decrease in reports of most material wellbeing benefits, such as nutrition, health, and income, and all relational and subjective benefits. My findings show that poorer people appear to depend on ecosystem services for their wellbeing more than their wealthier counterparts, in accordance to the literature (Suich et al. 2015). The patterns observed for wealth and livelihood activities were similar to that related to urbanization. Although I suspect that changes in wealth and livelihood activities could be partly responsible for the patterns of association between urbanization and ecosystem service benefits, I cannot infer causality from my data.

Although the reliance on ecosystem services for the rural poor has been demonstrated, there is a lack of research on the importance of ecosystem services on the urban poor (Suich et al. 2015). I can speculate that, in terms of material wellbeing in the Solomon Islands, people with less material wealth might face more challenges in meeting their basic material needs in cities, as alternatives to ecosystem services benefits for nutrition and health require money to be accessed. Decreases in relational wellbeing benefits from ecosystem services might also be

more detrimental to poorer urban dwellers. For example, good social relations are an essential wellbeing component in the Solomon Islands and the decreased contribution of ecosystem services to maintain these relationships for urban households could stem in part from an insufficient food production (and derived income) combined with a lack of paid employment and high costs of living in urban areas. While richer people can rely on other sources of income, these conditions can prevent poorer urban households from meeting social obligations of everyday sharing and reciprocity, and contributing to cultural traditions of Melanesia (e.g., associated with marriages and deaths; Maggio 2017). In times of hardship, people facing scarcity in cities can even become reliant on their village relatives, what has been called 'reverse remittance' (Lindstrom and Jourdan 2017, Rio 2017). Thus, the decreased benefits from provisioning services in urban contexts not only impact material, but also relational wellbeing. My findings show the importance of considering potential trade-offs between wellbeing benefits provided by ecosystem services as experienced by different social groups (Daw et al. 2011), in addition to trade-offs between ecosystem services (Howe et al. 2014, Lee and Lautenbach 2016).

5.4.5 Limitations and caveats

The main limitation of my study is that the wellbeing benefits that I measured were not weighted according to their relative contribution to overall wellbeing. Therefore, I do not know their cumulative impacts on overall wellbeing. Furthermore, as pointed out by Abunge et al. (2013), by asking an open question to identify wellbeing benefits, some potentially important benefits might have been omitted because these were not thought about during the interviews and focus group discussions. Abunge and colleagues (2013) therefore warn against over-interpreting absent or infrequent wellbeing benefits. Finally, I used frameworks for ecosystem services and wellbeing that were developed in the Global North. While I tried to adapt these to the Solomon Islands context, worldviews of wellbeing and nature held by Solomon Islanders are likely to be different. For example, collective wellbeing that is very important in Melanesian societies was not investigated here (Malvatumauri National Council of Chiefs, 2012). Further, western notions of human apart from nature (i.e. nature-culture dualism) are at odds with the relational value of humans as part of nature held by Melanesians (Jupiter 2017).

5.4.6 Future research directions

I showed that nature's contributions to human wellbeing decreased with urbanization in the Solomon Islands, but more research is needed to determine if this loss in wellbeing derived from nature is actually compensated by other non-ecosystem services in urban areas. To do so, I would need to know the relative importance of different wellbeing elements and the relative contribution of ecosystem services to these elements.

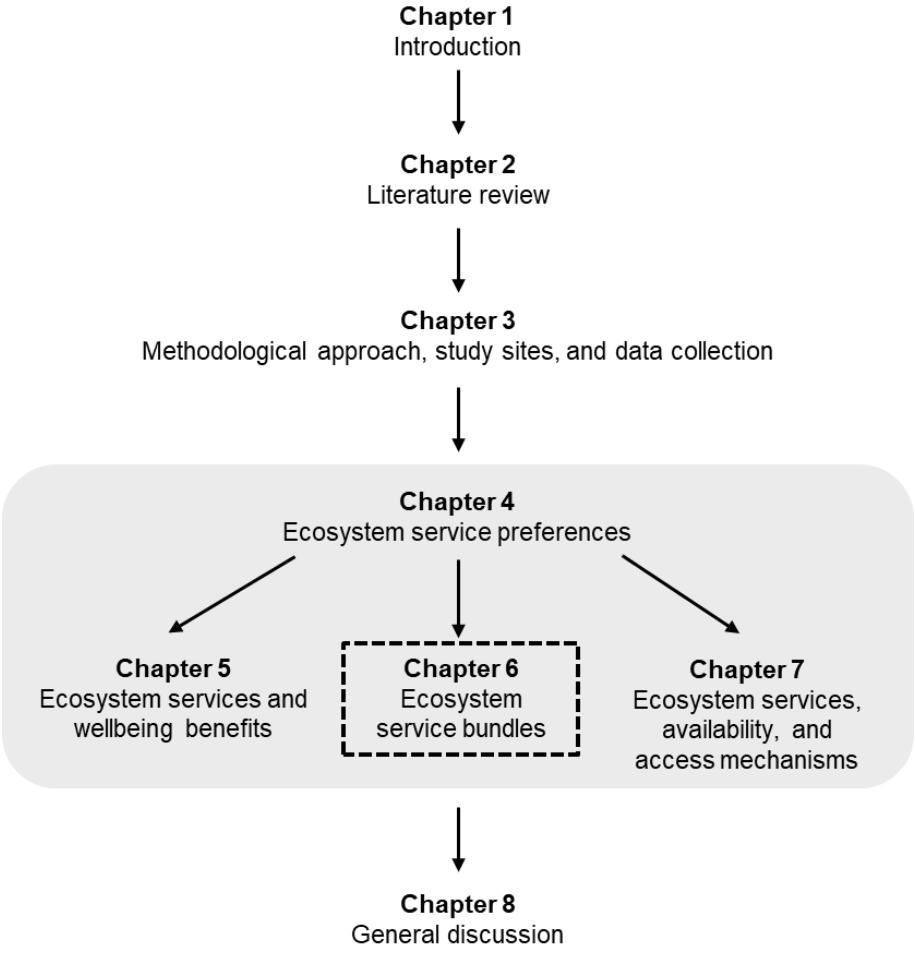
Furthermore, a next step would be to investigate the causal mechanisms responsible for the observed patterns in socio-cultural perceptions. Explanatory factors could range from needs, preferences, or socio-economic status at an individual scale, to limitations in terms availability and access to ecosystem services at biophysical and social-institutional scales (see Chapter 7).

5.5 Conclusion

Living in cities contributes to human wellbeing in several ways, but also alters human-nature relationships leading to a disconnect between people and nature. The impacts of this disconnect on multidimensional wellbeing of urban dwellers is not well understood. I have shown that living in cities was associated with fewer perceived material, relational, and subjective wellbeing benefits derived from ecosystem services. Similarly, the transition from subsistence to income-generating livelihoods and associated increased wealth that occurs with urbanization was also associated to decreased reports of ecosystem service wellbeing benefits. My findings demonstrate that the altered human-nature relationships in urban areas were associated with decreases in multidimensional wellbeing that people derive from nature. The relationships between ecosystem services and multidimensional wellbeing are complex, and oversimplification of these relationships through an omission of locally relevant wellbeing elements in environmental management could lead to trade-offs between aspects of wellbeing and between people with different needs and preferences.

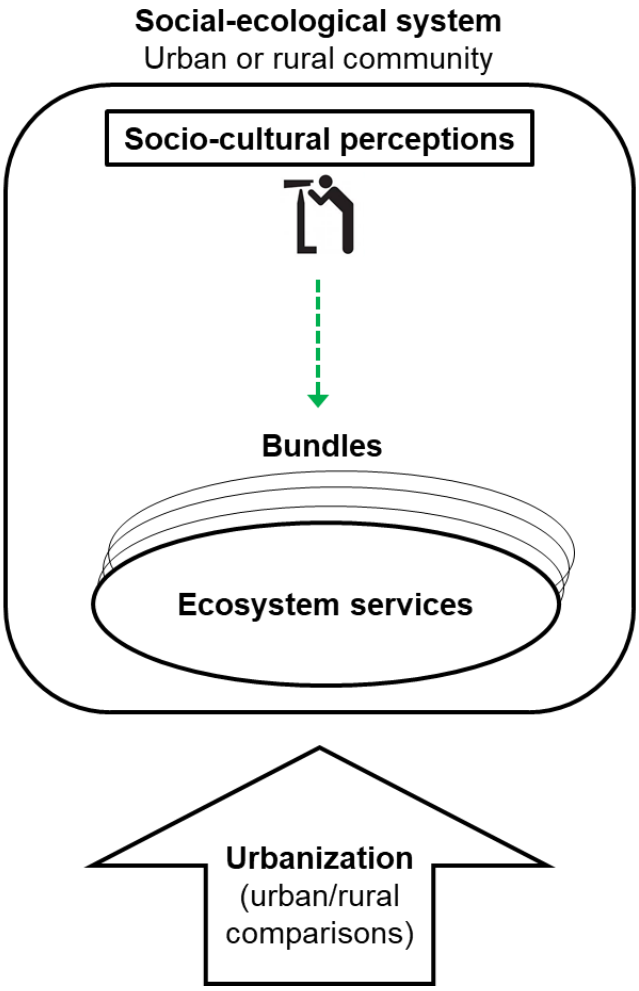
6. Ecosystem service bundles*

In the previous chapters, I have shown that human-nature relationships are transformed by urbanization, with detrimental consequences for the wellbeing benefits that urban dwellers derived from ecosystem services. In this chapter, I explore how these altered human-nature relationships translate into perceived distribution of ecosystem services and disservices in the land and seascapes.



* Lapointe M., Gurney G.G., and Cumming G.S. (2021) Urbanization affects how people perceive and benefit from ecosystem service bundles in coastal communities of the Global South. Ecosystems and People

Contributions: I developed the research question, methodology, collected the data, performed the data analyses, and developed the figures and tables with the advice of G. Cumming and G. Gurney. I wrote the first draft of the paper which was revised with editorial input from G. Cumming and G. Gurney.


Social-ecological system
Urban or rural community
Socio-cultural perceptions
Bundles
Ecosystem services
Urbanization
(urban/rural
comparisons)

Urbanization affects how people perceive and benefit from ecosystem service bundles in coastal communities of the Global South

Abstract

Urbanization profoundly transforms ecosystems and the bundles of services that they provide to people. The relationship between urbanization and ecosystem service provision and how ecosystem services are produced together to form bundles has received increased research interest. However, changes in people's perceptions of how they benefit from ecosystem service bundles resulting from urbanization, particularly in the fast-urbanizing Global South, are poorly understood. Perceptions matter because they influence how people relate to, use and manage their environment; both demand for and the supply of particular service bundles are driven by people's perceptions. I used a paired sampling design to contrast urban and rural dwellers' perceptions of ecosystem service bundles associated with local ecosystems in the Solomon Islands, a rapidly urbanizing Small Island Developing State. Interviews from 200 households revealed that urbanization simplified the composition of perceived ecosystem service bundles. Perceived contributions of provisioning and some cultural ecosystem services were reduced in bundles in urban areas, indicating a decrease in the diversity of experiences of nature and ecosystems providing those experiences. These findings reflect trends seen in the Global North and suggest generalizable effects of urbanization on perceived ecosystem service bundles. More generally, understanding changes in perceived ecosystem service bundles offers a valuable perspective on the implications of social-ecological change for ecosystem service demand and human wellbeing. My approach presents a novel and simple way to identify and analyse bundles that indicates how and where people benefit from nature, and provides useful information for environmental management to increase these benefits.

6.1 Introduction

Urbanization is a key driver of global environmental and social change, transforming ecosystems and altering the services that they provide to people (Seto et al. 2013). Understanding the impacts of drivers of change on ecosystem service distribution is a research priority given it is critical to the sustainable management of ecosystem services (Bennett et al. 2015). However, drivers of environmental change, such as urbanization, seldom affect the

provision of ecosystem services in isolation because ecosystem services are co-produced by ecological and socio-economic processes that result in ecosystem services bundling together (Bennett et al. 2009, Mouchet et al. 2014). Ecosystem service bundles are generally understood as *"sets of ecosystem services that repeatedly appear together across space or time"* (Raudsepp-Hearne et al. 2010a). Therefore, environmental management can benefit from considering ecosystem services as bundles to prevent unintended trade-offs between services that co-occur in the landscape or seascape (MA 2005a, Rodríguez et al. 2006). For example, Raudsepp-Hearne et al.'s (2010a) influential work on ecosystem service bundles showed that increasing the production of provisioning services from agricultural production led to a decreased supply of regulating and cultural services in a peri-urban zone of Canada. In turn, these trade-offs in ecosystem services can create winners and losers among beneficiaries. This occurs because the actual benefits that people derive from bundles depend not only on the biophysical availability of the bundle, but also on socio-economic factors affecting demand for ecosystem services including people's preferences, needs, and access (Howe et al. 2014, Daw et al. 2016).

The study of ecosystem service bundles has grown rapidly in the last decade, notably because of its potential to inform conservation and environmental management aimed at preserving and enhancing the multiple benefits that people derive from nature (Mouchet et al. 2014, Cord et al. 2017, Spake et al. 2017, Saidi and Spray 2018). The bulk of this research has focused on bundle supply in terms of capacity or flow of ecosystem services, expressed in biophysical terms for example, rather than on bundle demand assessed from social sciences approaches that examine people's preferences towards ecosystem services (Saidi and Spray 2018). Demand-side bundle research that analyses how people value, use, and benefit from their environment can help guide environmental management to address people's needs and preferences (Scholte et al. 2015, Cord et al. 2017), identify potential trade-offs between different stakeholders, and avoid potential conflicts (Mouchet et al. 2014). Given that higher population densities may increase demand for, relative to the supply of local ecosystem services, conflict between stakeholders might increase in and around urban areas. This chapter hence explores how urbanization affects people's perceptions of ecosystem service bundles.

Research comparing ecosystem service bundles in urban and rural areas can shed light on the effect of urbanization on bundles by substituting space for time (for a list of these papers, see Table E.1). Supply-side bundle research has reported lower levels of provisioning and regulating services in urban compared to rural areas (e.g., Bai et al. 2011, Depellegrin et al. 2016, Balzan et al. 2018, Müller et al. 2020). From the demand perspective, research has shown that urban dwellers tend to value provisioning services less, and some cultural services more compared with rural dwellers (Martín-López et al. 2012, Zoderer et al. 2019). In brief, urbanization in the Global North appears to decrease both supply and demand for local provisioning services, and supply of regulating services; but increase demand for some cultural services.

Current understanding of the effects of urbanization on ecosystem service bundles comes mostly from research focusing on the production or supply of ecosystem services and from the Global North (e.g., Yang et al. 2015, Baró et al. 2017; see Table E.1), pointing to two blind spots that I address in this chapter. First, I focus on people's perceptions of ecosystem service bundles, rather than bundle biophysical supply, to better understand how urbanization affects people's relationships with nature. My findings can help decision-makers and practitioners appreciate and address the disconnect with nature that occurs with urbanization (Louv 2005, Soga and Gaston 2016), which can be detrimental to the health of urban dwellers (Dye 2008, Cox et al. 2018). Second, research centred on Global South countries is warranted because most future urbanization will occur in these countries (United Nations 2019) and their populations often rely more directly on local ecosystem services for their wellbeing (Fisher et al. 2013, Suich et al. 2015, Marshall et al. 2018).

I investigated ecosystem service bundles in land- and seascapes of the Solomon Islands, a rapidly urbanizing Small Island Developing State (SIDS). SIDS face particular challenges because urbanization may contribute to their development and potentially improve people's wellbeing (UN-Habitat 2015, Marshall et al. 2018), while also being detrimental to fragile coastal ecosystems (Brown et al. 2008, Seto et al. 2013). Coastal ecosystems are already amongst the most threatened, housing about a third of the world's population on only 4% of its land surface, and facing the impacts of climate change (UNEP 2006, UN-Habitat 2015, IPCC 2019). Previous research conducted in the Solomon Islands has shown that urban dwellers'

relationships with nature were transformed by urbanization, with urban dwellers perceiving that they benefited less from provisioning, regulating, and cultural services than rural dwellers(Lapointe et al. 2020b, Chapter 4). However, this study did not explain how urbanization affects the distribution of ecosystem services in different ecosystems in the land- and seascapes. Perceived ecosystem service bundles can therefore demonstrate how and where urbanization affects people's relationships with local ecosystems, which can inform environmental management and urban planning.

Further, I compared urban and rural dwellers' perceptions of ecosystem services associated with ecosystem type into bundles in two paired coastal urban and rural sites. I focused on the ecosystem level for ecosystem service associations because it is a relevant conceptual scale for both beneficiaries and managers in small islands, and can give insight into the multifunctionality of different types of ecosystems (Saidi and Spray 2018). In fact, compared to supply-side bundle research, demand-side research is rarely spatially explicit, (i.e., does not specify where in the land- and seascapes ecosystem services and disservices are derived), which can limit its uptake into practice (although see Brown et al. 2015, Elbakidze et al. 2018, Plieninger et al. 2019). Furthermore, to be considered as bundles, ecosystem service associations must be repeated in space or time (Raudsepp-Hearne et al. 2010a, Mouchet et al. 2014), a criterion that was met using multiple study sites in addition to ecosystem service associations being reported by multiple beneficiaries. I also examined ecosystem disservices or "*the ecosystem generated functions, processes and attributes that result in perceived or actual negative impacts on human wellbeing*" (Shackleton et al. 2016), to provide a more complete picture of people's relationships with nature.

The literature suggests that living in cities compared to rural areas leads to changes in both supply of and demand for ecosystem service bundles. Therefore, I expected that people would report benefiting from fewer ecosystem services per bundle type and that fewer people would report benefiting from the various bundles with urbanization. I tested the competing hypotheses that living in urban compared to rural areas:
(H1) changes the composition of perceived bundles (i.e., the type and diversity of ecosystem (dis)services). Furthermore, the number of people benefiting from different ecosystem

services within a bundle also changes because of reduced supply of and/or demand for both bundles as well as ecosystem service types;

(H2) does not change bundle composition, but reduces the number of people benefiting from different ecosystem services within a bundle because changes in the supply and/or demand would be similar for all ecosystem services within bundles;

(H3) changes bundle composition, but not the number of people benefiting from different ecosystem services within a bundle because changes in supply and/or demand would affect differently ecosystem services within bundles, with people transferring the benefits that they obtain from some ecosystem services to others; and

(H4) does not change either the bundle composition or the number of people benefiting from different ecosystem services within a bundle because neither ecosystem service supply and nor demand would differ between urban and rural dwellers (null hypothesis).

Note that these hypotheses contrast different explanations for each possible case of a 2x2 design (i.e., urbanization changes or does not change bundle composition; and impacts or does not impact the number of beneficiaries).

6.2 Methods

6.2.1 Identification of ecosystems and bundles

In the household interviews, the research assistants presented respondents with 14 ecosystems, 9 ecosystem services (food, materials, firewood, clean air, clean water, soil protection, recreation, culture, and stewardship) and 3 ecosystem disservices (dangerous plants and animals, pests and diseases, and natural disasters), and asked respondents to identify which ecosystems provided each ecosystem service and disservice. Respondents were asked to refer to the ecosystems that they could potentially access in their daily life at their current residential location. I selected 14 ecosystem types that could be easily differentiated by people based on literature searches, field observations, and pilot interviews. The terrestrial ecosystems were: 1) large-scale agricultural fields, 2) backyards (the vegetated land area found around people's house), 3) beaches and coastline, 4) home gardens (not restricted in terms of distance from the respondent's house), 5) grasslands, 6) forests including small urban wooded areas and parks, and 7) agroforestry plantations. I removed the agriculture field category in the data analysis because few people reported benefiting from associated

ecosystem services or disservices. The freshwater ecosystems included: 1) rivers, streams and lakes, 2) ponds, and 3) wetlands. In the analysis, I grouped ponds with rivers, streams, and lakes because they were mentioned by few respondents. The marine ecosystems were: 1) coral reefs, 2) mangroves, 3) open ocean, and 4) seagrass beds. The different ecosystem types were represented by photos mostly taken in the Solomon Islands and did not show any people.

Bundles were described, separately in urban and rural areas, based on the number of people perceiving associations between the different ecosystem services and disservices with each ecosystem type. I do not present bundles determined from multivariate statistical analyses (e.g., ordination or clustering techniques) as recommended in Mouchet et al. (2014) because, considering my research design, these methods did not provide additional insights to the findings presented here.

6.2.2 Statistical analyses

To test whether the probability of identifying ecosystem services and disservices associated with ecosystem types differed between urban and rural respondents, I used Generalised Linear Mixed Models (GLMM) with a binomial distribution using the *lme4* package (Bates et al. 2019). The fixed effects were ecosystem types (12 levels), ecosystem services and disservices (12 levels), and urbanization level (urban and rural). The response variable was the identification of an ecosystem service or a disservice per ecosystem type per respondent, which I coded as a presence-absence binary variable (see Table E.2 for model description). I included only ecosystem (dis)service and ecosystem type associations that represented more than 5% of presence in both urban and rural areas to avoid complete and quasi-complete separation in the analysis. I included household as a random effect to account for non-independence between responses arising from multiple answers from each respondent. Study sites were not factored in the model because there were too few levels to be included in the random structure of the model (Bolker et al. 2009) and sites could not be considered as a fixed effect because they were collinear with urbanization level. Following the GLMMs, I conducted pairwise comparisons with a Tukey correction with the *emmeans* package (Lenth et al. 2019). All analyses were conducted in R (R Core Team 2019).

6.3 Results

I identified 12 bundles of ecosystem services and disservices in both urban and rural areas according to ecosystem type (Figure 6.1). The majority of people in both urban and rural areas reported benefiting from at least one ecosystem service in forests, rivers, beaches, the ocean and coral reefs (Table E.3). However, significantly fewer urban dwellers perceived benefiting from at least one ecosystem service in all bundles (Figure 6.2). The largest decreases were for provisioning services. For example, gardens and forests provided food to 99% and 52% of rural dwellers respectively, compared to 55% and 5% for urban dwellers. As a result, bundle composition appeared altered by urbanization, with most bundles showing the biggest decreases in the relative contribution of provisioning services. Additionally, significantly fewer urban dwellers associated recreation and culture to forests and rivers. In contrast, significantly more urban dwellers reported benefiting from provisioning services from their backyards (and firewood in grasslands) and associated stewardship to rivers, beaches, the ocean, and coral reefs. This evidence supports my first hypothesis that living in urban areas compared to rural areas changes both the composition of perceived bundles and the number of people benefiting from different ecosystem services within a bundle.

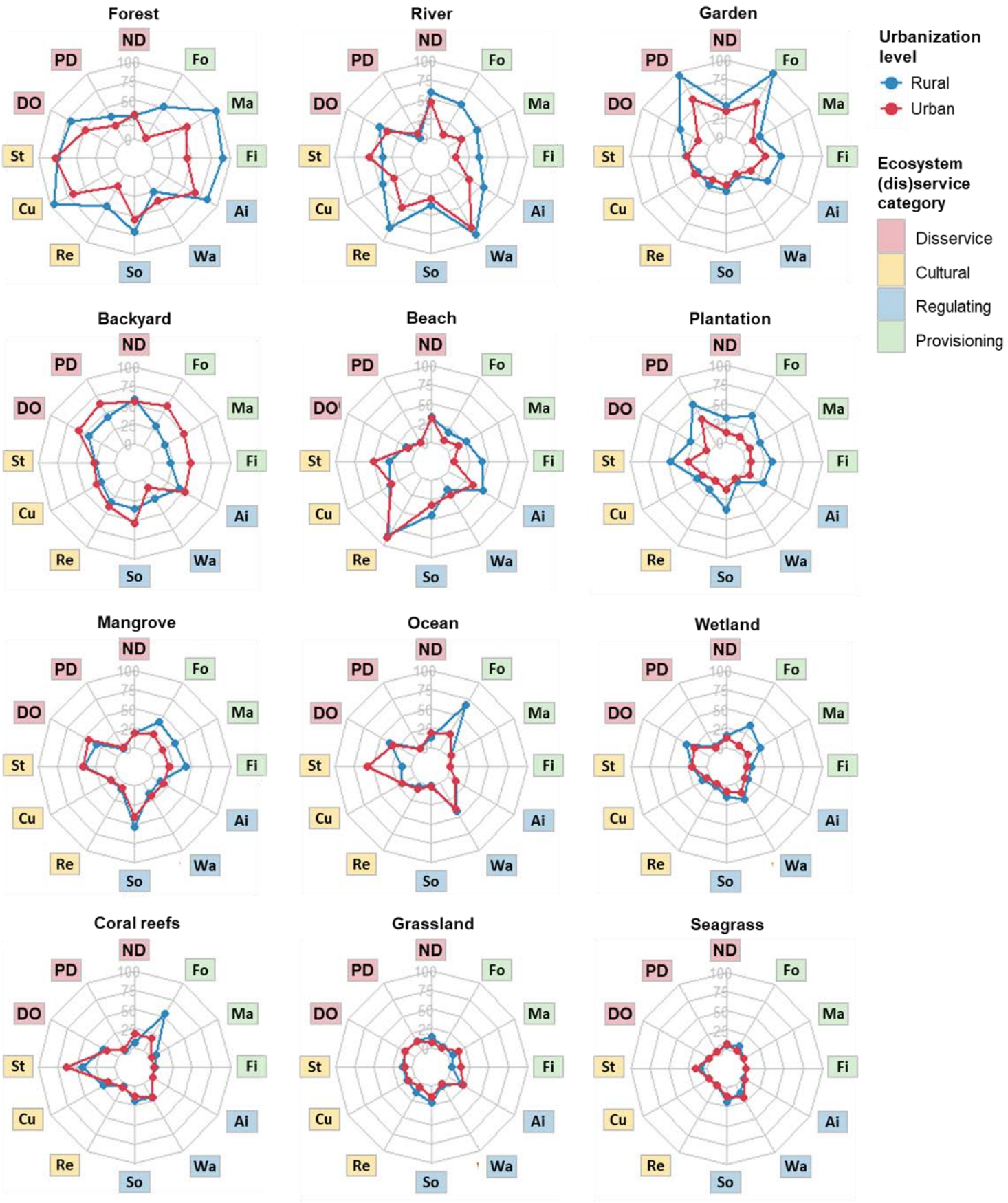

Forest
River
Garden
Backyard
Beach
Plantation
Mangrove
Ocean
Wetland
Coral reefs
Grassland
Seagrass
ND
Fo
Ma
Fi
Ai
Wa
So
Re
Cu
St
DO
PD
Urbanization level
Rural
Urban
Ecosystem (dis)service category
Disservice
Cultural
Regulating
Provisioning

Figure 6.1 Radar charts showing the percentage of urban (in red) and rural (in blue) dwellers reporting ecosystem service and disservice associations per bundle (ecosystem type).
Ecosystem service and disservice types: Fo: Food, Ma: Materials, Fi: Firewood, Ai: Clean air, Wa: Clean water, So: Soil protection, Re: Recreation, Cu: Culture, St: Stewardship, DO: Dangerous organisms, PD: Pests and diseases, and ND: Natural disasters.

Less than half of urban and rural dwellers reported disservices in most bundles (Table E.3). Further, urban and rural dwellers did not significantly differ for most associations between ecosystems and ecosystem disservices (Figures 6.1 and 6.2). In three bundles (forests, gardens, and plantations), significantly more rural dwellers reported disservices than urban dwellers, whereas urban dwellers reported more disservices in two bundles (backyards and coral reefs).

Both urban and rural dwellers identified a high diversity ecosystem services in forests and rivers, and a relatively low diversity in the case of grasslands and seagrass beds (Table E.3). Rural dwellers reported a greater number of ecosystems providing each ecosystem service type comparted to urban dwellers, with the exception of stewardship in which case urban dwellers mentioned, on average, a higher number of ecosystems (Table E.4).

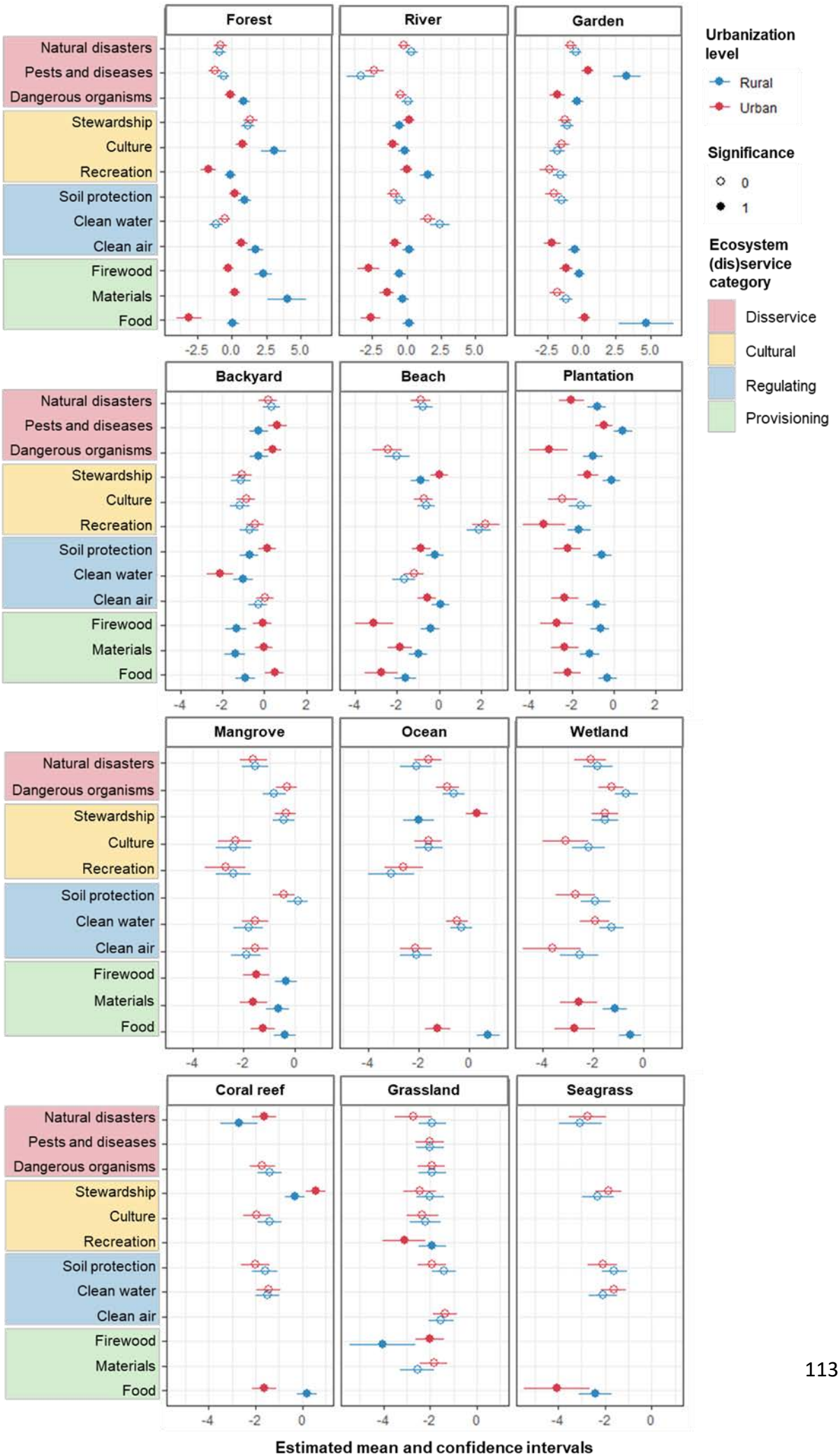

Forest
River
Garden
Backyard
Beach
Plantation
Mangrove
Ocean
Wetland
Coral reef
Grassland
Seagrass
Natural disasters
Pests and diseases
Dangerous organisms
Stewardship
Culture
Recreation
Soil protection
Clean water
Clean air
Firewood
Materials
Food
Urbanization level
Rural
Urban
Significance
0
1
Ecosystem (dis)service category
Disservice
Cultural
Regulating
Provisioning
Estimated mean and confidence intervals

Figure 6.2 Coefficient plots from a logistic regression comparing the probability of associating ecosystem services and disservices to ecosystem types between urban (in red) and rural (in blue) areas.

6.4 Discussion

I found that urban and rural dwellers presented both similarities and differences in their relationships with their local ecosystems as portrayed by perceived ecosystem service and disservice bundles. The majority of both urban and rural dwellers in the Solomon Islands acknowledged that most ecosystems provided bundles of services that benefited their households. Furthermore, the patterns of associations of various ecosystem services with specific ecosystems were similar between urban and rural dwellers. However, there were statistically significant differences between urban and rural populations. Perceived bundle composition was simplified for urban compared to rural dwellers because of a lower diversity of ecosystem services derived from local ecosystems, especially in terms of provisioning services. Fewer urban dwellers reported deriving ecosystem services from most ecosystems. Additionally, with the exception of stewardship (i.e., the will to protect nature), urban dwellers also reported a smaller number of ecosystems from which to derive ecosystem services. Therefore, I found strong support for my first hypothesis that living in urban compared to rural areas changes both the composition of perceived bundles and number of people benefiting from different ecosystem services within a bundle, probably because of a reduction in ecosystem service supply rather than demand (as I explain below). In other words, urbanization appeared to simplify ecosystem service bundles derived from local ecosystems and consequently, urban dwellers' relationships with their local environment.

My findings align with previous studies in terms of the decrease prevalence of provisioning services in urban bundles found from both the supply and demand perspectives (e.g., Bai et al. 2011, Martín-López et al. 2012). I found that the main difference in bundle composition between urban and rural was in decreased mentions of provisioning services in all ecosystems with increased urbanization, with the exception of people's backyards. Provision of several ecosystem services from all categories can decrease due to urbanization associated with overexploitation and pollution of ecosystems (Ministry of Environment Conservation and Meteorology 2008, Toki et al. 2017). As population densities increase, local ecosystems can

no longer meet the growing demand for provisioning ecosystem services that, consequently, need to be imported from further away and replaced by non-ecosystem services (Cumming et al. 2014). In addition, part of the production in cities' hinterlands worldwide is exported rather than used for local consumption (Haberman and Bennett 2019); this is also the case in the Solomon Islands, for example with logging (Toki et al. 2017). In the Solomon Islands, land ownership can also limit access to ecosystems and the services that they provide because customary tenure of land outside of the city boundaries prohibits use for non-owners (Corrin 2012, Foukona 2017). In Global North countries urban dwellers may fail to acknowledge changes in provisioning services, illustrating in part of the disconnect between people and nature (e.g., Martín-López et al. 2012, Soy-Massoni et al. 2016, Zoderer et al. 2019). In contrast, in urban areas of the Solomon Islands, backyards played a bigger role in providing provisioning services than in rural areas and compensated in part for a decrease in provisioning services from forests, gardens, and plantations in rural areas (indicating that urban dwellers still demand and value these services). Similarly in Ethiopia, home gardens were found to be important contributors to the livelihoods of urban dwellers, notably for the provisioning services that they provided (Elbakidze et al. 2018).

The supply of regulating services in bundles tend to be degraded in and around urban areas through transformation of ecosystems into build-up areas and intensification of agricultural uses (Raudsepp-Hearne et al. 2010a, Müller et al. 2020). Although regulating services are less frequently included than provisioning and cultural services in ecosystem service bundles research from a social science perspective (see Table E.1), a few studies have shown that regulating services, such as air filtration, can be highly valued by urban dwellers because of higher formal education levels and awareness of environmental degradation (Martín-López et al. 2012, Lindemann-Matthies et al. 2013, Baró et al. 2017, Elbakidze et al. 2018). I found that perceptions of regulating services in bundles were relatively less altered by urbanization than those of provisioning services. For example, urban and rural dwellers did not differ in relation to most ecosystems that they perceived to provide clean water, although there were decreases in urban areas in terms of air filtration and soil protection for several of the key ecosystems (except for people's backyards). The fact that people acknowledged that certain ecosystems provide services that contribute to their wellbeing does not mean that they are satisfied with the quality of the service. In fact, previous research has shown that urban

dwellers in the Solomon Islands were less satisfied with the benefits that they obtained from ecosystem services than rural dwellers, and would have preferred to benefit more from ecosystem services (Lapointe et al. 2020b, Chapter 4).

The three cultural services within bundles presented less cohesive relationships to urbanization than the other ecosystem service categories partly because of their diverse nature. In general, there were fewer significant differences between urban and rural dwellers in relation to cultural services. Urban areas of the Global North and their surroundings can be hotspots of cultural services delivery (Brown et al. 2015, Queiroz et al. 2015, Zoderer et al. 2019) because of high demand and ease of access (Plieninger et al. 2019). However, the ecosystem services of culture (including traditional knowledge and heritage value) and recreation were reported by fewer urban dwellers in the case of forest and river bundles. The differences between urban and rural dwellers could be due to lack of access to these ecosystems because of lower availability, poorer condition, longer travel time, or land ownership rights (Lapointe et al. 2020a, Chapter 7). In contrast, the ecosystem service of stewardship is quite different from other ecosystem services as it expresses the importance for people of preserving certain ecosystems. More urban than rural dwellers associated stewardship with the ocean, coral reef, and river bundles than rural dwellers. Similarly, Martin-Lopez et al. (2012) found that, in Spain, the moral satisfaction gained from conserving biodiversity increased in urban areas, which they attributed partly to higher formal education levels. Formal education levels were also higher in urban areas of the Solomon Islands (Lapointe et al. 2020a, Chapter 7). Furthermore, Gurney et al. (2017) have shown that, in a modern, connected world, people can form emotional connections with natural places without being physically connected to those places in their daily lives. In the Solomon Islands, the greater prevalence of stewardship in urban areas could also be due to urban dwellers being more exposed to and conscious of environmental degradation. Indeed, urban dwellers tend to keep close ties to their village roots and can experience ecosystems that are less degraded and often more accessible than in the urban areas in which they currently reside (McDougall 2017).

Few studies of bundles have also considered ecosystem disservices (Saidi and Spray 2018), although they can provide important information for environmental management to minimize

detrimental impacts of nature on wellbeing (Shackleton et al. 2016). Ecosystem disservice bundle composition differed only slightly between urban and rural dwellers. Dangerous organisms and pests and diseases were reported by fewer urban than rural dwellers in some ecosystems (e.g., forests, gardens, and plantations), although the reverse was true for backyards. These findings are not surprising as people who interact more with nature are usually more impacted by ecosystem disservices (Shackleton et al. 2016). Natural disasters were mainly reported to similarly affect urban and rural dwellers, and were more pronounced in rivers, backyards, and gardens. In brief, decreases in nature's negative impacts on human wellbeing due to urbanization were not as significant as the losses in beneficial impacts, resulting in a more negative balance between ecosystem services and disservices in urban than in rural areas.

The diversity of ecosystem services within bundles allowed me to investigate the degree of multifunctionality of ecosystems, which is key to inform environmental management to prevent trade-offs between ecosystem services and conflicts between beneficiaries with different needs and preferences (Mastrangelo et al. 2014, Manning et al. 2018). Some ecosystems were perceived as more multifunctional than others, providing a higher diversity of ecosystem services. Forest and river bundles provided the highest diversity of ecosystem services and to the most people in both urban and rural areas. For example, I found that forests provided many ecosystem services, similarly to findings from the Global North (Brown et al. 2015, Depellegrin et al. 2016, Baró et al. 2017, Müller et al. 2020). In contrast, other bundles appeared more specialized in terms of provisioning services and ecosystem disservices (gardens), provisioning and cultural services (coral reefs), and cultural services (beaches). A well known example in the literature is production-oriented ecosystems, such as crop production, which are reported to provide high levels of provisioning services which result in low levels of regulating services (Raudsepp-Hearne et al. 2010a). In the Solomon Islands, people also recognized that production-oriented ecosystems, i.e., gardens and plantations, had lower levels of regulating services. Gardens and plantations are both mainly planted in forests but presented lower frequencies of regulating services than forests. Other ecosystems such as coral reefs may appear more specialized because of people's preferences or the nature of the ecosystem services assessed rather than trade-offs between ecosystem services. At any rate, both multifunctional and specialized bundles were simplified with

urbanization, notably by losing their provisioning functions for some people. Similarly, Raudsepp-Hearne et al. (2010a) also found that higher levels of urbanization led to a decrease in ecosystem service bundle multifunctionality. I further observed that in most cases, urban dwellers had fewer ecosystem options than rural dwellers to obtain certain ecosystem services. For example, food production comes from a much greater diversity of ecosystems in rural than in urban areas. Thus, both the diversity of natural places (here, ecosystems) and experiences (through different ecosystem services) were simplified by urbanization through the direct, active and multisensory experience of nature provided notably by provisioning services (sensu Russell et al. 2013).

Preserving marine biodiversity is viewed as a key priority for people in SIDS, as expressed notably in the United Nations' Sustainable Developmental Goal 14 ("Life Below Water"). The emphasis on marine conservation is certainly justified in SIDS since land mass is limited compared to their territorial waters and the important benefits, notably in terms of nutrition that they provide to people. However, my data suggest that forests in the Solomon Islands provide a more diverse bundle of benefits to more people than marine and coastal ecosystems. In an urbanizing context, decision-makers are faced with the challenges of rapid population growth, the associated demand for housing and services and, in the case of SIDS, limited available land for expansion. Expansion is often at the expense of forests and other terrestrial ecosystems. Urban areas in the Solomon Islands are still few and relatively small, but forests have disappeared at alarming rates over the last decades due to logging for export, which has also contributed to the deterioration of river water supply and quality (Ministry of Environment Conservation and Meteorology 2008, Toki et al. 2017). In addition to limited availability of forests, urban dwellers are limited in their access to forest remnants surrounding urban areas by customary land ownership (Corrin 2012, Foukona 2017). Therefore, conservation and restoration initiatives will need to focus on both marine and terrestrial ecosystems and ecosystem services, and aim to maintain or enhance access to the benefits that they provide to both rural and urban dwellers.

Finally, my approach presents a novel and simple way to identify and analyse bundles. I defined bundles from the associations that people reported between ecosystem services and various ecosystems from which they derive the benefits. While studies of supply bundles

illustrate where and how ecosystems generate service bundles, I further show where and how people perceive benefiting from ecosystem services, which can differ from where these ecosystem services are supplied according to how people interact with ecosystems. Most bundle research from a social science perspective identifies bundles of ecosystem services according to similarities in preferences for multiple services and how these preferences can differ between different social groups distinguished by relevant socio-economic indicators or stakeholders (Martín-López et al. 2012, Casado-Arzuaga et al. 2013, Hicks and Cinner 2014). In contrast, my method provides information on the distribution of locally relevant ecosystem services in land and sea-scapes. The approach that I have taken can be extended by taking a more spatially detailed research approach, potentially involving participatory mapping methods (e.g., Raymond et al. 2009, Klain and Chan 2012, Brown et al. 2015). My approach to analysing bundles thus complements others and can provide a rapid assessment of the spatial distribution of benefits derived from ecosystems, which can be useful in environmental management to better understand the multifunctionality of ecosystems and prevent trade-offs between ecosystem services as well as conflicts between beneficiaries.

Limitations and future research needs

I limited my selection of ecosystem services to nine, which is not an exhaustive list of all the possible ecosystem services from which people benefit in the Solomon Islands. Omitting potentially important ecosystem services can alter results, especially in ecosystem service bundle research dealing with associations between ecosystem services (Spake et al. 2017, Saidi and Spray 2018). However, the consequences of these omissions might not be as important in this case because I was not specifically interested in trade-offs between ecosystem services, but rather in the relationship between people and their environment.

More research is necessary to clarify the roles of supply and demand for ecosystem service bundles as well as their interplay to explain my findings. Locating my results against a map of the supply of ecosystem services could inform us about the role that availability and access plays in forming bundles. Furthermore, the role of preferences in the differences observed between urban and rural dwellers is unclear. I asked interview respondents from which ecosystems they derived the different ecosystem services, hence measuring the ‘actual demand’ according to Cord et al. (2017). To determine the ‘potential demand’ (Cord et al.

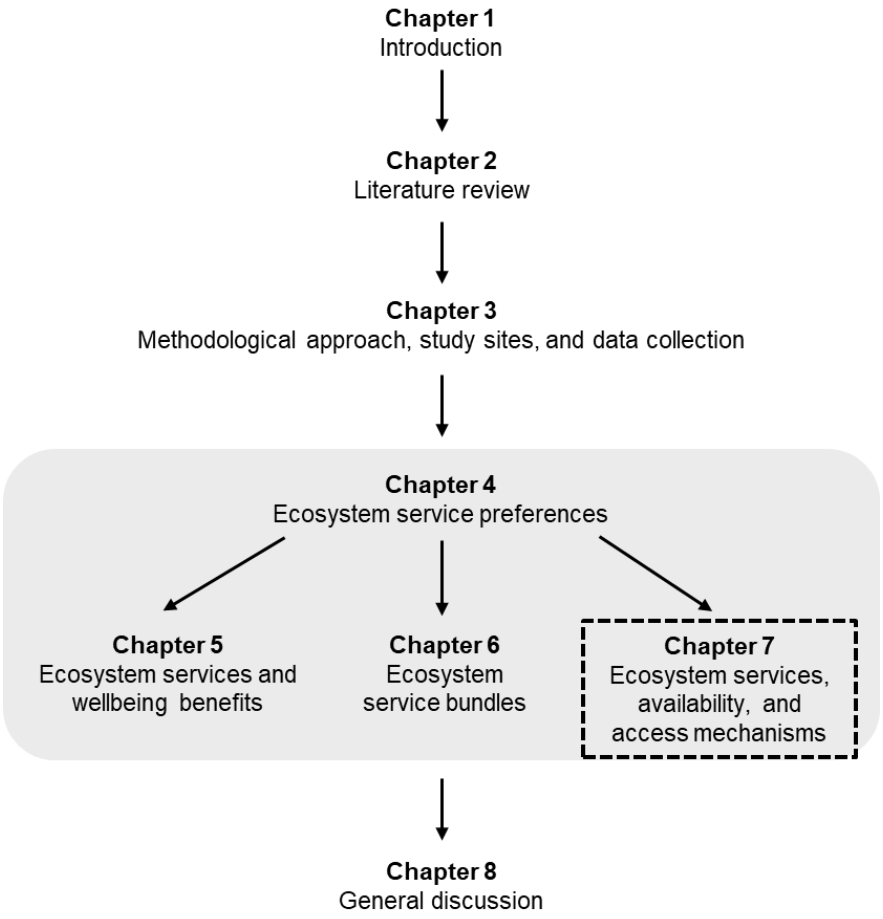
2017) relevant in planning exercises, I would need information on people's needs and expectations or satisfaction levels towards ecosystem service bundles.

6.5 Conclusion

To understand how urbanization affects people's relationships with nature, I compared rural and urban dwellers' perceptions of ecosystem services and disservices bundles in terrestrial, marine, and freshwater ecosystems of the Solomon Islands. I have shown that urbanization simplified the composition of perceived ecosystem service and disservice bundles. In particular, fewer urban dwellers could derive provisioning services from local ecosystems. These trends concur with the literature from the Global North, which suggests that urbanization can generate a disconnect with nature in very different societies with varying levels of urbanization. However, the consequences for people's wellbeing might be more important in the Global South where poorer people are more directly reliant on local ecosystem services. More research is needed on the effects of urbanization on the distribution of ecosystem service bundles and the relative roles of ecosystem service supply and demand, especially in the Global South where most urbanization will occur in the future. This line of research can help urban planners and environmental managers understand the multifunctionality of ecosystems from the perspective of the ecosystem service beneficiaries, thereby contributing to ensuring the maintenance or enhancement of related wellbeing benefits.

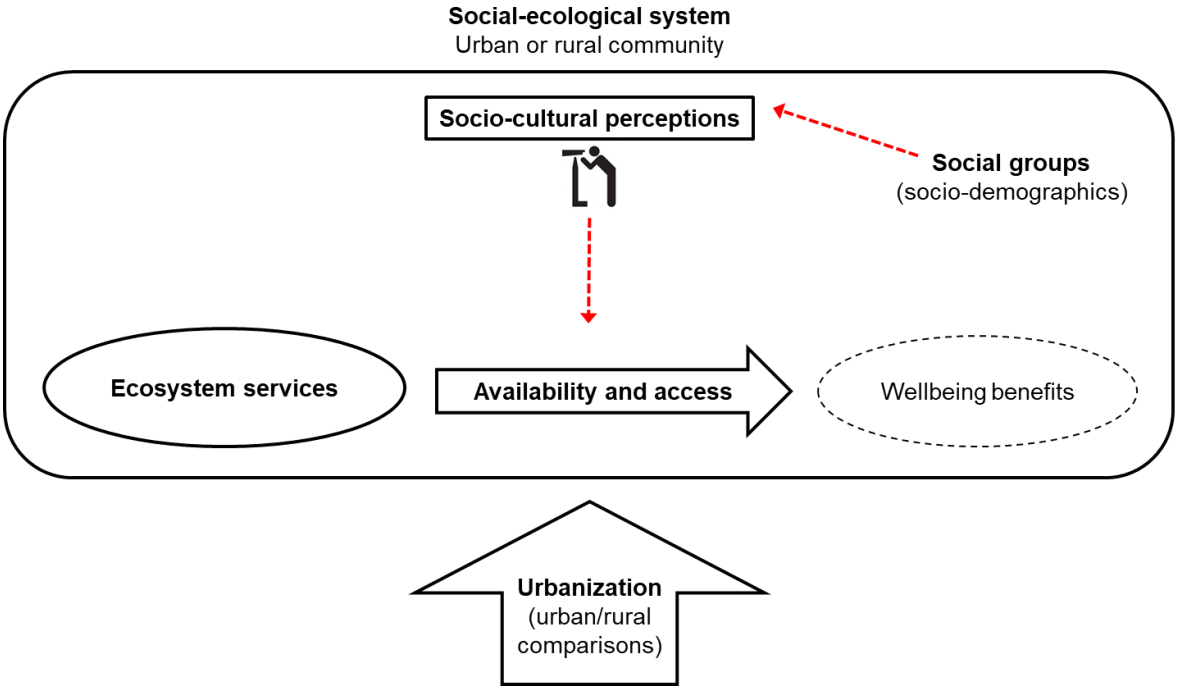
7. Ecosystem services, availability, and access mechanisms*

In this final data-based chapter, I explore potential mechanisms, in terms of ecosystem service availability and access, by which urbanization alters human-nature relationships as I described in the previous chapters.



* Lapointe M., Gurney G.G., and Cumming G.S. (2020) Perceived availability and access limitations to ecosystem service wellbeing benefits increase in urban areas. Ecology and Society

Contributions: I developed the research question, methodology, collected the data, performed the data analyses, and developed the figures and tables with the advice of G. Cumming and G. Gurney. I wrote the first draft of the paper which was revised with editorial input from G. Cumming and G. Gurney.


Social-ecological system
Urban or rural community
Socio-cultural perceptions
Social groups
(socio-demographics)
Ecosystem services
Availability and access
Wellbeing benefits
Urbanization
(urban/rural
comparisons)

Perceived availability and access limitations to ecosystem service wellbeing benefits increase in urban areas

Abstract

Access mechanisms can determine the benefits that people derive from a given ecosystem service supply. However, compared to ecosystem service availability, access has received little research attention. The relative importance of availability compared to access in limiting ecosystem service benefits is even less well understood. In cities, the observed disconnect between people and nature might result in part from changes in ecosystem service availability and access compared to rural areas. To address these research gaps, I compared perceived limitations to ecosystem service wellbeing benefits in urban and rural areas in the Solomon Islands. I predicted that more people would report being limited in ecosystem service benefits in urban than rural areas. Drawing on data from 200 respondents, I found that more urban dwellers reported being limited in both availability and access in the benefits that they derived from ecosystem services. Availability factors were the most frequently perceived limitations, although access played an important role for both provisioning and cultural services. In urban areas, poorer people, women, and older people identified the most limitations. Findings show the importance of investigating both ecosystem service availability and access to manage the environment in a way that sustains or increases benefits to people.

7.1 Introduction

Access to ecosystem services is an essential, but often overlooked, step in the cascade in which ecosystems provide wellbeing benefits to humans through different ecological and social processes (Haines-Young and Potschin 2010, Daw et al. 2016). Socially-differentiated access to ecosystem services was identified as a research gap in the Millennium Ecosystem Assessment (MA 2005a); a gap that still persists in recent regional Intergovernmental Science-Policy Platform for Biodiversity and Ecosystem Services (IPBES) reports (Mastrángelo et al. 2019). Failing to account for differential abilities to access ecosystem service benefits may result in unfair ecosystem service valuations and environmental management outcomes (Daw et al. 2011, Fisher et al. 2014, Gurney et al. 2015). Issues of access might be especially relevant in cities where social inequalities, exclusion, and segregation are more pronounced and can

even lead to conflict and violence (e.g., Smets and Salman 2008, Østby 2016). In addition, the availability of ecosystem services might also limit the benefits that people derive from ecosystems in built-up urban environments (Seto et al. 2013). Living in cities is thought to create a disconnect between people and nature (Louv 2009, Soga and Gaston 2016, Lapointe et al. 2019, Chapter 2), even in recently urbanized societies (Lapointe et al. 2020b, Chapter 7). The reasons why urbanization alters the human-nature relationship are poorly understood, but might lie at the interface between the availability of and access to ecosystem service benefits. In this chapter, I compared the limitations to ecosystem service benefits in terms of availability and access as perceived by urban versus rural dwellers.

The role of access challenges the implicit assumption, in some ecosystem service research, that an increase in ecosystem service supply or availability will result in an increase in the benefits to people or what is called a trickle-down effect (Daw et al. 2011, Wieland et al. 2016). For example, the benefits derived from recreating in an urban park depend on the physical availability of parks near people, people's needs, values, and preferences. But benefits to people also depend on transportation and costs, regulations such as access hours, or feeling of insecurity; these are all examples of access mechanisms as described by Ribot and Peluso (2003:153) who defined access as "the ability to derive benefits from things", here ecosystem services.

People's perceptions of what limits their access to ecosystem service benefits can provide insights into how these benefits vary across societal groups. A socially differentiated approach to examining ecosystem service benefits is crucial for ensuring environmental management is equitable. The few studies that have examined the role of access mechanisms in mediating benefits derived from ecosystem services using social science approaches have drawn on a range of literatures, including environmental justice, livelihood capitals, environmental entitlements, and access theory (e.g., Hicks and Cinner 2014, Woodhouse et al. 2015, Berbés-Blázquez et al. 2017, Chaudhary et al. 2018, Kibria et al. 2018, Lau et al. 2020). Even if not framed in terms of access, socio-cultural valuation research on ecosystem services that disaggregates by sociodemographic characteristics (e.g., Lau et al. 2018) addresses access through what Ribot and Peluso call social identity; showing how beneficiaries' sociodemographic characteristics, e.g., gender and age, are associated to differential benefits.

The studies cited above have expended the understanding of ecosystem service access in three ways. First, they have demonstrated the importance of disaggregating ecosystem service analyses to understand who benefits, from what ecosystem service and how. Second, they have shown the importance of looking at multiple dimensions of access, as described notably by Ribot and Peluso (2003). Third, access mechanisms appear to be in part context specific (Hicks and Cinner 2014).

Myers and Hansen's (2019) review of the literature drawing on the theory of access identified the lack of attention to how 'materiality' (i.e. physical characteristics) influences derived benefits as an important research gap. In this chapter, I contribute to meeting this gap by examining the physical characteristics affecting ecosystem service availability. In the ecosystem service literature, only a few authors have considered access and availability together. The physical characteristic examined in these studies include: land availability, coastal development, pollution, and geographic location (Brown et al. 2008), the quantity and quality of ecosystems (Milgroom et al. 2014), physical and spatial barriers (Wieland et al. 2016), land area (Kibria et al. 2018), distance (Szaboova et al. 2019), and weather (Lau et al. 2020). Examining the physical characteristics affecting availability in addition to access mechanisms provides more complete and useful information for planning and management of ecosystem services.

The relative role of availability and access in mediating the benefits that people derive from ecosystem services is likely to differ between and within ecosystem service categories. Some ecosystem services may have, by nature or because of the context, excludable properties which makes their access controllable by some and limited for others (Costanza 2008, Fisher et al. 2009). For example, provisioning (e.g., crops) can be commodified and some cultural (e.g., recreation) and regulating services (e.g., soil erosion prevention) may have excludable characteristics if the land upon which they are located is privatized. In contrast, several regulating and some cultural services are public goods and have non-excludable characteristics. For instance, the benefits provided from climate regulation and air filtration provided by vegetation or the educational or cultural values of nature may be more limited by the availability of the necessary ecosystems rather than as a result of restricted access.

Urbanization can also affect both availability and access to ecosystem services through alterations and destruction of ecosystems, increased population densities, and transformed socio-economic contexts (Seto et al. 2013). As a result, urban dwellers may face limitations in the availability of certain ecosystem services such as natural areas to recreate, land for gardening and foraging, mitigation of air pollution, or shading and cooling from urban trees (Gómez-Baggethun et al. 2013). Furthermore, wealth appears as an important access mechanism, with wealthier people found to have better access to urban green (Sander and Zhao 2015, Tan and Samsudin 2017, Charnley et al. 2018) and blue areas (Unnikrishnan and Nagendra 2015). However, more research involving stakeholders and using social sciences approaches is needed in research on urban ecosystem services (Haase et al. 2014, Luederitz et al. 2015). Moreover, most of the research on ecosystem services has taken place in wealthy modern cities, but conclusions might differ in societies of the Global South, notably because of differences in urban planning, but also in inhabitants' needs and values related to nature.

To address these research gaps, I compared urban to rural dwellers' perceptions of availability and access limitations to ecosystem service benefits in the Solomon Islands. Previous research has shown that, in the Solomon Islands, living in cities decreased perceived importance of and satisfaction towards ecosystem services (Lapointe et al. 2020b, Chapter 4). In this chapter, I explore potential underlying causes for these differences between urban and rural dwellers. The Solomon Islands is an interesting case study because of rapid urbanization (UN-Habitat 2012) and people's high dependency on nature (Solomon Islands National Statistics Office 2015). My analysis is designed to test the hypotheses that urban dwellers are more likely to perceive and report limitations to ecosystem service benefits compared to rural dwellers, and that this is because of differences in availability and access to ecosystem services due to urbanization.

7.2 Methods

7.2.1 Identification and classification of the limitations to ecosystem service availability and access

To identify ecosystem service availability and access limitations, we asked an open-ended question in the household interviews about what limited the household from benefiting more

from each ecosystem service. Respondents could give as many answers as they wanted. The answers were classified into the different access mechanisms and availability factors (Table 7.1). My classification of limitations was derived from 50 pilot interviews and based on the theory of access (Ribot and Peluso 2003), as well as considering previous research on access to ecosystem services (Hicks and Cinner 2014, Milgroom et al. 2014, Wieland et al. 2016). Answers also included factors related to the availability of ecosystem services, which I added to my classification. There were also cases in which respondents did not feel limited in the benefits they received from ecosystem services and answers were recorded as such.

Table 7.1 Availability and access limitations classification and correspondence with Ribot and Peluso's theory of access (2003).

Limitation	Category	Example of answers	Ribot and Peluso's (2003) access mechanisms
Quantity	Physical availability	There is not enough, there are too many people.	N/A
Quality	Physical availability	It is degraded, polluted.	N/A
Natural disasters	Physical availability	Weather events, seasonality, natural disasters, pests and diseases, and climate change.	N/A
Location	Physical availability	It is too far.	N/A
Context	Physical availability	Only found in rural areas.	N/A
Right of access	Rights/ Management	Do not have the rights or ownership.	Right-based
Management (governance and law enforcement)	Rights/ Management	Authorities restrict access, are corrupt, not doing their job.	Rights/ Authority
Social relations	Social/ Cultural	Social relations with *wantok*, conflicts with neighbours.	Social relations
Security	Social/ Cultural	Criminality or dangerous animals.	Social relations
Cultural	Social/ Cultural	Influence of other cultures, cultural diversity.	Social identity
Knowledge	Human capital	Do not know where or how to access.	Knowledge
Labour	Human capital	Lack of human resources, time, or interest.	Labour
Economic	Material capital	Too expensive.	Capital
Technology	Material capital	Lack of tools, equipment, infrastructure, transportation.	Technology

7.2.2 Socio-demographic characteristics selection

I used socio-demographic characteristics to disaggregate my findings: wealth, gender, age, education, and the time a person had been living in their community (Table F.1). I chose these

characteristics because of their potential role in facilitating or limiting the access to ecosystem services. First, wealth can influence preferences and enable access to technologies and other type of capitals necessary to benefit from ecosystem services, sometimes resulting in a capture of the benefits by an elite (Fisher et al. 2014). Moreover, disparities in wealth are especially pronounced in urban areas (Behrens and Robert-Nicoud 2014). Second, men and women can have different needs, preferences for ecosystem services (Fisher et al. 2014, Fortnam et al. 2019), and gendered roles often differ in the co-production of ecosystem services (e.g., Chaudhary et al. 2018, Lau et al. 2020). Third, age (e.g., Woodhouse et al. 2015, Lau et al. 2020), and fourth, education (e.g., Hicks and Cinner 2014, Kibria et al. 2018) can also influence the access to ecosystem service benefits; their specific relationship with ecosystem service benefits varying across studies. Fifth, in addition to these key characteristics, I assumed that time lived in the community would be a proxy for local knowledge as well as social inclusion, and could influence access to customary land in the Solomon Islands.

7.2.3 Statistical analyses

Urban-rural comparisons

I predicted that more urban dwellers would identify availability and access limitations to ecosystem services than rural dwellers. I tested my prediction across all 200 interview respondents who identified one or more of the 14 limitations for each of the nine ecosystem services. I used a generalized linear mixed model fitted with a binomial distribution using the *lme4* package (Bates et al. 2019) in R (R Core Team 2019). The response variable was the presence or absence of a limitation. Urbanization level (urban versus rural), ecosystem services (9 levels), limitations (14 levels), and the interaction between these three variables were the fixed effects (see Table F.2 for model description). Limitations that were reported by 5% or less people per ecosystem service were removed from the analyses. In all cases, I added respondents as a random factor to control for the non-independence of multiple responses per respondent. I did not include the study site in the random structure because it has only four levels; I would have included it as a fixed effect, but it was not possible in this case because each site was nested within an urbanization level. I tested whether the fixed effects contributed significantly to the models with an analysis of deviance (Wald test) using the *Anova* function of the *car* package (Fox et al. 2019). I performed post-hoc multiple

comparisons with the *emmeans* package (Lenth et al. 2019) with a Tukey correction for multiple testing. Assumptions were tested with the *Dharma* package (Hartig 2019).

Disaggregation of limitation within urban and rural areas

Within urban and rural areas (100 respondents for each), I tested the effect of the five socio-demographic characteristics. I again used generalized linear mixed models fitted with a binomial distribution (see Table F.3 for model description). The response variable was the same as above. The fixed effects were: ecosystem services or limitations, and the five socio-demographic characteristics. I performed the analysis per ecosystem service and also per limitation. I did not include interaction terms because of the large number of variables in the models. In addition to the assumptions tested above, I also checked, with variation inflation factors, that socio-demographic characteristics were not collinear.

7.3 Results

7.3.1 Comparison of perceived ecosystem service availability and access limitations between urban and rural areas

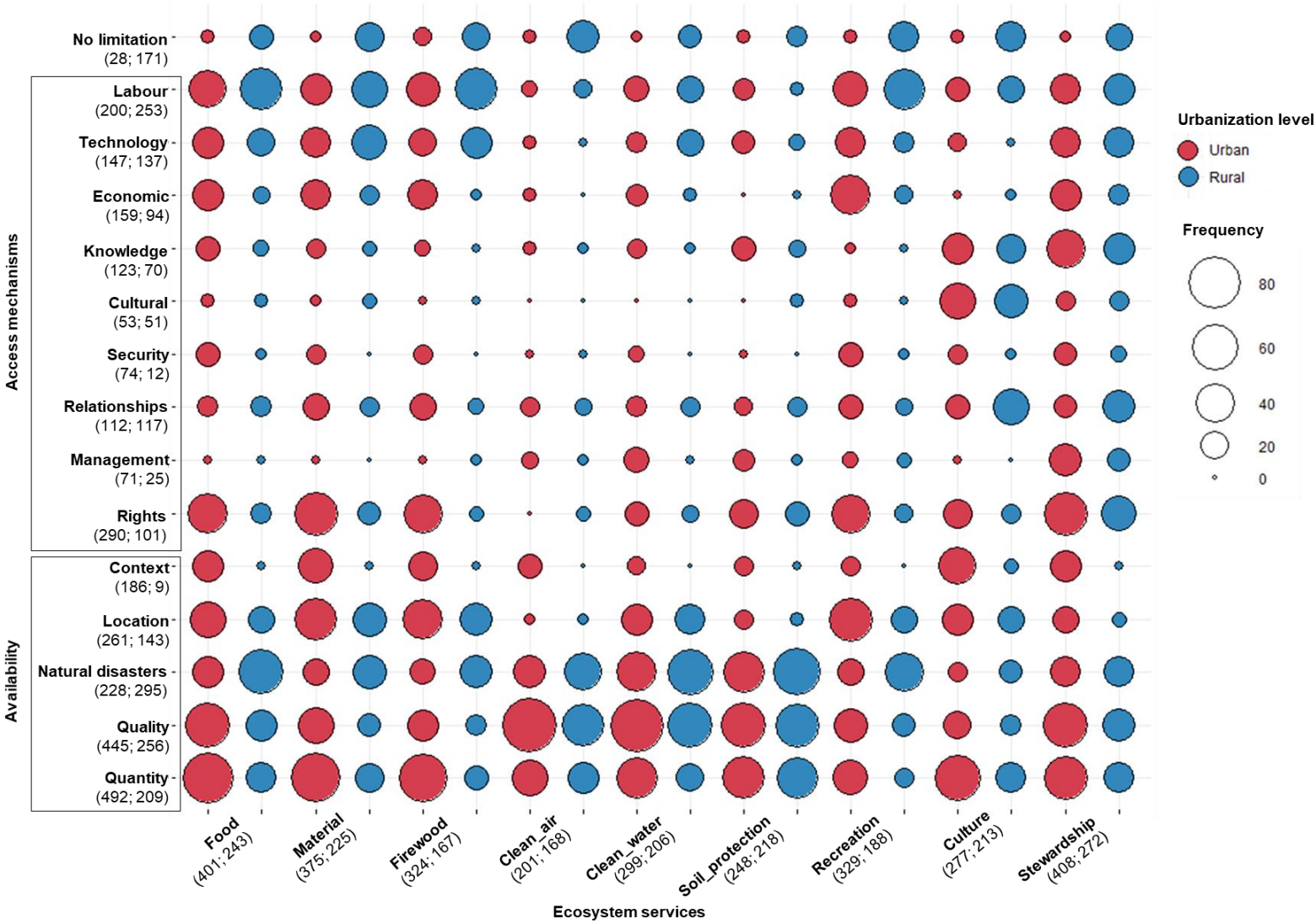


Figure 7.1 Frequency of urban and rural dwellers identifying a limitation for each ecosystem service.
The total number of mentions of a limitation, and of limitations per ecosystem service are indicated in parentheses for urban and rural, respectively.

Most limitations to ecosystem service benefits were reported for stewardship, food, and materials in both urban and rural areas (Figure 7.1). However, the number of people mentioning limitations were fewer in rural than in urban areas. The average number of limitations reported by rural dwellers was also lower compared to urban dwellers (Table 7.2). Additionally, the most often perceived limitations differed between urban and rural areas. The quantity of ecosystem services was the most often cited limitation in urban areas, but it came third in importance in rural areas. The context limitation indicated that an ecosystem service could not be found in an urban context, and was an important limitation for several ecosystem services in urban areas. Security was not one of the most frequent limitations identified, it

was mostly mentioned in urban areas for provisioning and cultural services. In addition, there were more people reporting no limitation in rural than in urban areas.

Table 7.2 Mean number of limitations and standard deviation per ecosystem service per person in urban and rural areas.

Category	Ecosystem service	Urban Mean	SD	Rural Mean	SD
Provisioning	Food	3.98	2.42	2.29	1.68
	Materials	3.73	2.34	2.04	1.51
	Firewood	3.17	2.19	1.72	1.32
Regulating	Clean air	1.98	1.15	1.39	1.23
	Clean water	3.00	1.93	2.12	1.33
	Soil protection	2.47	1.39	2.08	1.21
Cultural	Recreation	3.26	1.80	1.64	1.36
	Culture	2.81	1.65	1.90	1.48
	Stewardship	4.10	2.89	2.54	1.80

The model comparing urban and rural areas (Figure 7.2) showed that several limitations related to ecosystem service availability and access were significantly higher in urban areas. Rural dwellers only identified significantly more limitations related to natural disasters for provisioning services, soil protection, and recreation; social relationships for culture and stewardship; and labour in the case of firewood. Consequently, I rejected the null hypothesis of no difference between the limitations perceived between urban and rural dwellers.

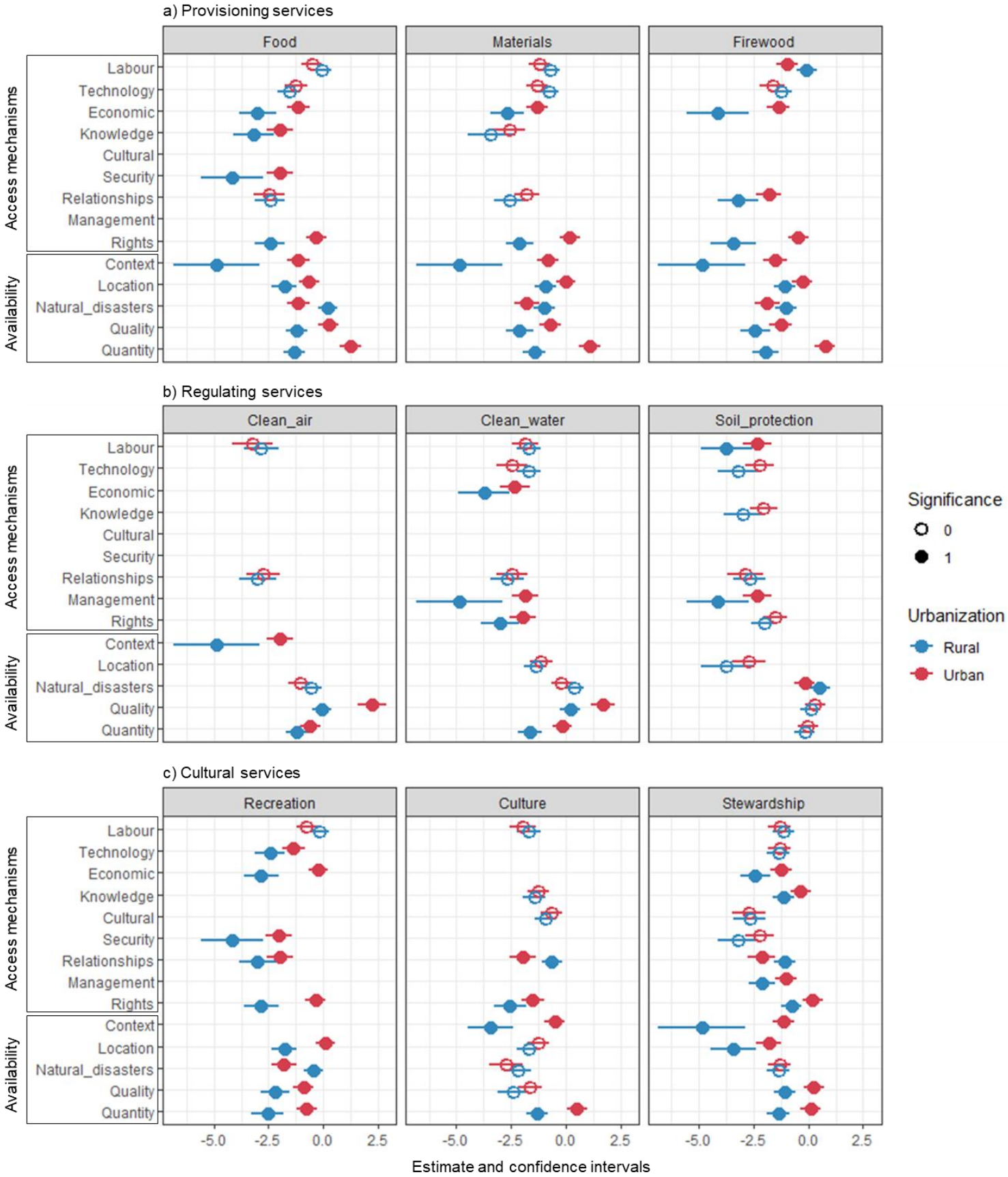


Figure 7.2 Comparison of limitations reported per ecosystem service between urban and rural dwellers for a) provisioning, b) regulating, and c) cultural services.
Values represent estimated marginal means with associated confidence limits from multiple comparisons following a logistic regression.

Provisioning services (food, materials, and firewood) were found to be limited by questions of availability in urban areas, mainly in terms of quantity: 75% of urban dwellers reported that the quantity of food was limiting, 72% for materials, and 66% for firewood. In terms of access mechanisms, rights were the most limiting factor in urban areas being reported by 43% of urban dwellers in the case of food, 54% for materials, and 40% for firewood; whereas issues of rights were reported significantly less frequently in rural areas (10%, 13%, and 4% for food, materials, and firewood, respectively). Furthermore, urban dwellers were also more frequently restricted in their access to food compared to rural dwellers by economic, knowledge, and security issues. The costs also limited access to materials in urban compared to rural areas. Economic and social relationships mechanisms limited further the access to firewood for urban dwellers. In contrast, the most frequently cited limitations to provisioning service benefits in rural areas were related to labour (e.g., motivation, time), technology, and natural disasters (e.g., cyclones, pests).

Regulating services were limited mainly by availability issues, both in urban and rural contexts, although significantly more so in urban areas. The quality of regulating services was the main issue in urban areas. For example, air and water quality was reported as limiting by 88% and 81% of urban dwellers respectively, compared to 49% and 55% by rural dwellers. The difference in availability factors for soil protection did not differ between urban and rural areas, except for natural disasters that had a significantly higher probability of being identified in rural areas. Regulating services were the least impacted ecosystem service category by access mechanisms, although issues of rights were also significantly more frequent in urban than in rural areas for both clean water and soil protection. There were also more economic limitations to access to clean water in urban compared to rural areas.

Cultural services, being quite different from one another, presented varying patterns of limiting factors, although more people perceived limitations for all three services in urban than in rural areas. In urban areas, people were limited in their opportunities to recreate in nature by the location (52%), the costs (45%), and the rights to access (42%) mainly beaches. In rural areas, the main limitations were related to damages caused by natural disasters (41%) or the will and time to recreate (47%, included in labour). Culture in urban areas was mentioned as being less present (61% of urban dwellers identifying quantity, and 39% context), and was

associated to the mix of different cultures (36%), and an erosion of traditional knowledge (25%). In rural areas, the different cultures (22%) and the loss of traditional knowledge (31%) were also reported to limit access to culture, but also relationships with people from different cultures (37%). Stewardship was limited by both availability and access mechanisms in both urban and rural areas. In urban areas, limitations related to the quantity (52% of respondents) and quality (55%) of natural areas were significantly higher than in rural areas. Rights also played an important role for both urban (54%) and rural (34%) dwellers, and were in fact the main limitation in rural areas. Furthermore, urban dwellers were significantly more limited by knowledge (42%), management (29%), and economic (25%) mechanisms in their stewardship of natural areas, whereas rural dwellers were more so by social relationships (28%).

7.3.2 Disaggregation by socio-demographic characteristics within urban and rural areas

I found significant effects of all five socio-demographic characteristics on some ecosystem service types in urban areas, and of the proportion of time living in the community, education level, and age in rural areas (Figure 7.3). As wealth increased in urban areas, perceived limitations decreased and significantly so for food, firewood, and stewardship. A greater proportion of life spent in a given urban or rural community tended to decrease the number of perceived limitations, although this was only significant for clean air and culture in urban areas, and soil protection in rural areas. In general, women tended to perceive more limitations compared to men, significantly so for firewood, recreation, and culture in urban areas. The patterns for the effect of formal education varied: education level increased perceived limitations for food in urban area and for recreation in rural areas, but decreased perceived limitations to soil protection in rural areas. Older people in urban areas perceived more limitations to all provisioning services. The trend was different in rural areas, with older people identifying significantly fewer limitations for soil protection.

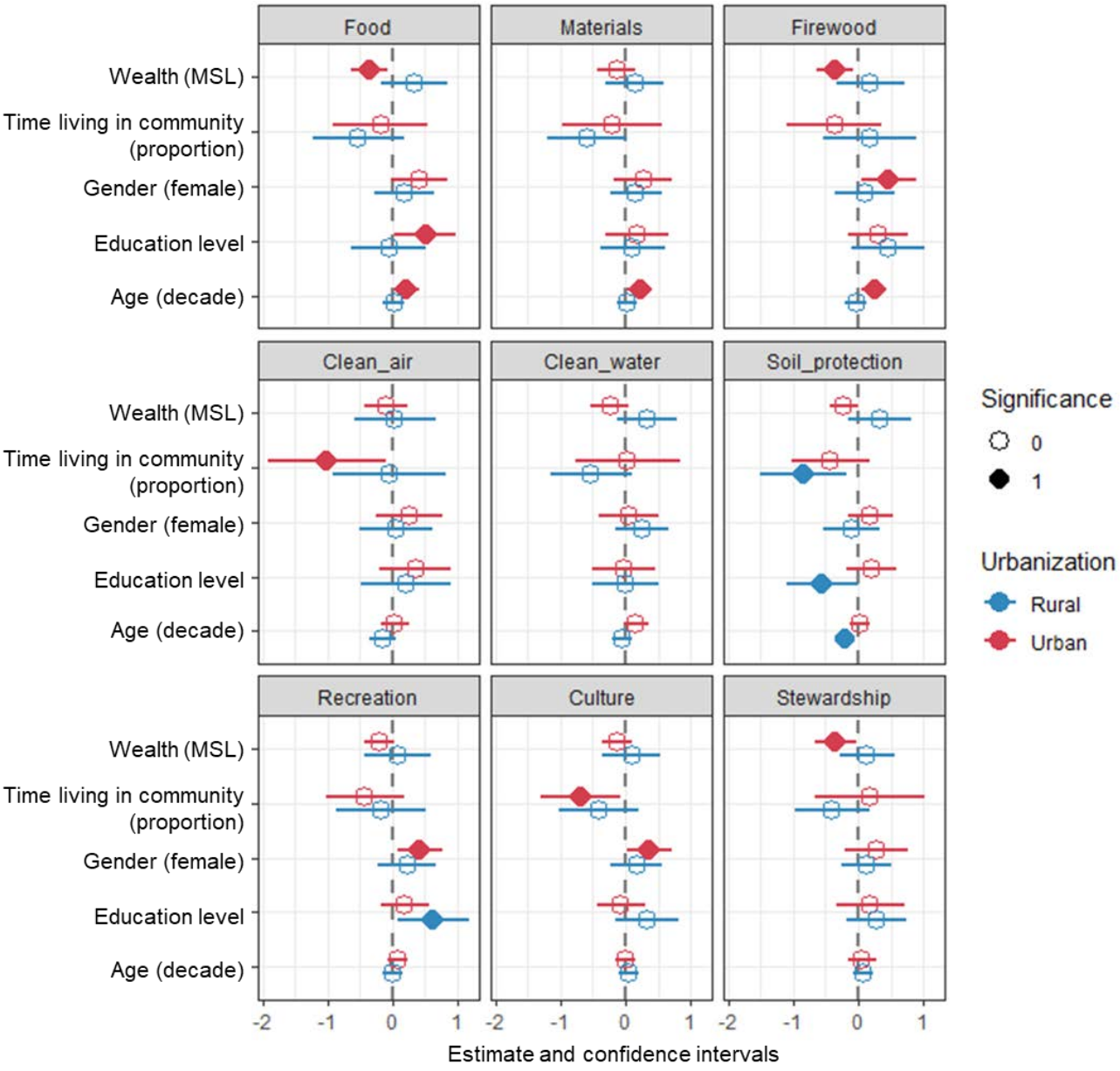
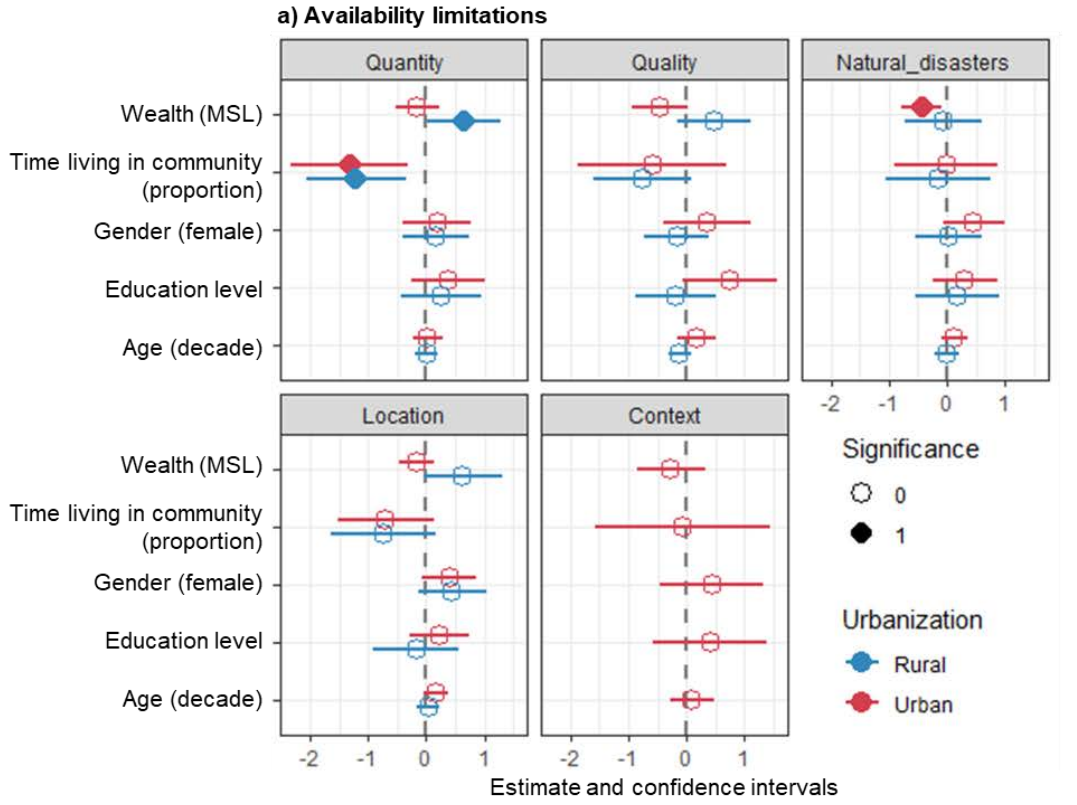


Figure 7.3 Relationship between socio-demographic characteristics and number of perceived limitations per ecosystem service types in urban and rural areas.
Limitations were included in the models, but are omitted from the graph. Urban and rural analyses were performed separately for each ecosystem service, but are illustrated in the same plots.


a) Availability limitations
Quantity
Quality
Natural_disasters
Location
Context
Wealth (MSL)
Time living in community (proportion)
Gender (female)
Education level
Age (decade)
-2
-1
0
1
Significance
0
1
Urbanization
Rural
Urban
Estimate and confidence intervals

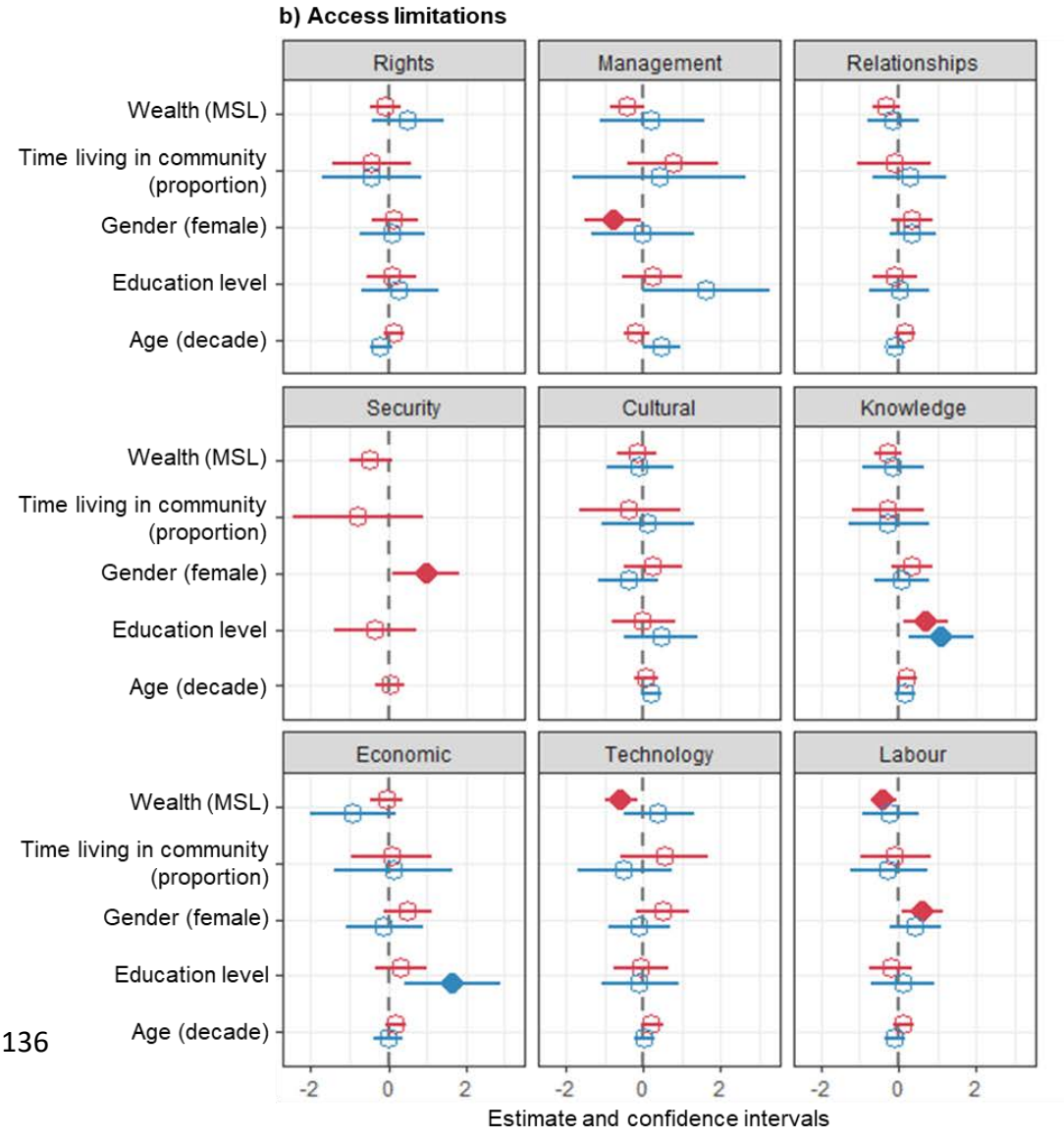

b) Access limitations
Rights
Management
Relationships
Security
Cultural
Knowledge
Economic
Technology
Labour
Wealth (MSL)
Time living in community (proportion)
Gender (female)
Education level
Age (decade)
-2
0
2
Estimate and confidence intervals

Figure 7.4 Relationship between socio-demographic characteristics and the number of perceived limitations to ecosystems services relating to a) availability and b) access in urban and rural areas.
Ecosystem service types were controlled for in the model, but are omitted from the graph. Urban and rural analyses were performed separately for each limitation, but are illustrated in the same plots**.**

I also found a few significant relationships between socio-demographic characteristics and the type of limitation within urban and rural areas (Figure 7.4). In urban areas, increased wealth decreased the probability of identifying natural disasters, technology, and labour as limitations to ecosystem service benefits. The pattern was opposite in rural areas with greater wealth associated with a higher probability to report quantity limitations. The longer people had been living in their urban or rural community, the fewer limitations to ecosystem service quantity were perceived. Women in urban areas perceived fewer management limitations, but more security and labour limitations compared to men. The only clear effect of formal education was to increase the likelihood of perceiving knowledge limitations in both urban and rural areas. Age was not significantly related to either availability or access limitations.

7.4 Discussion

I found strong support for my prediction that significantly more urban than rural dwellers would report limitations to ecosystem service benefits in the Solomon Islands. Urban dwellers also identified, on average, more limitations per ecosystem service than rural dwellers. Most limitations identified by urban dwellers were related to ecosystem service availability. The access mechanisms identified, especially issues of rights, also played an important role for provisioning and cultural services. When I disaggregated my findings according to socio-demographic characteristics, I found that wealth, gender, and age had a significant relationship with perceived limitations in urban areas.

My findings suggest that the landscape and seascape physical transformations resulting from urbanization (e.g., urban development, overexploitation, and pollution) could result in the reduced perceived ecosystem service availability, the most often reported limitations to ecosystem service benefits. The quantity of provisioning services available (food, materials, and firewood) was a more important limitation for urban dwellers, than quality and location.

Ecosystem service quality, including pollution of water, air, and soil degradation, was the main limitation for regulating services in urban areas. For cultural services in urban areas, recreation was limited mainly by distance, traditional culture was often perceived as absent from urban contexts, and stewardship was restricted by both the quantity and quality of natural areas to conserve. My findings demonstrate the importance of considering what Myers and Hansen (2019) named the materiality of the 'thing' when addressing questions of access to ecosystem services.

Several access mechanisms were more frequently identified in urban than in rural areas, although they were relatively less frequently cited than availability issues, especially for provisioning and regulating services. For all provisioning services, rights of use were the main limiting access mechanism, and were significantly more frequent in urban compared to rural areas because, as material goods, provisioning services have excludable properties that allow their commodification (Costanza 2008, Fisher et al. 2009). In contrast, because of their mostly non-excludable, public good nature (Costanza 2008), regulating services were the least impacted category of ecosystem services through access mechanisms. However, issues of rights were also significantly more frequent in urban than in rural areas for both clean water and soil protection because the ecosystems providing these services can be located on private land. The cultural services that I assessed were all very different in nature from one another and consequently presented different patterns of access limitations with the exception of rights, which were more often perceived as limiting in urban than in rural areas for all cultural services. The relative importance of rights of use compared to other access mechanisms probably stems from the customary tenure of land in the Solomon Islands. About 83% of the land is under customary tenure in the Solomon Islands and access to non-customary owners is restricted (Corrin 2012). For example, most of the land around Honiara is under customary tenure, which limits the geographical expansion of the city (Foukona 2017).

Only a few other studies have addressed both ecosystem service access and availability, but were conducted only in rural areas (e.g., Milgroom et al. 2014, Wieland et al. 2016). Like mine, these studies showed that, while looking at availability or access limitations separately is informative, it provides an incomplete picture of the potential benefits that certain people can derive from ecosystems. In fact, availability and access limitations can interact (Milgroom

et al. 2014) resulting in compounded impacts (Wieland et al. 2016). Therefore, understanding the role of ecosystem service availability and access limitations is essential to inform environmental management that aims to improve the flow of benefits to people.

Disaggregation highlighted a few trends between perceived availability and access limitations and the socio-demographic characteristics examined (including wealth, gender, age, time living in a community, and formal education). Fewer wealthier urban dwellers identified limitations to provisioning (food and firewood) and cultural services (stewardship), and were less likely to report being limited by natural disasters, technology, and labour. The reasons for this finding are likely to be twofold. First, the need for some ecosystem services might be lower for wealthier people who can afford alternatives to food, materials, firewood, and recreation opportunities, for example. Second, wealth can increase access to other types of capitals necessary in the co-production of most ecosystem services (sensu Palomo et al. 2016), notably natural capital through land ownership, but also technology (manufactured capital) and labour (human capital) as shown here. Increases in the availability of and access to ecosystem services for wealthy people, often at the expense of poorer people, is often referred to as elite capture (e.g., Fisher et al. 2014). These two hypotheses are not mutually exclusive, and it is more likely that a combination of both is at play. Interestingly, wealth had an opposite effect in rural areas where wealthier people reported more limitations in terms of the quantity of ecosystem services available. An explanation might be that, in rural areas, wealth is derived from selling provisioning services. Therefore, people who take part in the cash economy might be more prone to seeing limitations of revenue generation from provisioning services than people who use ecosystem services mainly for subsistence.

In contrast to the effect of wealth, women and older people in urban areas perceived more limitations. Women reported more limitations to provisioning and cultural service benefits, as well as more security and labour limitations. Women might be limited in their access to cultural services in part because of a heavier work load associated with reduction in leisure time, in addition to restricted access to some tambu areas (Asian Development Bank 2015). Women are also more responsible for gathering some provisioning services for the household (food, firewood, and medicines) and thus might be more aware of limitations. All these factors might have a greater impact in urban areas where ecosystem service availability is lower. In

contrast, men in urban areas reported more management limitations; this may be because men are traditionally in charge of decision-making in the Solomon Islands (Asian Development Bank 2015), but taking part in decision-making might be harder outside of customarily-owned land, as in urban areas. Older people also perceived more limitations to provisioning service benefits in urban areas. It is possible that older people might have higher expectations for ecosystem service benefits, having witnessed less transformed environments during their lifetime.

There were common trends shared among urban and rural dwellers regarding the effect of time living in a community and formal education. The longer someone had been in a community, the less they were limited by the quantity of ecosystem services available to them in both urban and rural areas. While the exact mechanisms need to be teased apart, this trend could be related to negotiating access with customary owners and developing local knowledge. When formal education level had a significant effect, it mostly increased perceived limitations for food in urban areas and recreation in rural areas. It also increased perceived traditional knowledge limitations in both urban and rural areas, and economic limitations in rural areas. Thus, formal education might raise awareness of ecosystem service availability and access limitations. However, the fact that the direction of the effect is the same in both urban and rural areas could indicate that formal education may conflict with traditional knowledge. This is likely because achieving higher education levels in the Solomon Islands requires attending school or university in urban areas; and the livelihoods typically adopted by people with high levels of formal education may be less connected to nature.

Most of these socio-demographic characteristics (i.e., gender, age, education, and time living in the community) can be considered as social identity access mechanisms according to Ribot and Peluso (2003). To my knowledge, my study is the first to combine the examination of social identity access mechanisms using socio-demographic data with perceived availability and access limitations to ecosystem service benefits in urban areas. Doing so is important for urban planning and environmental management, especially in countries of the Global South, like the Solomon Islands, where avoiding unfair trade-offs in ecosystem service benefits between people is critical given the precarious situations that people already live in (e.g., poverty and malnutrition).

With this chapter, I wanted to understand the reasons why fewer urban dwellers benefit from ecosystem services in the Solomon Islands, and which factors are responsible for the altered human-nature relationship. I have shown in previous research that urban dwellers were less satisfied than rural dwellers with the benefits that they derive from ecosystem services (Lapointe et al. 2020b, Chapter 4). In other words, urban dwellers' expectations towards ecosystem services were not met and they would have liked to benefit more from ecosystems. Taken together these findings suggest that in the Solomon Islands, urban dwellers are not voluntarily disconnected from nature, but rather become disconnected because of the reduction in ecosystem service availability and access, mainly through rights of use, in urban environments. Therefore, in urban areas, increasing the supply of ecosystem services would increase benefits to people, as long as legal access mechanisms were not compromised for provisioning and cultural services, especially for poorer people and women.

Caveat and future directions

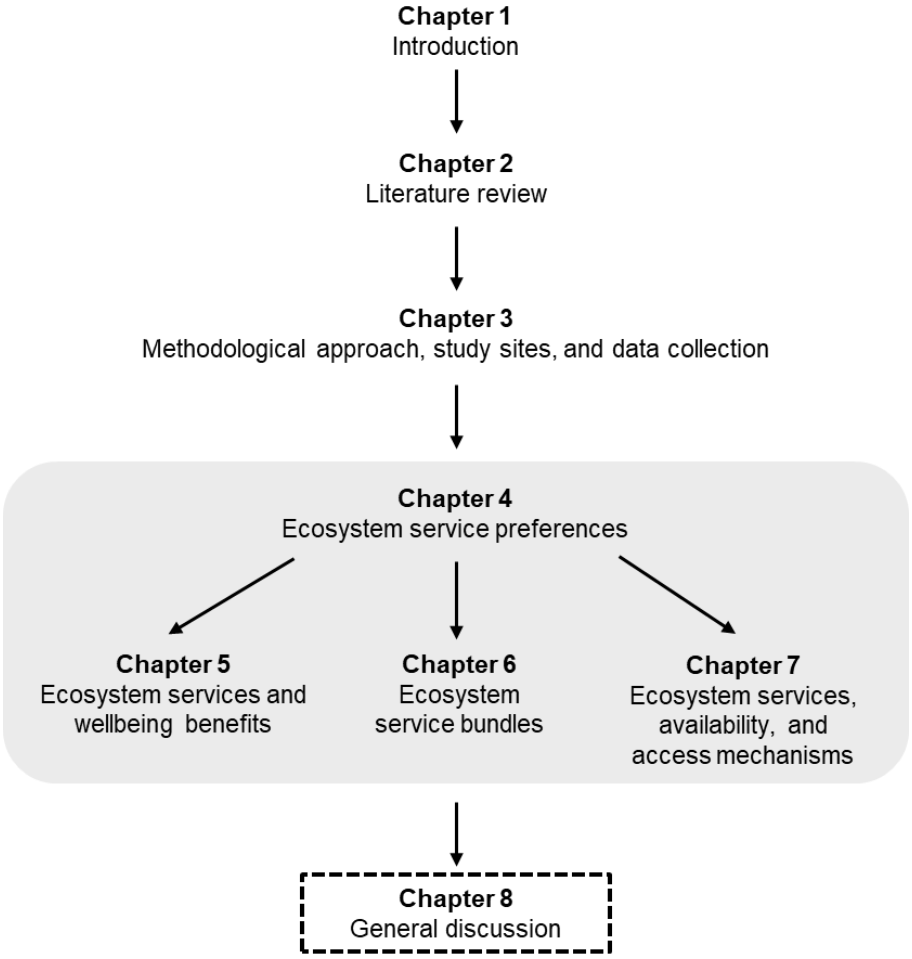
A potential limitation of my research is that the villages that I selected were rather populous by Solomon Islands standards; larger population sizes were needed to balance my sampling design. The high population densities in Tamboko and Nusa Hope might have limited the availability and access to ecosystem service benefits to some people, as the proportion of time spent in the community seems to point out. Thus, the contrast between urban and rural areas might even have been larger if I had chosen smaller villages.

Finally, I identified two important future research directions that could be useful in urban planning and environmental management. First, interdisciplinary research is needed on feedback mechanisms that operate between ecosystem service availability and access mechanisms, and the benefits and impacts on people's wellbeing. Second, research on availability of and access to ecosystem services should be spatially explicit, in particular to alleviate or avoid aggravating issues of social inequalities. This can be achieved through participatory mapping interviews or focus groups with ecosystem service beneficiaries (e.g., Brown et al. 2012), and is expected to be particularly useful for informing urban planning, including in relation to environmental features.

7.5 Conclusion

To summarize, I found perceived limitations in the availability of provisioning, regulating, and cultural services, as well as access to provisioning and cultural services to be partly responsible for the disconnect between nature and people observed in urban areas. In fact, I found that urban dwellers identified significantly more availability and access limitations to the wellbeing benefits that they derived from ecosystem services compared to rural dwellers in the Solomon Islands. In addition to these general trends in urban areas, poorer, older people and women reported more limitations to ecosystem service benefits. These results show the importance of investigating both the availability of and access to ecosystem services if environmental management and urban planning are to address the limitations faced by different social groups, and thus promote socially just access to nature's benefits.

8. General discussion



8.1 Key findings

By comparing urban and rural dwellers' perceptions of ecosystem services, I have shown that urbanization alters several aspects of the human-nature relationship. In this section, I discuss how I have met the four objectives associated with my data chapters.

The objective of my first data chapter (**Chapter 4**) was to compare how urban and rural dwellers differed in their socio-cultural valuation of ecosystem services and disservices (Objective 2). I found that ecosystem services were highly valued in both rural and urban areas, but that urbanization decreased the importance of the contributions of all ecosystem services categories to household's wellbeing. In addition, urbanization did not reduce the importance of disservices. Previous research had found lower importance of provisioning services in urban areas, while the trends were often less consistent for other service categories (Lapointe et al. 2019, Chapter 2). These differences with previous research could stem in part from the complex relationships that Solomon Islanders have with nature, which urbanization affects on several levels. Furthermore, satisfaction towards ecosystem services was also lower in urban than in rural areas indicating that urban dwellers would have liked to benefit more from their local ecosystems. Thus, I demonstrated in this chapter that human-nature relationships were altered even in this recently urbanized society.

Ecosystem service importance indicates if ecosystem services contribute to wellbeing, but it does not specify how. Therefore, in **chapter 5**, I aimed to understand the impacts of these transformed human-nature relationships on multidimensional human wellbeing, using the social wellbeing framework (Gough and McGregor 2007, McGregor 2007). My objective was to examine how people's perceptions of wellbeing benefits derived from ecosystem services differed between urban and rural areas, and how socio-demographic characteristics influenced these wellbeing benefits (Objective 3). I found that ecosystem services contributed in similar ways to the wellbeing of urban and rural dwellers, mostly to material wellbeing, but also relational and subjective wellbeing for provisioning and cultural services. The importance of ecosystem service contributions to material wellbeing was also demonstrated in previous studies conducted in the Global South (Abunge et al. 2013, Beauchamp et al. 2018). However, urban dwellers reported fewer wellbeing benefits compared to rural dwellers, especially in terms of 'Basic material needs', 'Connection to nature', and 'Feeling of happiness and

satisfaction'. I found that increased wealth and livelihood activities involving paid employment were related to decreased mentions of wellbeing benefits derived from ecosystem services. Finally, consequences for overall urban dwellers' wellbeing might be important because of the multiple ways that ecosystem services contribute to the wellbeing of Solomon Islanders as well as the lack of adequate alternatives to replace those services.

In **chapter 6**, I sought to understand how these altered human-nature relationships translated into perceived distribution of ecosystem services in the land and seascapes. My objective was thus to explore how people's relationships with ecosystems differed between urban and rural dwellers by comparing their perceptions of ecosystem service and disservice bundles associated with different ecosystem types (Objective 4). I found that people-ecosystem relationships, viewed in terms of ecosystem service bundles, were complex in rural areas of the Solomon Islands, each ecosystem providing several ecosystem services. However, urbanization simplified the composition of ecosystem service bundles, mainly through a reduction in the proportion of provisioning services in several bundles. With urbanization, fewer people benefited from active and multisensory experiences of nature (Russell et al. 2013) derived from provisioning services in most ecosystems, but also recreation in forests and rivers. Maybe in part because of these altered relationships with ecosystems, more urban than rural dwellers associated stewardship with the ocean, coral reefs, and rivers, a phenomenon also observed in urban areas of the Global North and attributed to higher levels of formal education (e.g., Martín-López et al. 2012). In addition, urban dwellers had access to a lower diversity of ecosystems to provide the different ecosystem services from which they benefited. For example, rather than relying on forests, gardens, and oceans as in rural areas for food, materials and firewood, more urban dwellers turned to their backyards to replace some of these services. Therefore, urbanization led to a decrease in the diversity of experiences of nature and ecosystems providing those experiences.

In **chapter 7**, I investigated some of the potential causes of the altered human-nature relationships. My objective was to identify how perceived limitations to ecosystem service benefits differed between urban and rural dwellers in terms of availability and access mechanisms, and how these limitations varied according to socio-demographic characteristics (Objective 5). I found that urbanization increased the number of people reporting limitations

and the number of limitations per ecosystem service. Furthermore, poorer people, women, and older people identified more limitations in urban areas. Availability limitations, such as the quantity and quality of ecosystem services, were reported more frequently than access ones (sensu Ribot and Peluso 2003). However, access limitations, in particular issues of user rights, were important for provisioning and cultural services. The fact that regulating services were less limited by access mechanisms is not surprising because these services are mostly public services (except for soil protection) with non-excludable and non-rival properties (Costanza 2008). I showed in this chapter that urban dwellers were not voluntarily disconnected from nature, but were limited mainly by availability of ecosystem services and the rights to access them. Therefore, in the case of the Solomon Islands, increasing the availability of and access to ecosystem services, for example through urban gardens, would improve benefits, especially to vulnerable people (e.g., poorer people and women).

8.2 Contribution to the ecosystem service research field

The main contributions of my thesis to the ecosystem service research field are in the areas of valuation, contributions to wellbeing, bundles, and access.

Ecosystem service valuation

Most commonly, socio-cultural valuation assesses the perceived importance of ecosystem services' contributions to human wellbeing. However, ecosystem service importance does not indicate if these contributions are optimal for people, i.e., if they meet people's needs and preferences. For example, it is possible that some people would give a higher importance value to ecosystem services if they had better access to them. This issue is especially relevant in urban areas harboring highly transformed ecosystems. Therefore, I chose to add the assessment of ecosystem service satisfaction in conjunction to importance in Chapter 4. I am not aware of previous ecosystem service research examining the influence of urbanization that simultaneously assessed both importance of and satisfaction with ecosystem services (although it has been done in rural areas; Hicks et al. 2013, Lau et al. 2018). According to the Expectancy Disconfirmation Model (Oliver 1977) from consumer research, satisfaction provides information on the perceived state of an ecosystem service and someone's expectations for it, and on the difference between them. Therefore, satisfaction values

allowed me to draw more accurate conclusions on human-nature relationships in the Solomon Islands giving insight into people's preferences and needs towards ecosystem services.

Ecosystem services and wellbeing

The relationships between ecosystem services and their actual contributions to human wellbeing has been a persisting research gap in the ecosystem service literature (Bennett et al. 2015, Daw et al. 2016). By linking the social wellbeing framework to the ecosystem service framework in Chapter 5, I demonstrate the complexity and the multidimensionality of the ecosystem service-wellbeing relationship. I therefore show the distinctions between ecosystem services and the wellbeing benefits which are often confounded in ecosystem service research (Daw et al. 2016, Lapointe et al. 2019, Chapter 2). Furthermore, the social wellbeing framework appears to be especially relevant to consider these relational values of nature that depart from the intrinsic/instrumental divide and that are now thought to be key in valuing nature (Chan et al. 2016). Finally, wellbeing benefits derived from ecosystem services are important to consider to avoid trade-offs between aspects of wellbeing and between people with different needs and preferences.

Ecosystem service bundles

I propose an alternative way of identifying and describing at ecosystem service bundles in Chapter 6. By grouping ecosystem services according to perceived associations with ecosystem types, I employ a demand perspective rather than the supply perspective. Most demand-side bundle research forms bundles of ecosystem services according to the preferences of different groups of people (Mouchet et al. 2014, Saidi and Spray 2018). While this type of bundling provides information on the social distribution of ecosystem service benefits, it does not specify where in the landscape or the seascape ecosystem services are provided or co-produced (for exceptions, see Brown et al. 2015, Zoderer et al. 2019). I also developed ways to view these bundles from different angles in terms of the number of people benefiting and ecosystem service composition. Therefore, this approach to analyzing bundles could inform environmental management and urban planning on how and where people perceive benefiting from ecosystem services in the land and seascape.

Ecosystem service access

Most ecosystem service research focuses on availability or supply of ecosystem services without consideration of socially differentiated access (Daw et al. 2011, Mastrángelo et al. 2019). In contrast, the natural resources literature drawing on Ribot & Peluso's theory of access (2003) often omits consideration of material aspects of the object of study, such as the availability of ecosystem services (Myers and Hansen 2019). I demonstrated in Chapter 7 the importance of considering availability in addition to access when looking at limitations to ecosystem service benefits, supporting previous findings from rural areas of Mozambique and Canada (e.g., Milgroom et al. 2014, Wieland et al. 2016). Therefore, understanding the relative roles of ecosystem service availability and access limitations is essential to inform environmental management that aims to improve the actual flow of benefits to people.

8.3 Limitations and caveats

My research has three main caveats. The main caveat of my study that might prevent further generalization is the fact that the urban and rural sites differ from those of the Global North and more populous countries of the Global South, and are considered by some as urban and rural hybrids (Moore 2015, Lindstrom and Jourdan 2017). However, urbanization occurs on a continuum from traditional rural areas based on subsistence activities to modern metropolises such as Tokyo with most people completely disconnected from direct access to provisioning services (Cumming et al. 2014). The sites that I selected were located at different points along this continuum, even if these urban sites do not fit the archetype of a modern city. The fact that these urban and rural sites were different enough to pick up an urbanization effect is an important and novel finding.

The second caveat is that I chose to limit the number of ecosystem services assessed to nine. Although I believe that the trends found would hold if different ecosystem services had been added, this needs to be investigated. However, I probably minimized the risk of omitting the most important ecosystem services for Solomon Islanders by consulting with experts and conducting focus group discussions to select the ecosystem services studied.

The third caveat is that while imposing a framework allows structuring of the research process from the planning to the interpretation of findings, it also simplifies complex realities into pre-determined concepts. I used frameworks for ecosystem services, social wellbeing, and access mechanisms that were developed in the Western world. These frameworks are flexible and have all been used in a wide range of contexts, but worldviews of nature and wellbeing held by Solomon Islanders might differ from the perspective proposed in these Western-centric frameworks. In consequence, some particularities of the human-nature relationships could have been overlooked or misunderstood. While it is not possible to avoid this caveat completely, I tried to minimize it by spending six months in the Solomon Islands, living with Solomon Islanders, learning Solomon Islands Pijin, and principally through the support of Solomon Islander research assistants.

8.4 Future research needs

I suggest three avenues for future research. First, more research using paired urban-rural comparisons needs to be conducted in different parts of the world, at different points along the rural-urban gradient, especially in the Global South. As I have shown in my literature review, few socio-cultural studies have used this approach so far. However, in addition to providing valuable localized information, similarities and differences between societies could help understand the effects of culture, natural ecosystems, and traditional human-nature relationships in mediating the impacts of urbanization on socio-cultural valuation. Commonalities among different types of societies could help make generalizations and predictions about the outcomes of urbanization on human-nature relationships. Urbanization is a worldwide phenomenon, not only happening in countries of the Global North and China, as the geographic representation of the research seems to imply. Moreover, the potential implications of this research in terms of wellbeing improvements might be even greater in countries of the Global South and for poor and vulnerable urban dwellers.

Second, although I suspect that urbanization affects urban dwellers' overall wellbeing through decreased contributions of ecosystem services – especially since subjective wellbeing was lower in urban than in rural areas – the relative role that ecosystem services play in a person's wellbeing require further investigations. For instance, research conducted in urban areas in

Italy has compared the value to people of ecosystem services and human-made services (e.g., infrastructures, services, institutions, businesses) found that 46% of livability was associated with ecosystem services (Antognelli and Vizzari 2016). In the case of the Solomon Islands, I suspect that the relative contribution of ecosystem services would be higher because of the importance of traditional rural roots with deep connections with nature as portrayed throughout this thesis as well as research drawing on traditional ecological knowledge (e.g., Aswani and Vaccaro 2008, Lauer and Aswani 2009). Since improving wellbeing is being considered more and more as the end goal of public policies (Costanza et al. 2014, Stiglitz et al. 2018), demonstrating the importance of ecosystems for human wellbeing could strengthen the argument to conserve and restore nature for decision-makers.

Finally, an interesting and challenging avenue for future research would be to link people's preferences for ecosystem services to actual impacts on the environment. This would transform the useful but overly simplistic ecosystem service cascade into a dynamic loop (Cumming et al. 2014). To do so, the links between people's preferences, needs and values and their behavior towards the environment would need to be investigated. Furthermore, the reasons why people would not act in accordance with their stated preferences, needs and values could shed light on the role of conflicting values, socio-economic contexts and incentives; all of which could guide environmental awareness programs and environmental policies.

8.5 Conclusion

In sum, I have shown in this thesis that urbanization in the Solomon Islands alters human-nature relationships and decreases the contributions of provisioning, regulating, and cultural ecosystem services to human wellbeing. These changes affected primarily the material, but also the relational and subjective wellbeing dimensions. Urbanization also simplified relationships with most ecosystems, which became more indirect through regulating services and stewardship, losing some of the connections through provisioning services, but also culture and recreation for some ecosystems. I found that the effects of urbanization were not due mainly to preferences, as indicated by lower satisfaction levels in urban areas, but rather to decreased ecosystem service availability for all ecosystem services and access mechanisms

in the case of provisioning and cultural services, as well as increased wealth associated to changes in livelihood activities in urban areas.

Now that that most of humanity lives in cities and urbanization will continue into the future, more research is needed to understand perceived impacts of living in cities on urban dwellers' relationships with nature. A better understanding of human-nature relationships viewed in terms of ecosystem services has implications for urban planning and environmental management. Considering people's perceptions of ecosystem services in urban planning and environmental management could help improve the wellbeing of urban dwellers, while conserving and restoring ecosystems in and around cities. Furthermore, this type of research can contribute in several ways to reach the Sustainable Development Goal 11 to *make cities and human settlements inclusive, safe, resilient and sustainable* (United Nations 2015).

Understanding people's needs and preferences towards nature and ecosystem services can help make cities more inclusive and safe. By identifying barriers to access for different people in societies, planning and management can lead to more equitable outcomes. Understanding what people perceive as ecosystem disservices might help mitigate their negative impacts on wellbeing and improve urban safety. Environmental, social, and economic resilience can be increased by maximizing the benefits that people receive from ecosystem services, especially when considered as bundles in the land and seascapes, to avoid unintended detrimental trade-offs between services. For example, urban gardens and forests in Honiara can provide food and medicine that can be important safety nets for vulnerable urban dwellers in times of hardship, but also places to recreate and meet neighbors, while plants filter air pollution and provide shade, and the soil absorbs water runoffs preventing inundations. Finally, understanding people's relationships with nature through socio-cultural valuation could help find opportunities to foster connections with nature and therefore pro-environmental behavior and, ultimately, facilitate the transition of societies along more sustainable trajectories.

References

Abunge, C., S. Coulthard, and T. M. Daw. 2013. Connecting marine ecosystem services to human well-being: insights from participatory well-being assessment in Kenya. Ambio **42**:1010-1021.

Adler, A., and M. E. Seligman. 2016. Using wellbeing for public policy: Theory, measurement, and recommendations. International Journal of Wellbeing **6**:1-35.

Agarwala, M., G. Atkinson, B. P. Fry, K. Homewood, S. Mourato, J. M. Rowcliffe, G. Wallace, and E. Milner-Gulland. 2014. Assessing the relationship between human well-being and ecosystem services: a review of frameworks. Conservation and Society **12**:437-449.

Aguado, M., J. A. González, C. López-Santiago, and C. Montes. 2018. Exploring subjective well-being and ecosystem services perception along a rural–urban gradient in the high Andes of Ecuador. Ecosystem Services **34**:1-10.

Ament, J. M., C. A. Moore, M. Herbst, and G. S. Cumming. 2016. Cultural Ecosystem Services in Protected Areas: Understanding Bundles, Trade-Offs, and Synergies. Conservation Letters.

Antognelli, S., and M. Vizzari. 2016. Ecosystem and urban services for landscape liveability: A model for quantification of stakeholders' perceived importance. Land use policy **50**:277-292.

Antognelli, S., and M. Vizzari. 2017. Landscape liveability spatial assessment integrating ecosystem and urban services with their perceived importance by stakeholders. Ecological Indicators **72**:703-725.

Asah, S. T., A. D. Guerry, D. J. Blahna, and J. J. Lawler. 2014. Perception, acquisition and use of ecosystem services: Human behavior, and ecosystem management and policy implications. Ecosystem Services **10**:180-186.

Asian Development Bank. 2015. Solomon Islands Country Gender Assessment. Mandaluyong City, Philippines.

Aswani, S., and I. Vaccaro. 2008. Lagoon ecology and social strategies: habitat diversity and ethnobiology. Human Ecology **36**:325-341.

Bai, Y., C. Zhuang, Z. Ouyang, H. Zheng, and B. Jiang. 2011. Spatial characteristics between biodiversity and ecosystem services in a human-dominated watershed. Ecological complexity **8**:177-183.

Balzan, M. V., J. Caruana, and A. Zammit. 2018. Assessing the capacity and flow of ecosystem services in multifunctional landscapes: Evidence of a rural-urban gradient in a Mediterranean small island state. Land use policy **75**:711-725.

Baró, F., E. Gómez-Baggethun, and D. Haase. 2017. Ecosystem service bundles along the urban-rural gradient: Insights for landscape planning and management. Ecosystem Services **24**:147-159.

Barrera-Hernández, L. F., M. A. Sotelo-Castillo, S. B. Echeverría-Castro, and C. O. Tapia-Fonllem. 2020. Connectedness to Nature: Its Impact on Sustainable Behaviors and Happiness in Children. Frontiers in Psychology **11**.

Bates, D., M. Maechler, B. Bolker, S. Walker, R. H. B. Christensen, H. Singmann, B. Dai, F. Scheipl, G. Grothendieck, P. Green, and J. Fox. 2019. lme4.

Beauchamp, E., E. Woodhouse, T. Clements, and E. J. Milner-Gulland. 2018. "Living a good life": conceptualizations of well-being in a conservation context in Cambodia. Ecology and Society **23**.

Behrens, K., and F. Robert-Nicoud. 2014. Do cities widen the gap between rich and poor.*in* World Economic Forum.

Bennett, E., W. Cramer, A. Begossi, G. Cundill, S. Díaz, B. Egoh, I. Geijzendorffer, C. Krug, S. Lavorel, and E. Lazos. 2015. Linking biodiversity, ecosystem services, and human well-being: three challenges for designing research for sustainability. Current Opinion in Environmental Sustainability **14**:76-85.

Bennett, E., G. Peterson, and L. Gordon. 2009. Understanding relationships among multiple ecosystem services. Ecology Letters **12**:1394-1404.

Bennett, N. J. 2016. Using perceptions as evidence to improve conservation and environmental management. Conservation Biology **30**:582-592.

Berbés-Blázquez, M., M. J. Bunch, P. R. Mulvihill, G. D. Peterson, and B. v. W. de Joode. 2017. Understanding how access shapes the transformation of ecosystem services to human well-being with an example from Costa Rica. Ecosystem Services **28**:320-327.

Blanco, J., N. Dendoncker, C. Barnaud, and C. Sirami. 2019. Ecosystem disservices matter: Towards their systematic integration within ecosystem service research and policy. Ecosystem Services **36**:100913.

Bolker, B. M., M. E. Brooks, C. J. Clark, S. W. Geange, J. R. Poulsen, M. H. H. Stevens, and J.-S. S. White. 2009. Generalized linear mixed models: a practical guide for ecology and evolution. Trends in ecology & evolution **24**:127-135.

Braito, M. T., K. Böck, C. Flint, A. Muhar, S. Muhar, and M. Penker. 2017. Human-Nature Relationships and Linkages to Environmental Behaviour. Environmental Values **26**:365-389.

Bratman, G. N., C. B. Anderson, M. G. Berman, B. Cochran, S. de Vries, J. Flanders, C. Folke, H. Frumkin, J. J. Gross, and T. Hartig. 2019. Nature and mental health: An ecosystem service perspective. Science advances **5**:eaax0903.

Bren d'Amour, C., F. Reitsma, G. Baiocchi, S. Barthel, B. Güneralp, K.-H. Erb, H. Haberl, F. Creutzig, and K. C. Seto. 2017. Future urban land expansion and implications for global croplands. Proceedings of the National Academy of Sciences **114**:8939-8944.

Britton, E., and S. Coulthard. 2013. Assessing the social wellbeing of Northern Ireland's fishing society using a three-dimensional approach. Marine Policy **37**:28-36.

Brown, G., V. Helene Hausner, and E. Lægreid. 2015. Physical landscape associations with mapped ecosystem values with implications for spatial value transfer: An empirical study from Norway. Ecosystem Services **15**:19-34.

Brown, G., J. M. Montag, and K. Lyon. 2012. Public participation GIS: a method for identifying ecosystem services. Society & natural resources **25**:633-651.

Brown, K., T. Daw, S. Rosendo, M. Bunce, and N. Cherrett. 2008. Ecosystem services for poverty alleviation: marine & coastal situational analysis, synthesis report. Ecosystem for Poverty Alleviation Programme: DFID/NERC/SRC.

Burkhard, B., F. Kroll, S. Nedkov, and F. Müller. 2012. Mapping ecosystem service supply, demand and budgets. Ecological Indicators **21**:17-29.

Caballero-Serrano, V., M. Onaindia, J. G. Alday, D. Caballero, J. C. Carrasco, B. McLaren, and J. Amigo. 2016. Plant diversity and ecosystem services in Amazonian homegardens of Ecuador. Agriculture, Ecosystems & Environment **225**:116-125.

Campagne, C. S., P. K. Roche, and J.-M. Salles. 2018. Looking into Pandora's Box: ecosystem disservices assessment and correlations with ecosystem services. Ecosystem Services **30**:126-136.

Campbell, S. 2010. Comparative Case Study.–Encyclopedia of Case Study Research. Ed. Mills, AJ, Durepos, G., Wiebe, E. SAGE research methods.

Caro-Borrero, A., E. Corbera, K. C. Neitzel, and L. Almeida-Leñero. 2015. "We are the city lungs": Payments for ecosystem services in the outskirts of Mexico City. Land use policy **43**:138-148.

Carvalho-Ribeiro, S. M., and A. Lovett. 2011. Is an attractive forest also considered well managed? Public preferences for forest cover and stand structure across a rural/urban gradient in northern Portugal. Forest Policy and Economics **13**:46-54.

Casado-Arzuaga, I., I. Madariaga, and M. Onaindia. 2013. Perception, demand and user contribution to ecosystem services in the Bilbao Metropolitan Greenbelt. Journal of Environmental Management **129**:33-43.

Chaigneau, T., K. Brown, S. Coulthard, T. M. Daw, and L. Szaboova. 2019. Money, use and experience: Identifying the mechanisms through which ecosystem services contribute to wellbeing in coastal Kenya and Mozambique. Ecosystem Services **38**:100957.

Chan, K. M., P. Balvanera, K. Benessaiah, M. Chapman, S. Díaz, E. Gómez-Baggethun, R. Gould, N. Hannahs, K. Jax, and S. Klain. 2016. Opinion: Why protect nature? Rethinking values and the environment. Proceedings of the National Academy of Sciences **113**:1462-1465.

Chan, K. M., A. D. Guerry, P. Balvanera, S. Klain, T. Satterfield, X. Basurto, A. Bostrom, R. Chuenpagdee, R. Gould, and B. S. Halpern. 2012. Where are cultural and social in ecosystem services? A framework for constructive engagement. BioScience **62**:744-756.

Charnley, S., R. J. McLain, and M. R. Poe. 2018. Natural resource access rights and wrongs: Nontimber forest products gathering in urban environments. Society & natural resources **31**:734-750.

Chaudhary, S., A. McGregor, D. Houston, and N. Chettri. 2018. Environmental justice and ecosystem services: A disaggregated analysis of community access to forest benefits in Nepal. Ecosystem Services **29**:99-115.

Christensen, R. H. B. 2019a. Cumulative link models for ordinal regression with the R package Ordinal.

Christensen, R. H. B. 2019b. Regression Models for Ordinal Data.

Christie, M., I. Fazey, R. Cooper, T. Hyde, and J. O. Kenter. 2012. An evaluation of monetary and non-monetary techniques for assessing the importance of biodiversity and ecosystem services to people in countries with developing economies. Ecological economics **83**:67-78.

CIA. 2019. The World Factbook. Solomon Islands.

Cord, A. F., B. Bartkowski, M. Beckmann, A. Dittrich, K. Hermans-Neumann, A. Kaim, N. Lienhoop, K. Locher-Krause, J. Priess, C. Schröter-Schlaack, N. Schwarz, R. Seppelt, M. Strauch, T. Václavík, and M. Volk. 2017. Towards systematic analyses of ecosystem service trade-offs and synergies: Main concepts, methods and the road ahead. Ecosystem Services **28**:264-272.

Corrin, J. C. 2012. Customary land in Solomon Islands: A victim of legal pluralism. Droit Foncier Et Gouvernance Judiciaire Dans Le Pacifique: Land Law and Governance in the South Pacific:12-11.

Costanza, R. 2008. Ecosystem services: Multiple classification systems are needed. Biological conservation **141**:350-352.

Costanza, R., R. d'Arge, R. De Groot, S. Farber, M. Grasso, B. Hannon, K. Limburg, S. Naeem, R. V. O'neill, and J. Paruelo. 1997. The value of the world's ecosystem services and natural capital. Nature **387**:253-260.

Costanza, R., R. de Groot, L. Braat, I. Kubiszewski, L. Fioramonti, P. Sutton, S. Farber, and M. Grasso. 2017. Twenty years of ecosystem services: How far have we come and how far do we still need to go? Ecosystem Services **28**:1-16.

Costanza, R., L. Graumlich, W. Steffen, C. Crumley, J. Dearing, K. Hibbard, R. Leemans, C. Redman, and D. Schimel. 2007. Sustainability or collapse: what can we learn from integrating the history of humans and the rest of nature? AMBIO: A Journal of the Human Environment **36**:522-527.

Costanza, R., I. Kubiszewski, E. Giovannini, H. Lovins, J. McGlade, K. E. Pickett, K. V. Ragnarsdóttir, D. Roberts, R. De Vogli, and R. Wilkinson. 2014. Time to leave GDP behind. Nature **505**:283-285.

Coulthard, S., L. Evans, R. Turner, D. Mills, S. Foale, K. Abernethy, C. Hicks, and I. Monnereau. 2017. Exploring 'islandness' and the impacts of nature conservation through the lens of wellbeing. Environmental Conservation **44**:298-309.

Coulthard, S., D. Johnson, and J. A. McGregor. 2011. Poverty, sustainability and human wellbeing: a social wellbeing approach to the global fisheries crisis. Global Environmental Change **21**:453-463.

Coulthard, S., N. Paranamana, L. SANDARUWAN, R. MANIMOHAN, R. MAYA, O. AMARASINGHE, D. KORALGAMA, E. BRITTON, J. BENE, and A. MCGREGOR. 2015. Exploring wellbeing in fishing communities (South Asia). Methods handbook, Online open access publication available at https://www. researchgate. net/profile/Sarah_Coulthard.

Coulthard, S., L. Sandaruwan, N. Paranamana, and D. Koralgama. 2014. Taking a well-being approach to fisheries research: Insights from a Sri Lankan fishing village and relevance for sustainable fisheries. Pages 76-100 *in* L. Camfield, editor. Methodological challenges and new approaches to research in international development. Palgrave Macmillan, London.

Coutts, C., and M. Hahn. 2015. Green infrastructure, ecosystem services, and human health. International journal of environmental research and public health **12**:9768-9798.

Cox, D. T., D. F. Shanahan, H. L. Hudson, R. A. Fuller, and K. J. Gaston. 2018. The impact of urbanisation on nature dose and the implications for human health. Landscape and Urban Planning **179**:72-80.

Cumming, G. S., A. Buerkert, E. M. Hoffmann, E. Schlecht, S. von Cramon-Taubadel, and T. Tscharntke. 2014. Implications of agricultural transitions and urbanization for ecosystem services. Nature **515**:50-57.

Cumming, G. S., and K. Maciejewski. 2017. Reconciling community ecology and ecosystem services: Cultural services and benefits from birds in South African National Parks. Ecosystem Services **28**:219-227.

Cumming, G. S., and S. von Cramon-Taubadel. 2018. Linking economic growth pathways and environmental sustainability by understanding development as alternate social–ecological regimes. Proceedings of the National Academy of Sciences **115**:9533-9538.

da Cunha Ávila, J. V., A. S. d. Santos de Mello, M. E. Beretta, R. Trevisan, P. Fiaschi, and N. Hanazaki. 2017. Agrobiodiversity and in situ conservation in quilombola home gardens with different intensities of urbanization. Acta Botanica Brasilica:0-0.

Daily, G. C. 1997. Introduction: what are ecosystem services.*in* G. C. Daily, editor. Nature's Services: Societal Dependence On Natural Ecosystems. Island Press, Washington, DC.

Daily, G. C., S. Polasky, J. Goldstein, P. M. Kareiva, H. A. Mooney, L. Pejchar, T. H. Ricketts, J. Salzman, and R. Shallenberger. 2009. Ecosystem services in decision making: time to deliver. Frontiers in Ecology and the Environment **7**:21-28.

Daniel, T. C., A. Muhar, A. Arnberger, O. Aznar, J. W. Boyd, K. M. Chan, R. Costanza, T. Elmqvist, C. G. Flint, and P. H. Gobster. 2012. Contributions of cultural services to the ecosystem services agenda. Proceedings of the National Academy of Sciences **109**:8812-8819.

Daw, T., K. Brown, S. Rosendo, and R. Pomeroy. 2011. Applying the ecosystem services concept to poverty alleviation: the need to disaggregate human well-being. Environmental Conservation **38**:370-379.

Daw, T., C. Hicks, K. Brown, T. Chaigneau, F. Januchowski-Hartley, W. Cheung, S. Rosendo, B. Crona, S. Coulthard, and C. Sandbrook. 2016. Elasticity in ecosystem services: exploring the variable relationship between ecosystems and human well-being. Ecology and Society **21**:11.

Dawson, N., and A. Martin. 2015. Assessing the contribution of ecosystem services to human wellbeing: A disaggregated study in western Rwanda. Ecological economics **117**:62-72.

De Groot, R. S., R. Alkemade, L. Braat, L. Hein, and L. Willemen. 2010. Challenges in integrating the concept of ecosystem services and values in landscape planning, management and decision making. Ecological complexity **7**:260-272.

Depellegrin, D., P. Pereira, I. Misiunė, and L. Egarter-Vigl. 2016. Mapping ecosystem services potential in Lithuania. International Journal of Sustainable Development & World Ecology **23**:441-455.

Di Minin, E., N. Leader-Williams, and C. J. Bradshaw. 2016. Banning trophy hunting will exacerbate biodiversity loss. Trends in ecology & evolution **31**:99-102.

Díaz, S., S. Demissew, J. Carabias, C. Joly, M. Lonsdale, N. Ash, A. Larigauderie, J. R. Adhikari, S. Arico, and A. Báldi. 2015. The IPBES Conceptual Framework—connecting nature and people. Current Opinion in Environmental Sustainability **14**:1-16.

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

Dolnicar, S., B. Grun, F. Leisch, and J. Rossiter. 2011. Three good reasons NOT to use five and seven point Likert items.

Duraiappah, A. K., and D. Rogers. 2011. The Intergovernmental Platform on Biodiversity and Ecosystem Services: opportunities for the social sciences. Innovation: The European Journal of Social Science Research **24**:217-224.

Dyball, R., C. D. Ives, and I. White. 2013. Regional Assessment of Oceania.*in* T. Elmqvist, M. Fragkias, J. Goodness, B. Güneralp, P. J. Marcotullio, R. I. McDonald, S. Parnell, M. Schewenius, M. Sendstad, K. C. Seto, and C. Wilkinson, editors. Urbanization, Biodiversity and Ecosystem Services: Challenges and Opportunities: A Global Assessment. Springer Netherlands.

Dye, C. 2008. Health and urban living. Science **319**:766-769.

Elbakidze, M., M. Gebrehiwot, P. Angelstam, T. Yamelynets, and D. Surová. 2018. Defining Priority Land Covers that Secure the Livelihoods of Urban and Rural People in Ethiopia: a Case Study Based on Citizens' Preferences. Sustainability **10**:1701.

Elmqvist, T., M. Fragkias, J. Goodness, B. Güneralp, P. J. Marcotullio, R. I. McDonald, S. Parnell, M. Schewenius, M. Sendstad, and K. C. Seto. 2013a. Stewardship of the biosphere in the urban era. Pages 719-746 Urbanization, biodiversity and ecosystem services: Challenges and opportunities. Springer, Dordrecht.

Elmqvist, T., M. Fragkias, J. Goodness, B. Güneralp, P. J. Marcotullio, R. I. McDonald, S. Parnell, M. Schewenius, M. Sendstad, K. C. Seto, and C. Wilkinson. 2013b. Urbanization, Biodiversity and Ecosystem Services: Challenges and Opportunities: A Global Assessment. Springer Netherlands.

Elmqvist, T., C. L. Redman , S. Barthel, and R. Costanza. 2013c. History of Urbanization and the Missing Ecology. Pages 13-30 *in* T. Elmqvist, M. Fragkias, J. Goodness, B. Güneralp, P. J. Marcotullio, R. I. McDonald, S. Parnell, M. Schewenius, M. Sendstad,

K. C. Seto, and C. Wilkinson, editors. Urbanization, Biodiversity and Ecosystem Services: Challenges and Opportunities: A Global Assessment. Springer Netherlands.

ESPA. 2018. Wellbeing: for whom and how? Policy and Practice Briefing. Available online: https://www.espa.ac.uk/files/espa/ESPA%20Wellbeing%20Policy%20Brief%20FINAL%20WEB_0.pdfhttps://www.espa.ac.uk/files/espa/ESPA%20Wellbeing%20Policy%20Brief%20FINAL%20WEB_0.pdf.

Fagerholm, N., N. Käyhkö, F. Ndumbaro, and M. Khamis. 2012. Community stakeholders' knowledge in landscape assessments–Mapping indicators for landscape services. Ecological Indicators **18**:421-433.

Feeny, S., L. McDonald, and A. Posso. 2014. Are poor people less happy? Findings from Melanesia. World Development **64**:448-459.

Felipe-Lucia, M. R., F. A. Comín, and J. Escalera-Reyes. 2015. A framework for the social valuation of ecosystem services. Ambio **44**:308-318.

Fernandes, R., and P. Pinho. 2017. The distinctive nature of spatial development on small islands. Progress in Planning **112**:1-18.

Fisher, B., R. K. Turner, and P. Morling. 2009. Defining and classifying ecosystem services for decision making. Ecological economics **68**:643-653.

Fisher, J. A., G. Patenaude, K. Giri, K. Lewis, P. Meir, P. Pinho, M. D. Rounsevell, and M. Williams. 2014. Understanding the relationships between ecosystem services and poverty alleviation: A conceptual framework. Ecosystem Services **7**:34-45.

Fisher, J. A., G. Patenaude, P. Meir, A. J. Nightingale, M. D. Rounsevell, M. Williams, and I. H. Woodhouse. 2013. Strengthening conceptual foundations: analysing frameworks for ecosystem services and poverty alleviation research. Global Environmental Change **23**:1098-1111.

Fortnam, M., K. Brown, T. Chaigneau, B. Crona, T. M. Daw, D. Gonçalves, C. Hicks, M. Revmatas, C. Sandbrook, and B. Schulte-Herbruggen. 2019. The gendered nature of ecosystem services. Ecological economics **159**:312-325.

Foukona, J. D. 2017. Solomon Islands' Urban Land Tenure: Growing Complexity. State, Society & Governance in Melanesia.

Fox, J., S. Weisberg, B. Price, D. Adler, D. Bates, G. Baud-Bovy, B. Bolker, S. Ellison, D. Firth, M. Friendly, G. Gorjanc, S. Graves, R. Heiberger, R. Laboissiere, M. Maechler, G. Monette, D. Murdoch, H. Nilsson, D. Ogle, B. Ripley, W. Venables, S. Walker, D.

Winsemius, A. Zeileis, and R-Core. 2019. car: Companion to Applied Regression. R package version 3.0-2.

García-Llorente, M., A. J. Castro, C. Quintas-Soriano, I. López, H. Castro, C. Montes, and B. Martín-López. 2016. The value of time in biological conservation and supplied ecosystem services: A willingness to give up time exercise. Journal of Arid Environments **124**:13-21.

Gollin, D., R. Jedwab, and D. Vollrath. 2016. Urbanization with and without Industrialization. Journal of Economic Growth **21**:35-70.

Gómez-Baggethun, E., Å. Gren, D. N. Barton, J. Langemeyer, T. McPhearson, P. O'Farrell, E. Andersson, Z. Hamstead, and P. Kremer. 2013. Urban Ecosystem Services. Pages 505-537 *in* T. Elmqvist, M. Fragkias, J. Goodness, B. Güneralp, P. J. Marcotullio, R. I. McDonald, S. Parnell, M. Schewenius, M. Sendstad, K. C. Seto, and C. Wilkinson, editors. Urbanization, Biodiversity and Ecosystem Services: Challenges and Opportunities: A Global Assessment. Springer Netherlands.

Gough, I., and J. A. McGregor. 2007. Wellbeing in developing countries: from theory to research. Cambridge University Press.

Granek, E. F., S. Polasky, C. V. Kappel, D. J. Reed, D. M. Stoms, E. W. Koch, C. J. Kennedy, L. A. Cramer, S. D. Hacker, and E. B. Barbier. 2010. Ecosystem services as a common language for coastal ecosystem-based management. Conservation Biology **24**:207-216.

Guerry, A. D., S. Polasky, J. Lubchenco, R. Chaplin-Kramer, G. C. Daily, R. Griffin, M. Ruckelshaus, I. J. Bateman, A. Duraiappah, and T. Elmqvist. 2015. Natural capital and ecosystem services informing decisions: From promise to practice. Proceedings of the National Academy of Sciences **112**:7348-7355.

Gurney, G. G., J. Blythe, H. Adams, W. N. Adger, M. Curnock, L. Faulkner, T. James, and N. A. Marshall. 2017. Redefining community based on place attachment in a connected world. Proceedings of the National Academy of Sciences **114**:10077-10082.

Gurney, G. G., J. Cinner, N. C. Ban, R. L. Pressey, R. Pollnac, S. J. Campbell, S. Tasidjawa, and F. Setiawan. 2014. Poverty and protected areas: An evaluation of a marine integrated conservation and development project in Indonesia. Global Environmental Change **26**:98-107.

Gurney, G. G., J. E. Cinner, J. Sartin, R. L. Pressey, N. C. Ban, N. A. Marshall, and D. Prabuning. 2016. Participation in devolved commons management: Multiscale socioeconomic factors related to individuals' participation in community-based management of marine protected areas in Indonesia. Environmental science & policy **61**:212-220.

Gurney, G. G., and E. S. Darling. 2017. A Global Social-Ecological Systems Monitoring Framework for Coastal Fisheries Management: A Practical Monitoring Handbook. Wildlife Conservation Society, New York.

Gurney, G. G., E. S. Darling, S. D. Jupiter, S. Mangubhai, T. R. McClanahan, P. Lestari, S. Pardede, S. J. Campbell, M. Fox, W. Naisilisili, N. A. Muthiga, S. D'agata, K. E. Holmes, and N. A. Rossi. 2019. Implementing a social-ecological systems framework for conservation monitoring: lessons from a multi-country coral reef program. Biological conservation **240**:108298.

Gurney, G. G., R. L. Pressey, J. E. Cinner, R. Pollnac, and S. J. Campbell. 2015. Integrated conservation and development: evaluating a community-based marine protected area project for equality of socioeconomic impacts. Phil. Trans. R. Soc. B **370**:20140277.

Haase, D., N. Larondelle, E. Andersson, M. Artmann, S. Borgström, J. Breuste, E. Gomez-Baggethun, Å. Gren, Z. Hamstead, and R. Hansen. 2014. A quantitative review of urban ecosystem service assessments: concepts, models, and implementation. Ambio **43**:413-433.

Haberman, D., and E. M. Bennett. 2019. Ecosystem service bundles in global hinterlands. Environmental Research Letters **14**:084005.

Haines-Young, R., and M. Potschin. 2010. The links between biodiversity, ecosystem services and human well-being. Ecosystem Ecology: a new synthesis:110-139.

Haines-Young, R., and M. B. Potschin. 2018. Common International Classification of Ecosystem Services (CICES) V5.1 and Guidance on the Application of the Revised Structure. Available from www.cices.eu.

Harlan, S. L., and D. M. Ruddell. 2011. Climate change and health in cities: impacts of heat and air pollution and potential co-benefits from mitigation and adaptation. Current Opinion in Environmental Sustainability **3**:126-134.

Hartig, F. 2019. DHARMa.

Hartig, T., and P. H. Kahn. 2016. Living in cities, naturally. Science **352**:938-940.

Henderson, J. V. 2010. Cities and development. Journal of Regional Science **50**:515-540.

Hicks, C. C. 2011. How do we value our reefs? Risks and tradeoffs across scales in "biomass-based" economies. Coastal Management **39**:358-376.

Hicks, C. C. 2013. Ecosystem service values and societal settings for coral reef governance James Cook University.

Hicks, C. C., and J. E. Cinner. 2014. Social, institutional, and knowledge mechanisms mediate diverse ecosystem service benefits from coral reefs. Proceedings of the National Academy of Sciences **111**:17791-17796.

Hicks, C. C., N. A. J. Graham, and J. E. Cinner. 2013. Synergies and tradeoffs in how managers, scientists, and fishers value coral reef ecosystem services. Global Environmental Change **23**:1444-1453.

Horcea-Milcu, A.-I., J. Leventon, J. Hanspach, and J. Fischer. 2016. Disaggregated contributions of ecosystem services to human well-being: a case study from Eastern Europe. Regional Environmental Change **16**:1779-1791.

Howe, C., H. Suich, B. Vira, and G. M. Mace. 2014. Creating win-wins from trade-offs? Ecosystem services for human well-being: a meta-analysis of ecosystem service trade-offs and synergies in the real world. Global Environmental Change **28**:263-275.

Hviding, E. 1998. Contextual flexibility: present status and future of customary marine tenure in Solomon Islands. Ocean & Coastal Management **40**:253-269.

Iniesta-Arandia, I., M. García-Llorente, P. A. Aguilera, C. Montes, and B. Martín-López. 2014. Socio-cultural valuation of ecosystem services: uncovering the links between values, drivers of change, and human well-being. Ecological economics **108**:36-48.

IPCC. 2019. Global Warming of 1.5°C: An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty

Jax, K., D. N. Barton, K. M. Chan, R. de Groot, U. Doyle, U. Eser, C. Görg, E. Gómez-Baggethun, Y. Griewald, and W. Haber. 2013. Ecosystem services and ethics. Ecological economics **93**:260-268.

Jupiter, S. 2017. Culture, kastom and conservation in Melanesia: what happens when worldviews collide? Pacific Conservation Biology **23**:139-145.

Kadykalo, A. N., M. D. López-Rodriguez, J. Ainscough, N. Droste, H. Ryu, G. Ávila-Flores, S. Le Clec'h, M. C. Muñoz, L. Nilsson, and S. Rana. 2019. Disentangling 'ecosystem services' and 'nature's contributions to people'. Ecosystems and People **15**:269-287.

Kahn Jr, P. H., and B. Friedman. 1995. Environmental views and values of children in an inner-city black community. Child development **66**:1403-1417.

Kaly, U. L., C. R. Pratt, and J. Mitchell. 2004. The Demonstration Environmental Vulnerability Index (EVI)

Kareiva, P., S. Watts, R. McDonald, and T. Boucher. 2007. Domesticated nature: shaping landscapes and ecosystems for human welfare. Science **316**:1866-1869.

Kenwick, R. A., M. R. Shammin, and W. C. Sullivan. 2009. Preferences for riparian buffers. Landscape and Urban Planning **91**:88-96.

Kibria, A. S., R. Costanza, C. Groves, and A. M. Behie. 2018. The interactions between livelihood capitals and access of local communities to the forest provisioning services of the Sundarbans Mangrove Forest, Bangladesh. Ecosystem Services **32**:41-49.

King, M. F., V. F. Renó, and E. M. Novo. 2014. The concept, dimensions and methods of assessment of human well-being within a socioecological context: a literature review. Social indicators research **116**:681-698.

Klain, S. C., and K. M. Chan. 2012. Navigating coastal values: participatory mapping of ecosystem services for spatial planning. Ecological economics **82**:104-113.

Kremer, P., Z. Hamstead, D. Haase, T. McPhearson, N. Frantzeskaki, E. Andersson, N. Kabisch, N. Larondelle, E. L. Rall, and A. Voigt. 2016. Key insights for the future of urban ecosystem services research. Ecology and Society **21**.

Lapointe, M., G. S. Cumming, and G. G. Gurney. 2019. Comparing Ecosystem Service Preferences between Urban and Rural Dwellers. BioScience **69**:108-116.

Lapointe, M., G. G. Gurney, and G. S. Cumming. 2020a. Perceived availability and access limitations to ecosystem service wellbeing benefits increase in urban areas. Ecology and Society **25**:32.

Lapointe, M., G. G. Gurney, and G. S. Cumming. 2020b. Urbanization alters ecosystem service preferences in a Small Island Developing State. Ecosystem Services **43**:101109.

Lau, J. D., J. E. Cinner, M. Fabinyi, G. G. Gurney, and C. C. Hicks. 2020. Access to marine ecosystem services: Examining entanglement and legitimacy in customary institutions. World Development **126**:104730.

Lau, J. D., C. C. Hicks, G. G. Gurney, and J. E. Cinner. 2018. Disaggregating ecosystem service values and priorities by wealth, age, and education. Ecosystem Services **29**:91-98.

Lau, J. D., C. C. Hicks, G. G. Gurney, and J. E. Cinner. 2019. What matters to whom and why? Understanding the importance of coastal ecosystem services in developing coastal communities. Ecosystem Services **35**:219-230.

Lauer, M., and S. Aswani. 2009. Indigenous ecological knowledge as situated practices: understanding fishers' knowledge in the western Solomon Islands. American Anthropologist **111**:317-329.

Lautenbach, S., A.-C. Mupepele, C. F. Dormann, H. Lee, S. Schmidt, S. S. Scholte, R. Seppelt, A. J. van Teeffelen, W. Verhagen, and M. Volk. 2019. Blind spots in ecosystem services research and challenges for implementation. Regional Environmental Change:1-22.

Lee, H., and S. Lautenbach. 2016. A quantitative review of relationships between ecosystem services. Ecological Indicators **66**:340-351.

Lele, S. 2013. Environmentalisms, justices and the limits of ecosystem services frameworks. Pages 119-139 *in* T. Sikor, editor. The Justices and Injustices of Ecosystem Services. . Routledge, New York, USA.

Lele, S., O. Springate-Baginski, R. Lakerveld, D. Deb, and P. Dash. 2013. Ecosystem services: origins, contributions, pitfalls, and alternatives. Conservation and Society **11**:343.

Lenth, R., H. Singmann, J. Love , P. Buerkner, and M. Herve. 2019. Estimated Marginal Means, aka Least-Squares Means. R package version 1.3. 3.

Lin, B. B., R. A. Fuller, R. Bush, K. J. Gaston, and D. F. Shanahan. 2014. Opportunity or orientation? Who uses urban parks and why. PloS one **9**:e87422.

Lindemann-Matthies, P., D. Keller, X. Li, and B. Schmid. 2013. Attitudes toward forest diversity and forest ecosystem services—a cross-cultural comparison between China and Switzerland. Journal of Plant Ecology **7**:1-9.

Lindsey, P. A., P. Roulet, and S. Romanach. 2007. Economic and conservation significance of the trophy hunting industry in sub-Saharan Africa. Biological conservation **134**:455-469.

Lindstrom, L., and C. Jourdan. 2017. Urban Melanesia. Journal de la Société des Océanistes:5-22.

Long, H., Y. Liu, X. Hou, T. Li, and Y. Li. 2014. Effects of land use transitions due to rapid urbanization on ecosystem services: Implications for urban planning in the new developing area of China. Habitat International **44**:536-544.

López-Santiago, C., E. Oteros-Rozas, B. Martín-López, T. Plieninger, E. González Martín, and J. González. 2014. Using visual stimuli to explore the social perceptions of ecosystem services in cultural landscapes: the case of transhumance in Mediterranean Spain. Ecology and Society **19**.

Louv, R. 2005. Last child in the woods: Saving our kids from nature deficit disorder. Algonquin Books New York, NY.

Louv, R. 2009. Do our kids have nature-deficit disorder. Educational Leadership **67**:24-30.

Luederitz, C., E. Brink, F. Gralla, V. Hermelingmeier, M. Meyer, L. Niven, L. Panzer, S. Partelow, A.-L. Rau, and R. Sasaki. 2015. A review of urban ecosystem services: six key challenges for future research. Ecosystem Services **14**:98-112.

Lyytimäki, J., and M. Sipilä. 2009. Hopping on one leg–The challenge of ecosystem disservices for urban green management. Urban forestry & urban greening **8**:309-315.

MA. 2005a. Ecosystems and human well-being. Millennium Ecosystem Assessment, Island Press, Washington, DC, USA.

MA. 2005b. Urban Systems. Ecosystems and human well-being. Millennium Ecosystem Assessment, Island Press, Washington, DC, USA.

Mackay, C. M., and M. T. Schmitt. 2019. Do people who feel connected to nature do more to protect it? A meta-analysis. Journal of Environmental Psychology **65**:101323.

Maestre-Andrés, S., L. Calvet-Mir, and J. C. van den Bergh. 2016. Sociocultural valuation of ecosystem services to improve protected area management: a multi-method approach applied to Catalonia, Spain. Regional Environmental Change **16**:717-731.

Maggio, R. 2017. Relative Customers: Demand-Sharing, Kinship and Selling in Solomon Islands. Pages 155-175 *in* D. C. Wood, editor. Anthropological Considerations of Production, Exchange, Vending and Tourism. Emerald Publishing Limited.

Malvatumauri National Council of Chiefs. 2012. Alternative Indicators of Well-being for Melanesia.

Manning, P., F. van der Plas, S. Soliveres, E. Allan, F. T. Maestre, G. Mace, M. J. Whittingham, and M. Fischer. 2018. Redefining ecosystem multifunctionality. Nature Ecology & Evolution **2**:427-436.

Marshall, F., J. Dolley, R. Bisht, R. Priya, L. Waldman, P. Amerasinghe, and P. Randhawa. 2018. Ecosystem services and poverty alleviation in urbanising contexts. Pages 111-125 Ecosystem Services and Poverty Alleviation (OPEN ACCESS). Routledge.

Martín-López, B., E. Gómez-Baggethun, M. García-Llorente, and C. Montes. 2014. Trade-offs across value-domains in ecosystem services assessment. Ecological Indicators **37**:220-228.

Martín-López, B., I. Iniesta-Arandia, M. García-Llorente, I. Palomo, I. Casado-Arzuaga, D. G. Del Amo, E. Gómez-Baggethun, E. Oteros-Rozas, I. Palacios-Agundez, and B. Willaarts. 2012. Uncovering ecosystem service bundles through social preferences. PloS one **7**:e38970.

Martin, K. 2007. Your own buai you must buy: The ideology of possessive individualism in Papua New Guinea. Pages 285-298 *in* Anthropological Forum. Taylor & Francis.

Mastrángelo, M. E., N. Pérez-Harguindeguy, L. Enrico, E. Bennett, S. Lavorel, G. S. Cumming, D. Abeygunawardane, L. D. Amarilla, B. Burkhard, and B. N. Egoh. 2019. Key knowledge gaps to achieve global sustainability goals. Nature Sustainability:1-7.

Mastrangelo, M. E., F. Weyland, S. H. Villarino, M. P. Barral, L. Nahuelhual, and P. Laterra. 2014. Concepts and methods for landscape multifunctionality and a unifying framework based on ecosystem services. Landscape ecology **29**:345-358.

McCarter, J., E. Sterling, S. Jupiter, G. Cullman, S. Albert, M. Basi, E. Betley, D. Boseto, E. Bulehite, and R. Harron. 2018. Biocultural approaches to developing well-being indicators in Solomon Islands. Ecology and Society **23**.

McDougall, D. 2017. Lost passports? Disconnection and immobility in the rural and urban Solomon Islands. Journal de la Société des Océanistes:63-76.

McGregor, J. A. 2007. Researching Human Wellbeing: From Concepts to Methodology.*in* I. Gough and J. A. McGregor, editors. Well-Being in Developing Countries: New Approaches and Research Strategies. Cambridge University Press.

McHale, M. R., D. N. Bunn, S. T. Pickett, and W. Twine. 2013. Urban ecology in a developing world: why advanced socioecological theory needs Africa. Frontiers in Ecology and the Environment **11**:556-564.

Mecartney, S., and J. Connell. 2017. Urban Melanesia: The challenges of managing land, modernity and tradition. Pages 57-84 *in* S. McDonnell, M. G. Allen, and C. Filer, editors. Kastom, Property and Ideology: Land Transformations in Melanesia; . ANU Press.

Milgroom, J., K. E. Giller, and C. Leeuwis. 2014. Three interwoven dimensions of natural resource use: Quantity, quality and access in the Great Limpopo Transfrontier Conservation Area. Human Ecology **42**:199-215.

Ministry of Environment Conservation and Meteorology. 2008. Solomon Islands State of Environment Report. Honiara, Solomon Islands.

Mombo, F., L. Lusambo, S. Speelman, J. Buysse, P. Munishi, and G. Van Huylenbroeck. 2014. Scope for introducing payments for ecosystem services as a strategy to reduce deforestation in the Kilombero wetlands catchment area. Forest Policy and Economics **38**:81-89.

Moore, C. 2015. Honiara: Arrival city and Pacific hybrid living space. The Journal of Pacific History **50**:419-436.

Mouchet, M. A., P. Lamarque, B. Martín-López, E. Crouzat, P. Gos, C. Byczek, and S. Lavorel. 2014. An interdisciplinary methodological guide for quantifying associations between ecosystem services. Global Environmental Change **28**:298-308.

Muhar, A., C. M. Raymond, R. J. van den Born, N. Bauer, K. Böck, M. Braito, A. Buijs, C. Flint, W. T. de Groot, and C. D. Ives. 2017. A model integrating social-cultural concepts of nature into frameworks of interaction between social and natural systems. Journal of Environmental Planning and Management:1-22.

Müller, F., S. Bicking, K. Ahrendt, D. K. Bac, I. Blindow, C. Fürst, P. Haase, M. Kruse, T. Kruse, and L. Ma. 2020. Assessing ecosystem service potentials to evaluate terrestrial, coastal and marine ecosystem types in Northern Germany–An expert-based matrix approach. Ecological Indicators **112**:106116.

Myers, R., and C. P. Hansen. 2019. Revisiting a theory of access: a review. Society & natural resources:1-21.

Naeem, S., D. E. Bunker, A. Hector, M. Loreau, and C. Perrings. 2009. Biodiversity, ecosystem functioning, and human wellbeing: an ecological and economic perspective. Oxford University Press.

Nagendra, H., X. Bai, E. S. Brondizio, and S. Lwasa. 2018. The urban south and the predicament of global sustainability. Nature Sustainability **1**:341-349.

Noro Town Council. 2017. Three years development plan: policy objectives ,target projects and programs and activities 2017-2019.

Oliver, R. L. 1977. Effect of expectation and disconfirmation on postexposure product evaluations: An alternative interpretation. Journal of applied psychology **62**:480.

Orenstein, D. E., and E. Groner. 2014. In the eye of the stakeholder: changes in perceptions of ecosystem services across an international border. Ecosystem Services **8**:185-196.

Østby, G. 2016. Rural–urban migration, inequality and urban social disorder: evidence from African and Asian cities. Conflict Management and Peace Science **33**:491-515.

Oteros-Rozas, E., B. Martín-López, J. A. González, T. Plieninger, C. A. López, and C. Montes. 2014. Socio-cultural valuation of ecosystem services in a transhumance social-ecological network. Regional Environmental Change **14**:1269-1289.

Palomo, I., M. R. Felipe-Lucia, E. M. Bennett, B. Martín-López, and U. Pascual. 2016. Chapter Six-Disentangling the Pathways and Effects of Ecosystem Service Co-Production. Advances in Ecological Research **54**:245-283.

Pan, Y., S. Marshall, and L. Maltby. 2016. Prioritising ecosystem services in Chinese rural and urban communities. Ecosystem Services **21**:1-5.

Papworth, S. K., J. Rist, L. Coad, and E. J. Milner-Gulland. 2009. Evidence for shifting baseline syndrome in conservation. Conservation Letters **2**:93-100.

Pascual, U., P. Balvanera, S. Díaz, G. Pataki, E. Roth, M. Stenseke, R. T. Watson, E. B. Dessane, M. Islar, and E. Kelemen. 2017. Valuing nature's contributions to people: the IPBES approach. Current Opinion in Environmental Sustainability **26**:7-16.

Paudyal, K., H. Baral, B. Burkhard, S. P. Bhandari, and R. J. Keenan. 2015. Participatory assessment and mapping of ecosystem services in a data-poor region: Case study of community-managed forests in central Nepal. Ecosystem Services **13**:81-92.

Pauly, D. 1995. Anecdotes and the shifting baseline syndrome of fisheries. Trends in ecology & evolution **10**:430.

Plieninger, T., S. Dijks, E. Oteros-Rozas, and C. Bieling. 2013. Assessing, mapping, and quantifying cultural ecosystem services at community level. Land use policy **33**:118-129.

Plieninger, T., M. Torralba, T. Hartel, and N. Fagerholm. 2019. Perceived ecosystem services synergies, trade-offs, and bundles in European high nature value farming landscapes. Landscape ecology:1-17.

Poteete, A. R., M. A. Janssen, and E. Ostrom. 2010. Working together: collective action, the commons, and multiple methods in practice. Princeton University Press.

Potts, S. G., H. T. Ngo, J. C. Biesmeijer, T. D. Breeze, L. V. Dicks, L. A. Garibaldi, R. Hill, J. Settele, and A. Vanbergen. 2016. The assessment report of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services on pollinators, pollination and food production.

Power, A. G. 2010. Ecosystem services and agriculture: tradeoffs and synergies. Philosophical Transactions of the Royal Society of London B: Biological Sciences **365**:2959-2971.

Pyle, R. M. 2003. Nature matrix: reconnecting people and nature. Oryx **37**:206-214.

Qiu, J., and M. G. Turner. 2013. Spatial interactions among ecosystem services in an urbanizing agricultural watershed. Proceedings of the National Academy of Sciences **110**:12149-12154.

Queiroz, C., M. Meacham, K. Richter, A. V. Norström, E. Andersson, J. Norberg, and G. Peterson. 2015. Mapping bundles of ecosystem services reveals distinct types of multifunctionality within a Swedish landscape. Ambio **44**:89-101.

R Core Team. 2018. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria.

R Core Team. 2019. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria.

Racevskis, L. A., and F. Lupi. 2006. Comparing urban and rural perceptions of and familiarity with the management of forest ecosystems. Society and natural resources **19**:479-495.

Radford, K. G., and P. James. 2013. Changes in the value of ecosystem services along a rural–urban gradient: A case study of Greater Manchester, UK. Landscape and Urban Planning **109**:117-127.

Rall, E., C. Bieling, S. Zytynska, and D. Haase. 2017. Exploring city-wide patterns of cultural ecosystem service perceptions and use. Ecological Indicators **77**:80-95.

Raudsepp-Hearne, C., G. D. Peterson, and E. Bennett. 2010a. Ecosystem service bundles for analyzing tradeoffs in diverse landscapes. Proceedings of the National Academy of Sciences **107**:5242-5247.

Raudsepp-Hearne, C., G. D. Peterson, M. Tengö, E. M. Bennett, T. Holland, K. Benessaiah, G. K. MacDonald, and L. Pfeifer. 2010b. Untangling the environmentalist's paradox: why is human well-being increasing as ecosystem services degrade? BioScience **60**:576-589.

Raymond, C. M., B. A. Bryan, D. H. MacDonald, A. Cast, S. Strathearn, A. Grandgirard, and T. Kalivas. 2009. Mapping community values for natural capital and ecosystem services. Ecological economics **68**:1301-1315.

Reyers, B., G. Bidoglio, U. Dhar, H. Gundimeda, P. O'Farrell, M. L. Paracchini, O. G. Prieto, and F. Schutyser. 2010. Measuring biophysical quantities and the use of indicators.*in* P. Kumar, editor. The economics of ecosystems and biodiversity: ecological and economic foundations. UNEP/Earthprint.

Ribot, J. C., and N. L. Peluso. 2003. A theory of access. Rural sociology **68**:153-181.

Rieb, J. T., R. Chaplin-Kramer, G. C. Daily, P. R. Armsworth, K. Böhning-Gaese, A. Bonn, G. S. Cumming, F. Eigenbrod, V. Grimm, and B. M. Jackson. 2017. When, where, and how nature matters for ecosystem services: challenges for the next generation of ecosystem service models. BioScience **67**:820-833.

Rio, K. 2017. Demand-sharing and fences: Aspects of the new Port Vila household. Journal de la Société des Océanistes:91a-104a.

Robards, M. D., M. L. Schoon, C. L. Meek, and N. L. Engle. 2011. The importance of social drivers in the resilient provision of ecosystem services. Global Environmental Change **21**:522-529.

Rodríguez, J. P., T. D. Beard, E. M. Bennett, G. S. Cumming, S. J. Cork, J. Agard, A. P. Dobson, and G. D. Peterson. 2006. Trade-offs across space, time, and ecosystem services. Ecology and Society **11**:28.

Russell, R., A. D. Guerry, P. Balvanera, R. K. Gould, X. Basurto, K. M. Chan, S. Klain, J. Levine, and J. Tam. 2013. Humans and nature: how knowing and experiencing nature affect well-being. Annual Review of Environment and Resources **38**:473-502.

Saidi, N., and C. Spray. 2018. Ecosystem services bundles: challenges and opportunities for implementation and further research. Environmental Research Letters **13**:113001.

Sander, H. A., and C. Zhao. 2015. Urban green and blue: Who values what and where? Land use policy **42**:194-209.

Scholte, S. S., A. J. van Teeffelen, and P. H. Verburg. 2015. Integrating socio-cultural perspectives into ecosystem service valuation: a review of concepts and methods. Ecological economics **114**:67-78.

Seto, K. C., J. S. Golden, M. Alberti, and B. L. Turner. 2017. Sustainability in an urbanizing planet. Proceedings of the National Academy of Sciences **114**:8935-8938.

Seto, K. C., S. Parnell, and T. Elmqvist. 2013. A Global Outlook on Urbanization. Pages 1-12 *in* T. Elmqvist, M. Fragkias, J. Goodness, B. Güneralp, P. J. Marcotullio, R. I. McDonald, S. Parnell, M. Schewenius, M. Sendstad, K. C. Seto, and C. Wilkinson, editors. Urbanization, Biodiversity and Ecosystem Services: Challenges and Opportunities: A Global Assessment. Springer Netherlands.

Seto, K. C., A. Reenberg, C. G. Boone, M. Fragkias, D. Haase, T. Langanke, P. Marcotullio, D. K. Munroe, B. Olah, and D. Simon. 2012. Urban land teleconnections and sustainability. Proceedings of the National Academy of Sciences **109**:7687-7692.

Shackleton, C., S. Ruwanza, G. S. Sanni, S. Bennett, P. De Lacy, R. Modipa, N. Mtati, M. Sachikonye, and G. Thondhlana. 2016. Unpacking Pandora's box: understanding and categorising ecosystem disservices for environmental management and human wellbeing. Ecosystems **19**:587-600.

Shanahan, D. F., R. Bush, K. J. Gaston, B. B. Lin, J. Dean, E. Barber, and R. A. Fuller. 2016. Health benefits from nature experiences depend on dose. Scientific reports **6**:28551.

Shi, H., M. Zhao, F. A. Aregay, K. Zhao, and Z. Jiang. 2016. Residential Environment Induced Preference Heterogeneity for River Ecosystem Service Improvements: A Comparison between Urban and Rural Households in the Wei River Basin, China. Discrete Dynamics in Nature and Society **2016**.

Smets, P., and T. Salman. 2008. Countering urban segregation: Theoretical and policy innovations from around the globe. Urban Studies **45**:1307-1332.

Soga, M., and K. J. Gaston. 2016. Extinction of experience: the loss of human–nature interactions. Frontiers in Ecology and the Environment **14**:94-101.

Soga, M., and K. J. Gaston. 2018. Shifting baseline syndrome: causes, consequences, and implications. Frontiers in Ecology and the Environment **16**:222-230.

Solomon Islands National Statistics Office. 2015. Solomon Islands 2012/13 Household Income and Expenditure Survey National Analytical Report.

Song, M., L. Huntsinger, and M. Han. 2018. How does the Ecological Well-Being of Urban and Rural Residents Change with Rural-Urban Land Conversion? The Case of Hubei, China. Sustainability **10**:527.

Soy-Massoni, E., C. Bieling, J. Langemeyer, D. Varga, M. Sáez, and J. Pintó. 2016. Societal benefits from agricultural landscapes in Girona, Catalonia. Outlook on Agriculture **45**:100-110.

Spake, R., R. Lasseur, E. Crouzat, J. M. Bullock, S. Lavorel, K. E. Parks, M. Schaafsma, E. M. Bennett, J. Maes, and M. Mulligan. 2017. Unpacking ecosystem service bundles: Towards predictive mapping of synergies and trade-offs between ecosystem services. Global Environmental Change **47**:37-50.

Spangenberg, J. H., C. Görg, D. T. Truong, V. Tekken, J. V. Bustamante, and J. Settele. 2014. Provision of ecosystem services is determined by human agency, not ecosystem functions. Four case studies. International Journal of Biodiversity Science, Ecosystem Services & Management **10**:40-53.

SPC. 2015. Pocket Statistical Summary, Noumea, New Caledonia.

Stiglitz, J. E., J.-P. Fitoussi, and M. Durand. 2018. Beyond GDP: Measuring What Counts for Economic and Social Performance. OECD.

Stiglitz, J. E., A. Sen, and J.-P. Fitoussi. 2009. Report by the commission on the measurement of economic performance and social progress. Commission on the Measurement of Economic Performance and Social Progress, Paris.

Su, S., R. Xiao, Z. Jiang, and Y. Zhang. 2012. Characterizing landscape pattern and ecosystem service value changes for urbanization impacts at an eco-regional scale. Applied Geography **34**:295-305.

Suich, H., C. Howe, and G. Mace. 2015. Ecosystem services and poverty alleviation: a review of the empirical links. Ecosystem Services **12**:137-147.

Summers, J., L. Smith, J. Case, and R. Linthurst. 2012. A review of the elements of human well-being with an emphasis on the contribution of ecosystem services. Ambio **41**:327-340.

Szaboova, L., K. Brown, and J. A. Fisher. 2019. Access to Ecosystem Benefits: More than Proximity. Society & natural resources:1-17.

Tan, P. Y., and R. Samsudin. 2017. Effects of spatial scale on assessment of spatial equity of urban park provision. Landscape and Urban Planning **158**:139-154.

Toki, B., L. Leger, S. Richards, S. Hipkin, J. Lorimer, and R. Coulton. 2017. Solomon Islands Ecosystem and Socio-economic Resilience Analysis and Mapping (ESRAM). Secretariat of the Pacific Regional Environment Programme (SPREP), Apia, Samoa.

UN-Habitat. 2012. Solomon Islands: National Urban Profile. Nairobi, Kenya.

UN-Habitat. 2015. Urbanization and Climate Change in Small Island Developing States. Nairobi, Kenya.

UNDP. 2018. Human Development Indices and Indicators: 2018 Statistical Update. Briefing note for countries on the 2018 Statistical Update. Solomon Islands.

UNEP. 2006. Marine and coastal ecosystems and human wellbeing: A synthesis report based on the findings of the Millennium Ecosystem Assessment.

United Nations. 2014. World Urbanization Prospects: The 2014 Revision, Highlights (ST/ESA/SER.A/352).

United Nations. 2015. Transforming our world: the 2030 Agenda for Sustainable Development. Resolution adopted by the General Assembly on 25 September 2015.

United Nations. 2017. The Sustainable Development Goals Report 2017, New York.

United Nations. 2019. World Urbanization Prospects: The 2018 Revision (ST/ESA/SER.A/420). Department of Economic and Social Affairs, Population Division. New York: United Nations.

Unnikrishnan, H., and H. Nagendra. 2015. Privatizing the commons: impact on ecosystem services in Bangalore's lakes. Urban Ecosystems **18**:613-632.

von Döhren, P., and D. Haase. 2015. Ecosystem disservices research: A review of the state of the art with a focus on cities. Ecological Indicators **52**:490-497.

Weinzettel, J., E. G. Hertwich, G. P. Peters, K. Steen-Olsen, and A. Galli. 2013. Affluence drives the global displacement of land use. Global Environmental Change **23**:433-438.

Whitburn, J., W. Linklater, and W. Abrahamse. 2020. Meta-analysis of human connection to nature and proenvironmental behavior. Conservation Biology **34**:180-193.

White, S. C. 2008. But what is well-being? A framework for analysis in social and development policy and practice.*in* Conference on regeneration and wellbeing: research into practice, University of Bradford.

White, S. C. 2010. Analysing wellbeing: a framework for development practice. Development in Practice **20**:158-172.

Wieland, R., S. Ravensbergen, E. J. Gregr, T. Satterfield, and K. M. Chan. 2016. Debunking trickle-down ecosystem services: the fallacy of omnipotent, homogeneous beneficiaries. Ecological economics **121**:175-180.

Willemen, L., A. Veldkamp, P. Verburg, L. Hein, and R. Leemans. 2012. A multi-scale modelling approach for analysing landscape service dynamics. Journal of Environmental Management **100**:86-95.

Williams, K., K. Biedenweg, and L. Cerveny. 2017. Understanding Ecosystem Service Preferences across Residential Classifications near Mt. Baker Snoqualmie National Forest, Washington (USA). Forests **8**:157.

Williams, S. 2011. Public Land Governance in Solomon Islands. World Bank Justice for the Poor Briefing Notes **6**.

Woodhouse, E., K. M. Homewood, E. Beauchamp, T. Clements, J. T. McCabe, D. Wilkie, and E. Milner-Gulland. 2015. Guiding principles for evaluating the impacts of conservation interventions on human well-being. Philosophical Transactions of the Royal Society B: Biological Sciences **370**:20150103.

Yang, G., Y. Ge, H. Xue, W. Yang, Y. Shi, C. Peng, Y. Du, X. Fan, Y. Ren, and J. Chang. 2015. Using ecosystem service bundles to detect trade-offs and synergies across urban–rural complexes. Landscape and Urban Planning **136**:110-121.

Yang, S., W. Zhao, P. Pereira, and Y. Liu. 2019. Socio-cultural valuation of rural and urban perception on ecosystem services and human well-being in Yanhe watershed of China. Journal of Environmental Management **251**:109615.

Yin, R. K. 2014. Case study research: Design and methods. 2014. Utgave–SAGE Publications.

Zelenski, J. M., and E. K. Nisbet. 2014. Happiness and feeling connected: The distinct role of nature relatedness. Environment and behavior **46**:3-23.

Ziter, C. 2016. The biodiversity–ecosystem service relationship in urban areas: a quantitative review. Oikos **125**:761-768.

Zoderer, B. M., E. Tasser, S. Carver, and U. Tappeiner. 2019. Stakeholder perspectives on ecosystem service supply and ecosystem service demand bundles. Ecosystem Services **37**:100938.

Zylstra, M. J., A. T. Knight, K. J. Esler, and L. L. Le Grange. 2014. Connectedness as a core conservation concern: An interdisciplinary review of theory and a call for practice. Springer Science Reviews **2**:119-143.

Appendices

Appendix A. Supplementary material for Chapter 2

List of papers reviewed

Caro-Borrero, A., E. Corbera, K. C. Neitzel, and L. Almeida-Leñero. 2015. "We are the city lungs": Payments for ecosystem services in the outskirts of Mexico City. Land use policy 43:138-148.

Carvalho-Ribeiro, S. M., and A. Lovett. 2011. Is an attractive forest also considered well managed? Public preferences for forest cover and stand structure across a rural/urban gradient in northern Portugal. Forest Policy and Economics 13:46-54.

Casado-Arzuaga, I., I. Madariaga, and M. Onaindia. 2013. Perception, demand and user contribution to ecosystem services in the Bilbao Metropolitan Greenbelt. Journal of Environmental Management 129:33-43.

da Cunha Ávila, J. V., A. S. d. Santos de Mello, M. E. Beretta, R. Trevisan, P. Fiaschi, and N. Hanazaki. 2017. Agrobiodiversity and in situ conservation in quilombola home gardens with different intensities of urbanization. Acta Botanica Brasilica:0-0.

García-Llorente, M., A. J. Castro, C. Quintas-Soriano, I. López, H. Castro, C. Montes, and B. Martín-López. 2016. The value of time in biological conservation and supplied ecosystem services: A willingness to give up time exercise. Journal of Arid Environments 124:13-21.

Kenwick, R. A., M. R. Shammin, and W. C. Sullivan. 2009. Preferences for riparian buffers. Landscape and Urban Planning 91:88-96.

Lindemann-Matthies, P., D. Keller, X. Li, and B. Schmid. 2013. Attitudes toward forest diversity and forest ecosystem services—a cross-cultural comparison between China and Switzerland. Journal of Plant Ecology 7:1-9.

López-Santiago, C., E. Oteros-Rozas, B. Martín-López, T. Plieninger, E. González Martín, and J. González. 2014. Using visual stimuli to explore the social perceptions of ecosystem services in cultural landscapes: the case of transhumance in Mediterranean Spain. Ecology and Society 19.

Martín-López, B., I. Iniesta-Arandia, M. García-Llorente, I. Palomo, I. Casado-Arzuaga, D. G. Del Amo, E. Gómez-Baggethun, E. Oteros-Rozas, I. Palacios-Agundez, and B. Willaarts. 2012. Uncovering ecosystem service bundles through social preferences. PloS one 7:e38970.

Mombo, F., L. Lusambo, S. Speelman, J. Buysse, P. Munishi, and G. Van Huylenbroeck. 2014. Scope for introducing payments for ecosystem services as a strategy to reduce deforestation in the Kilombero wetlands catchment area. Forest Policy and Economics 38:81-89.

Obeng, E. A., and F. X. Aguilar. 2018. Value orientation and payment for ecosystem services: Perceived detrimental consequences lead to willingness-to-pay for ecosystem services. Journal of Environmental Management 206:458-471.

Orenstein, D. E., and E. Groner. 2014. In the eye of the stakeholder: changes in perceptions of ecosystem services across an international border. Ecosystem Services 8:185-196.

Pan, Y., S. Marshall, and L. Maltby. 2016. Prioritising ecosystem services in Chinese rural and urban communities. Ecosystem Services 21:1-5.

Racevskis, L. A., and F. Lupi. 2006. Comparing urban and rural perceptions of and familiarity with the management of forest ecosystems. Society and natural resources 19:479-495.

Shi, H., M. Zhao, F. A. Aregay, K. Zhao, and Z. Jiang. 2016. Residential Environment Induced Preference Heterogeneity for River Ecosystem Service Improvements: A Comparison between Urban and Rural Households in the Wei River Basin, China. Discrete Dynamics in Nature and Society 2016.

Soy-Massoni, E., C. Bieling, J. Langemeyer, D. Varga, M. Sáez, and J. Pintó. 2016. Societal benefits from agricultural landscapes in Girona, Catalonia. Outlook on Agriculture 45:100-110.

Williams, K., K. Biedenweg, and L. Cerveny. 2017. Understanding Ecosystem Service Preferences across Residential Classifications near Mt. Baker Snoqualmie National Forest, Washington (USA). Forests 8:157.

Table A.1 Variable name and description of how it was recorded.

Variable	Description
Country of origin	Where the study was conducted? Is the country traditionally classified as a developed or developing country?
Context of the study	Ecosystems assessed and where are the ecosystems located in relation to rural and urban participants to the study.
Type of methodology	Data collection methods: focus group discussions, interviews, self-administered surveys. Did the study assess perceptions or actual resource use? Were the preferences assessed using ranking and rating methods? Was there a spatial component?
Stakeholders involved	Who was targeted for the study and how were participants involved?
Ecosystem services assessed	The ecosystem service classification used was recorded (Millennium Ecosystem Assessment (MA), CICES or other). In order to make ecosystem service comparisons across studies, ecosystem services assessed were converted into the CICES version 5.1 (Haines-Young and Potschin 2018) at the class level (or at the group level for soil quality). Ecosystem services were recorded for each paper as presence/absence for each class. For example, a paper might have assessed several types of recreational activities or crops. However, in these cases, only one ecosystem service class occurrence was recorded. To lighten the text, simplified class names have been used in the text. The 32 corresponding complete class names are presented in Table A.2. I also recorded mentions of ecosystem disservices (i.e., the ecosystem generated functions, processes and attributes that result in perceived or actual negative impacts on human wellbeing (Shackleton et al. 2016)).
Findings and interpretation of the urban-rural ecosystem service valuation	The result and discussion sections of the papers were analyzed to identify similarities and contrasts between rural and urban ecosystem service preferences or use at the category level (provisioning, regulating and cultural called sections in CICES) because ecosystem service classes assessed varied among papers.
Influence of socio-demographic indicators	Do authors further interpret their valuation results with socio-demographic characteristics?
Link between ecosystem services and wellbeing	Papers were scanned for mentions of wellbeing and if links were made between ecosystem services and the MA wellbeing constituents (i.e., security, basic material for a good life, health and good social relations).

Table A.2 Correspondence between ecosystem services simplified class names and the complete class name, CICES version 5.1.

Simplified class name	Complete class name (CICES version 5.1)	Code
	Provisioning	
Cultivated plants for nutrition	Cultivated terrestrial plants (including fungi, algae) grown for nutritional purposes	1.1.1.1
Cultivated plants materials	Fibres and other materials from cultivated plants, fungi, algae and bacteria for direct use or processing (excluding genetic materials)	1.1.1.2
Animals reared for nutrition	Animals reared for nutritional purposes	1.1.3.1
Fish aquaculture for nutrition	Animals reared by in-situ aquaculture for nutritional purposes	1.1.4.1
Wild plants for nutrition	Wild plants (terrestrial and aquatic, including fungi, algae) used for nutrition	1.1.5.1
Wild plants materials	Fibres and other materials from wild plants for direct use or processing (excluding genetic materials)	1.1.5.2
Wild plants for energy	Wild plants (terrestrial and aquatic, including fungi, algae) used as a source of energy	1.1.5.3
Wild animals for nutrition	Wild animals (terrestrial and aquatic) used for nutritional purposes	1.1.6.1
Plant genetic material	Seeds, spores and other plant materials collected for maintaining or establishing a population	1.2.1.1
Animal genetic material	Animal material collected for the purposes of maintaining or establishing a population	1.2.2.1
Water for drinking	Surface water for drinking (abiotic)	4.2.1.1
Water used as a material	Surface water used as a material (non-drinking purposes) (abiotic)	4.2.1.2
	Regulation and maintenance	
Air filtration	Filtration/sequestration/storage/accumulation by micro-organisms, algae, plants, and animals	2.1.1.2
Erosion control	Control of erosion rates	2.2.1.1
Water flow regulation	Hydrological cycle and water flow regulation (Including flood control, and coastal protection)	2.2.1.3
Fire protection	Fire protection	2.2.1.5
Pollination	Pollination (or 'gamete' dispersal in a marine context)	2.2.2.1
Seed dispersal	Seed dispersal	2.2.2.2
Habitats	Maintaining nursery populations and habitats (Including gene pool protection)	2.2.2.3
Soil quality	Regulation of soil quality (group level)	2.2.4.1 2.2.4.2
Freshwater quality	Regulation of the chemical condition of freshwaters by living processes	2.2.5.1
Global climate regulation	Regulation of chemical composition of atmosphere and oceans	2.2.6.1
Micro-climate regulation	Regulation of temperature and humidity, including ventilation and transpiration	2.2.6.2
	Cultural	
Active interactions (e.g., recreation)	Characteristics of living systems that enable activities promoting health, recuperation or enjoyment through active or immersive interactions	3.1.1.1
Passive interactions (e.g., tourism)	Characteristics of living systems that enable activities promoting health, recuperation or enjoyment through passive or observational interactions	3.1.1.2
Scientific or traditional ecological knowledge	Characteristics of living systems that enable scientific investigation or the creation of traditional ecological knowledge	3.1.2.1
Education and training	Characteristics of living systems that enable education and training	3.1.2.2
Culture or heritage	Characteristics of living systems that are resonant in terms of culture or heritage	3.1.2.3
Aesthetic experience	Characteristics of living systems that enable aesthetic experiences	3.1.2.4

Sacred or religious meaning	Elements of living systems that have sacred or religious meaning	3.2.1.2
Existence value	Characteristics or features of living systems that have an existence value	3.2.2.1
Option or bequest value	Characteristics or features of living systems that have an option or bequest value	3.2.2.2

Table A.3 Explanatory factor description

Explanatory factor	Description
Physical access	the distance to a natural area or the presence of roads
Institutional context	management or policies related to ecosystem services
Culture and worldviews	also includes history, traditions, nationality, and biophilia and anthropocentric views
Needs	link between ecosystem services and livelihood or subsistence, or the dependence on ecosystem services
Knowledge	specific environmental or local ecological knowledge
Environmental characteristics	type of ecosystem or ecosystem and landscape features
Use and experience	frequency of visits of a natural area or user type for example

Appendix B. Supplementary material for Chapter 3

Interview questionnaire (English version)

Interviewer name _____	**Date** _____	**Questionnaire**
	Time_____	**number**_____
Village/town, province _____	**Name of respondent**	**Household**
_____	_____	**number**_____

*****Give information sheet to the person**

*****Read consent form and collect signature (put in envelop with questionnaire)**

Important: ***There are no right or wrong answers, we just want to know what they think***

SECTION 1. SOCIO-DEMOGRAPHIC CHARACTERISTICS

1) Respondent characteristics

a) Respondent's sex: ☐Women ☐Man

b) Age: _____years old

c) Marital status: ☐Never married ☐Married ☐Widowed/Separated/Divorced

d) Head of household? ☐Yes ☐No
If NO: specify respondent's position to head of household: _____

e) Birth location: ☐This village/town ☐This island ☐This province ☐Other province ☐Other country_____
How many years have you lived here? ☐All your life OR ☐Number of years _____

f) What is your ethnicity? ☐Melanesian ☐Micronesian ☐other (specify) _____

g) What is your religion(s)? _____

h) What is your highest education level completed?

☐ None/primary ☐ Form 1-3 ☐ Form 4- 7 ☐ Professional (technical/vocational) ☐ Tertiary (college, university)

2) Household characteristics

a) How many people usually live and eat in this house:

Number of adults (>18 years old)		Number of children/youth	
Female	Male	Female	Male

b) If RURAL: Is your household part of the main tribe of the village? ☐Yes ☐No
If NO: Where is your tribe located (or where is their customary land)?_____If URBAN: Where is your customary land?_____

3) Customary land access

a) Does your household have access to customary land freely without paying in cash or other ways for its use? ☐ Yes ☐ No
b) Do you have a garden plot? ☐ Yes ☐ No
c) Land/forest ☐ Full access ☐ None ☐ Some
(specify)_____
d) Sea ☐ Full access ☐ None ☐ Some
(specify)_____

4) Occupation and income

What activities do you or other people in your household do to bring food or money to your house?

Livelihood activity [Read all]	**Indicate all relevant** (Yes/No)	**Most important for respondent** (Check all that apply)	**Rank importance for HH** (1 is most important)
Production for own subsistence - Fishing			
- Animal rearing			
- Vegetable and fruit growing or harvesting			
Home production of goods for sale (cash-crops, fruits/veggies, fish, livestock, handicraft)			
Wages/salary (e.g., teacher, salesperson, farm worker)			
Own business			
Remittances (regular, such as scholarship) and gifts (irregular, such as custom fees)			
Property income (income from what you own, e.g., land lease and house rent)			
Unemployed - Out of workforce: e.g., retired, disabled			
- Student			

5) Subjective wellbeing

Overall, how are you satisfied with your life? Are you:
[Show Likert scale for Satisfaction]

☐ 1.Very unsatisfied	☐ 2.Unsatisfied	☐ 3.Neither satisfied nor unsatisfied	☐ 4.Satisfied	☐ 5.Very satisfied

All things considered, how do you think that your household is doing compared to others? Is it:

☐ 1.A lot worse off	☐ 2.Worse off	☐ 3.The same	☐ 4.Better off	☐ 5.A lot better off

SECTION 2. NATURE USES AND NATURAL AREAS

Let's talk about how you use and benefit from nature **in and around where you currently live in your everyday life.**

By **nature**, we mean:
[Show and go through all the natural areas images. Leave them in sight]

A **nature use** is ***what nature does for us or gives us***. It can be:

1. **Food** from plants and animals (including fish) that you grow/rear or harvest/hunt/fish in nature
2. **Materials** from plants and animals, e.g. building materials and medicine that you grow or harvest in nature (Everything that is not food or fuel.)
3. **Fuel** from plants for cooking or lighting that you grow or harvest in nature
4. Plants that **clean the air**, e.g. by removing dusts and pollutants
5. Plants and animals that **clean the water** (filtrate wastes)
6. Plants and animals that **prevent of soil erosion** (e.g., plant roots that stabilise the soil) and protect the coast (e.g., by reducing waves)
7. Places for activities or to relax and have an **enjoyable time** (e.g., activities to come together, swimming, walking).
8. **Culture**, heritage and traditional knowledge associated with nature including stories, tambu plants and animals
9. Protect or **conserve** plants, animals and nature for their own value or for future generations

QUESTION 1.
In and around where you currently live,
Where (i.e., in what natural areas) do you use or benefit from [nature use**] and**
How important are these natural areas to provide you with [nature use**] in and around where you currently live?**
[Show Likert scale for Importance]
[Ask 'Anywhere else?' after each natural area]

IMPORTANCE OF NATURAL AREAS [**Rate** all that apply]	1. Food	2. Materials	3. Fuel	4. Clean air	5. Clean water	6. Erosion control	7. Enjoy	8. Culture	9. Conserve
Agriculture									
Backyard									
Beach/coastline									
Coral reef									
Forest									
Garden									
Grassland									
Mangrove									
Ocean									
Plantation									
Pond									
River, stream, lake									
Seagrass									
Swamp/wetland									
Other (specify)									
I don't benefit									

SECTION 3. NATURE USES AND WELLBEING BENEFITS

Could you explain all the ways you and the people in your household benefit from each nature use and how does it contribute to you living a good life?

For example, a nature use can help you and your family in terms of:

- income or employment
- nutrition
- health
- education or skills
- shelter for your family and belongings
- protection from disasters
- healthy nature
- good relationships with your family, wantok, community, government, etc.
- being happy
- achieving your goals
- identifying with your culture

Or anything else that you can think of.

QUESTION 2. How do you benefit from [nature use**]?**

[After each benefit, ask '*Anything else?*'.]

QUESTION 3. How important is [nature use**] for your life and the life of the people in your household?**

Is it: [Show Likert scale for Importance]

QUESTION 2. BENEFITS [Check all that apply]	1. Food	2. Materials	3. Fuel	4. Clean air	5. Clean water	6. Erosion control	7. Enjoy	8. Culture	9. Conserve
1. Nutrition									
2. Health and survival									
3. Income/savings									
4. Shelter and material comfort									
5. Protection from natural disaster									
6. Livelihood security for future needs									
7. Social relationships									
8. Connection to nature									
9. Healthy environment									
10. Easy (saves time for other things)									
11. Education/skills									
12. Traditional knowledge & practices									
13. Cultural identity (pride & respect)									
14. Being happy, satisfied in life									
15. Refresh mind, relieve stress									
Other (specify)									
No benefits									
Don't know									
QUESTION 3. IMPORTANCE [rate]									

SECTION 4. NATURE USES, AVAILABILITY AND ACCESS

In your everyday life in and around where you currently live, how satisfied are you with the benefits that you receive from each nature use and what limits you (if anything) from benefiting more?

For example, the limitations could be in terms of:

- Availability or quality of the resource
- How it is located in relation to you and when it is available
- Use rights, management of the resource, relationship with others
- Knowledge of the use
- Tools or technology needed

Or anything else that you can think of that can limit you from benefiting from nature.

It is also possible that there are no limitations.

QUESTION 4. How satisfied are you with the benefits that you receive from [nature use**]?** Are you:
[Show Likert scale for Satisfaction]

QUESTION 5. Please describe what limits you (if anything) from benefiting more from [nature use**]?**
[After each answer, ask: '*Anything else?*'.]

	1.Food	2. Materials	3. Fuel	4. Clean air	5. Clean water	6. Erosion control	7. Enjoy	8. Culture	9. Conserve
QUESTION 4. SATISFACTION [rate]									
QUESTION 5. LIMITATIONS [Check all that apply]									
1. Availability/Quantity									
2. Quality: pollution, degraded									
3. Climatic or environmental factors									
4. Distance: too far									
5. Location/context									
6. Use rights, resource ownership									
7. Governance									
8. Management									
9. Law enforcement									
10. Social relations									
11. Feeling of insecurity/criminality									
12. Culture									
13. Economic: too expensive									
14. Lack of knowledge									
15. Lack of tools and equipment									
16. Labour: lack of time or interest									
Other (specify)									
No limitation									
Don't know									

SECTION 5. NEGATIVE THINGS FROM NATURE

Nature can also impact us negatively.

1. Dangerous plants and animals (including insects) can harm you (directly or by carrying diseases)
2. Pests (animals and insects) and diseases can affect the food or materials (plants or animals) that you grow/rear or harvest/fish/hunt in nature
3. Natural disasters

In and around where you currently live?

QUESTION 6. Where [negative thing from nature] is located (in which natural area) [Show pictures of natural areas]?

- [Show pictures of natural areas]

QUESTION 6. NATURAL AREA [Check all that apply]	**1. Dangerous plants and animals**	**2. Pests and diseases that affect the food or materials**	**3. Natural disasters**
Agriculture			
Backyard			
Beach/coastline			
Coral reef			
Forest			
Garden			
Grassland			
Mangrove			
Ocean			
Plantation			
Pond			
River, stream, lake			
Seagrass			
Swamp/wetland			
Other (specify)			
Not a problem			

Notes:

QUESTION 7. Could you explain all the ways you and the people in your household are affected by [negative thing from nature]?

[See wellbeing elements on page 5 if necessary]

[After each impact, ask '*Anything else?*']

QUESTION 8. Overall, are the negative impacts of [negative thing from nature] on you and your family:

(1) not important at all

(2) of little importance

(3) somewhat important

(4) very important

(5) extremely important

QUESTION 7. NEGATIVE IMPACTS [Check all that apply]	**1. Dangerous plants and animals**	**2. Pests and diseases that affect the food or materials**	**3. Natural disasters**
1. Nutrition			
2. Health and survival			
3. Income/savings			
4. Shelter and material comfort			
5. Protection from natural disaster			
6. Livelihood security for future needs			
7. Social relationships			
9. Health, clean, comfortable environment			
11. Education/skills			
14. Being happy, satisfied in life			
15. Refresh mind, relieve stress			
16. Feeling secure			
Other (specify)			
No impact			
Don't know			
QUESTION 8. IMPORTANCE [rate]			

Notes:

SECTION 6. SOCIO-DEMOGRAPHIC CHARACTERISTICS…continued

Material assets [select only one per category]

What type of _____ does your household have?

Water supply	**Toilet facilities**	**Garbage disposal**
☐ River ☐ Communal well ☐ Water tank ☐ Piped ☐ Other _____	☐ Compost ☐ Flush ☐ No toilet ☐ Other_____	☐ Ocean/river ☐ Burnt in backyard ☐ Buried in backyard ☐ Collected

Does someone in your household own?

Refrigerator/Freezer	**Radio**	**Television**
☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No
Mobile phone	**Computer/tablet/smart phone**	**Satellite dish**
☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No
Canoe	**Motor-boat**	**Car**
☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No
Chickens	**Pigs**	**House**
☐ Yes ☐ No	☐ Yes ☐ No	☐ Rented ☐ Owned

This was our last question. Thank you very much for your time and participation. The information you have given us today helps us understand the importance of nature for people. Would you be interested in learning about the results next year? ☐ Yes ☐ No
Thank you again.

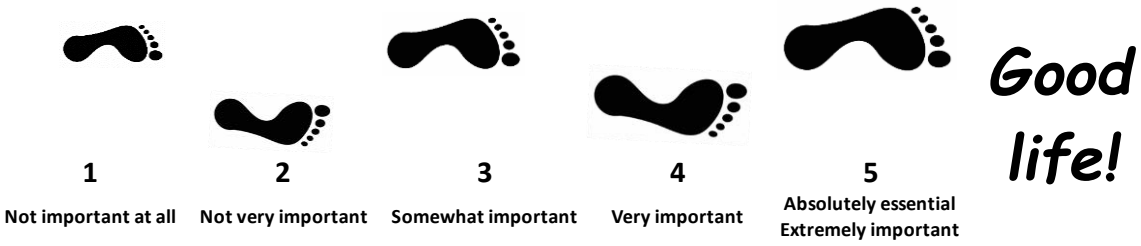
End time _____

Assess visually:

Electricity	**Cooking facilities**	**Source of lighting**
☐ Solar ☐ Generator ☐ Grid ☐ No electricity	☐ Wood/coconut ☐ Coal ☐ Kerosene ☐ Gas ☐ Electricity ☐ Other _____	☐ Electricity ☐ Solar lamp ☐ Kerosene lamp ☐ Other _____
Roof material	**Wall material**	**Floor material**
☐ Thatched (leaf) ☐ Wood ☐ Copper ☐ Other_____	☐ Thatched ☐ Wood ☐ Plywood/Masonite ☐ Concrete ☐ Other_____	☐ Soil ☐ Wood ☐ Concrete ☐ Tile ☐ Other _____

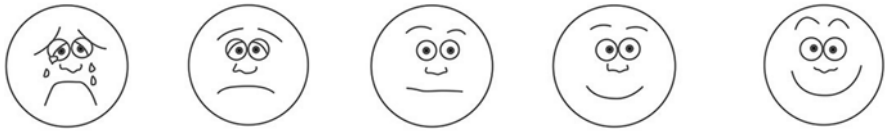
Likert-type scales

IMPORTANCE



1	2	3	4	5
Not important at all	Not very important	Somewhat important	Very important	Absolutely essential Extremely important

SATISFACTION



1	2	3	4	5
Very unsatisfied	Unsatisfied	Neutral	Satisfied	Very satisfied

Appendix C. Supplementary material for Chapter 4

Table C.1 Description of the Cumulative Links Mixed Models (CLMM).

Model description	Model in R
Importance per ES[a]	clmm(Rating category[b] ~ Urbanization level[c] * ES + (1|Site[d]/HH[e]), link = "probit", threshold = "flexible")
Importance per category[f]	clmm(Rating category ~ Urbanization level * ES category[f] + (1|Site/HH), link = "probit", threshold = "flexible")
Importance within urban or rural areas (separate models)	clmm(Rating category ~ ES category + (1|HH), link = "probit", threshold = "flexible")
Satisfaction per ES	clmm(Rating category ~ Urbanization level * ES + (1|Site/HH), link = "probit", threshold = "flexible")
Satisfaction per category	clmm(Rating category ~ Urbanization level * ES category + (1|Site/HH), link = "probit", threshold = "flexible")
Satisfaction within urban or rural areas (separate models)	clmm(Rating category ~ ES category + (1|HH), link = "probit", threshold = "flexible")
Importance per EDS[g]	clmm(Rating category ~ Urbanization level * EDS + (1|Site/HH), link = "probit", threshold = "flexible")
Importance per category, per site	clmm(Rating category ~ Sit[f] * ES category + (1|HH), link = "probit", threshold = "flexible")
Satisfaction per category, per site	clmm(Rating category ~ Site * ES category + (1|HH), link = "logit", threshold = "symmetric2")
EDS per category, per site	clmm(Rating category ~ Site *EDS + (1|HH), link = "probit", threshold = "symmetric2")

[a] ES=Ecosystem services: 9 levels

[b] Rating categories: 1, 2, and 3 = Low; 4 = Medium, and 5 = High

[c] Urbanization level: 2 levels (urban and rural)

[d] Sites: 4 levels

[e] HH=Household (N=200)

[f] ES categories: 3 levels

[g] EDS=Ecosystem disservices: 3 levels

Table C.2 Results of the analyses of deviance following cumulative links modelling for importance ratings of ecosystem service (ES) types and categories and urbanization level (urban and rural). Significant p-values at the 0.05 level are indicated in bold.

Model	Variable	Chi squared	DF[a]	p-value
Urbanization level + ES + interaction	Urbanization	6.030	1	**0.014**
	ES	187.312	8	**0.000**
	Urbanization * ES	24.562	8	**0.002**
Urbanization level + Category + interaction	Context	6.018	1	**0.014**
	Category	85.715	2	**0.000**
	Urbanization *Category	18.418	2	**0.000**

[a]Degrees of freedom

Table C.3 Results of post-hoc comparisons of rural to urban sites following cumulative links modelling of ecosystem service (ES) importance ratings. Significant p-values at the 0.05 level are indicated in bold.

Model	Ecosystem service	EMM[a]	SE[b]	p-value
Importance rating per ES category	Provisioning	1.87	0.475	**0.000**
	Regulating	1.51	0.474	**0.001**
	Cultural	1.40	4.474	**0.003**
Importance rating per ES type	Food	2.26	0.535	**0.000**
	Materials	1.96	0.499	**0.000**
	Firewood	2.22	0.503	**0.000**
	Clean air	1.43	0.521	**0.006**
	Clean water	1.60	0.522	**0.004**
	Soil protection	1.61	0.512	**0.002**
	Recreation	1.70	0.487	**0.001**
	Culture	1.18	0.486	**0.015**
	Stewardship	1.07	0.511	**0.036**

[a] Estimated Marginal Means

[b] Standard error of the mean

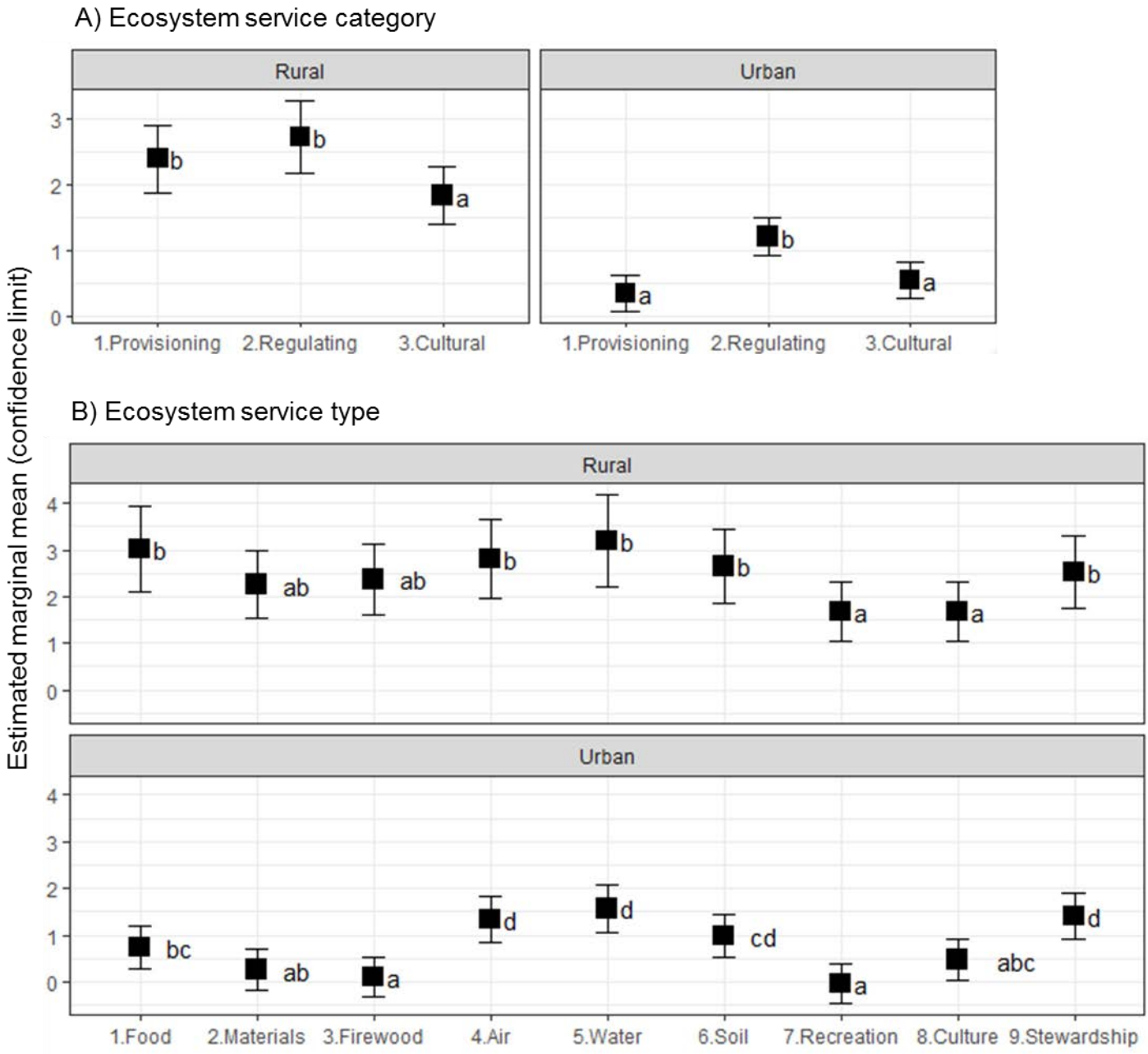


Figure C.1 Coefficient plots from the Cumulative Links Mixed Models comparing ecosystem service importance rating in rural and urban areas separately for A) Ecosystem service categories and B) types. Sites sharing a letter in the same panel are not significantly different from one another.

Table C.4 Results of the analyses of deviance following cumulative links modelling for satisfaction ratings of ecosystem service (ES) types and categories and urbanization level (urban and rural). Significant p-values at the 0.05 level are indicated in bold.

Model	Variable	Chi squared	DF[a]	p-value
Urbanization level + ES + interaction	Urbanization	5.458	1	**0.020**
	ES	23.356	8	**0.003**
	Urbanization * ES	15.838	8	**0.045**
Urbanization level + Category + interaction	Urbanization	5.471	1	**0.019**
	Category	2.984	2	0.225
	Urbanization *Category	10.815	2	**0.005**

[a]Degrees of freedom

Table C.5 Results of post-hoc comparisons of rural to urban sites following cumulative links modelling of ecosystem service (ES) satisfaction ratings. Significant p-values at the 0.05 level are indicated in bold.

Model	Ecosystem service	EMM[a]	SE[b]	p-value
Satisfaction rating per ES category	Provisioning	2.00	0.437	**0.000**
	Regulating	1.46	0.443	**0.001**
	Cultural	1.24	0.429	**0.004**
Satisfaction rating per ES type	Food	1.77	0.506	**0.001**
	Materials	1.89	0.506	**0.000**
	Firewood	2.04	0.509	**0.000**
	Clean air	1.68	0.505	**0.001**
	Clean water	1.47	0.503	**0.004**
	Soil protection	1.44	0.503	**0.004**
	Recreation	1.66	0.506	**0.001**
	Culture	1.37	0.503	**0.006**
	Stewardship	1.23	0.503	**0.015**

[a] Estimated Marginal Means

[b] Standard error of the mean

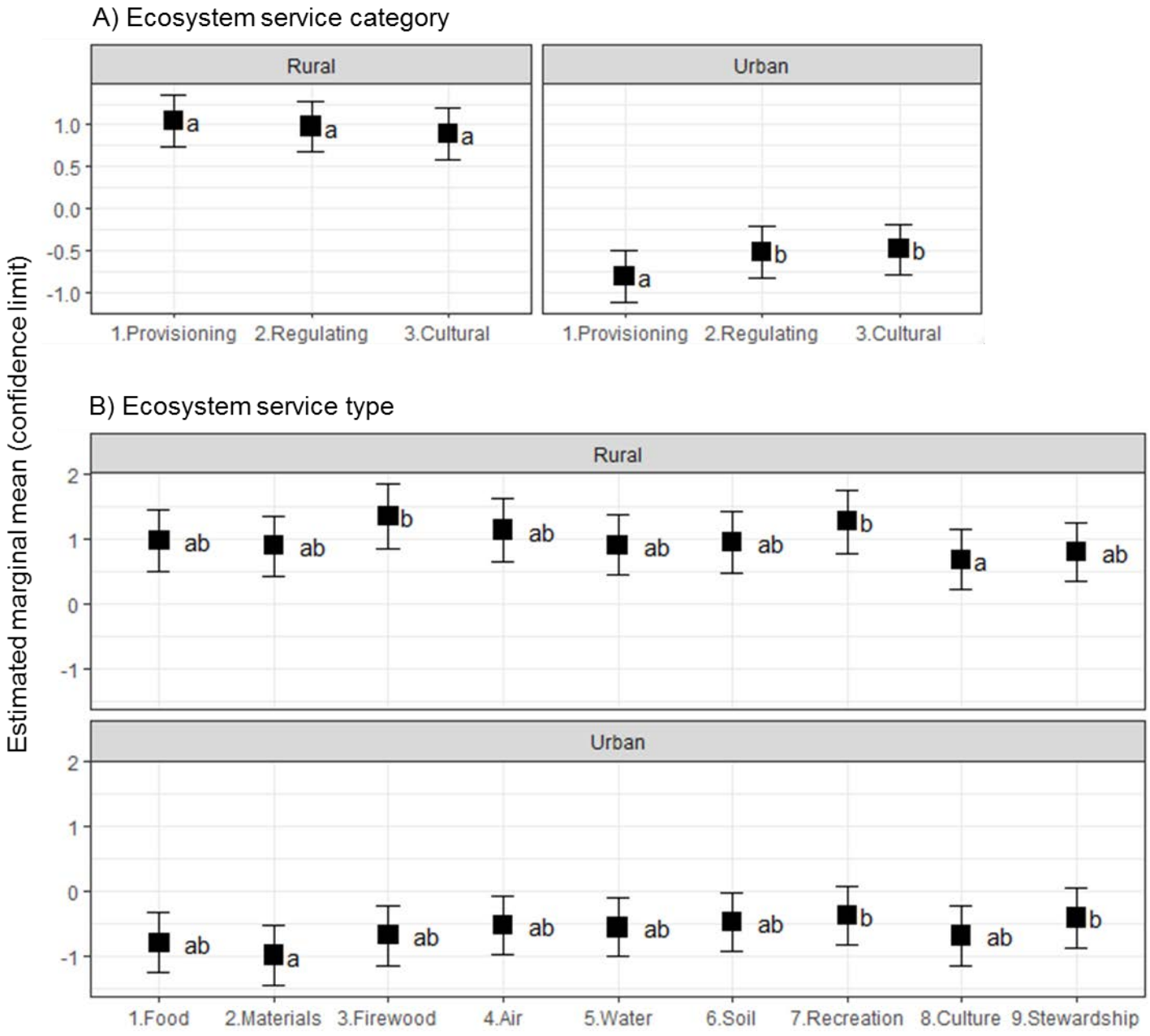


Figure C.2 Coefficient plots from the Cumulative Links Mixed Models comparing ecosystem service satisfaction rating in rural and urban areas separately for A) ecosystem service categories and B) types. Sites sharing a letter in the same panel are not significantly different from one another.

Table C.6. Results of the analyses of deviance following cumulative links modelling for ecosystem disservice (EDS) importance and urbanization level (urban and rural). Significant p-values at the 0.05 level are indicated in bold.

Model	Variable	Chi squared	DF[a]	p-value
Urbanization level + EDS + interaction	Urbanization	1.069	1	0.301
	EDS	17.282	2	**0.000**
	Urbanization * EDS	1.186	2	0.553

[a]Degrees of freedom

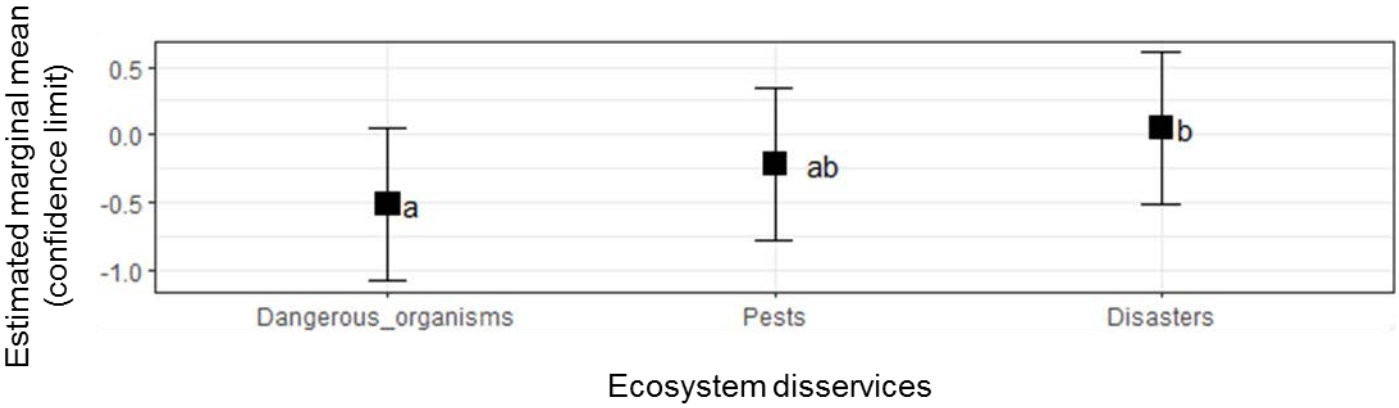


Figure C.3. Coefficient plot from the Cumulative Links Mixed Model comparing ecosystem disservice importance rating. Sites sharing a letter in the same panel are not significantly different from one another.

Appendix D. Supplementary material for Chapter 5

Table D.1 Classification of wellbeing benefits reported.*

Wellbeing dimension	**Wellbeing benefit** (name used in text showed in bold)
Material	**Nutrition**
Material	**Health** and survival
Material	**Income**/savings
Material	Shelter and **material comfort**
Material	**Protection from** natural **disaster**
Material	**Livelihood security** for future needs
Material	**Healthy**, clean, comfortable **environment**
Material	**Convenience** (easy to access, saves time for other things)
Material	**Education**/skills
Relational	Good **social relationships**
Relational/Subjective	**Connection to nature**
Relational	**Traditional knowledge** and practices
Relational	**Cultural identity** (including pride and respect)
Relational /Subjective	Feeling secure
Subjective	**Feeling happy**, satisfied in life
Subjective	**Feeling relaxed**, refresh minded, stress free
Subjective/Relational	Freedom to make choices and act
Subjective	Developing through new experiences
	No benefits
	Don't know
	Other (specify)

*Classification from White (2008).

Table D.2 Material Style of Life Principle Component Analysis (PCA) factor loading.

Variable	**Factor loading**
Water source	0.48
Toilet facility	0.75
Electricity access	0.84
Cooking facility	0.69
Lighting source	0.86
Roof materials	0.60
Refrigerator	0.67
Radio	0.18
Television	0.78
Mobile phone	0.47
Computer	0.66
Mean of transportation	0.33

	Urbanization	Site	Gender	Age	Education	Livelihood	MSL	Time in community
Urbanization	1							
Site	1	1						
Gender	0.03	0.06	1					
Age	0.27	0.29	0.06	1				
Education	0.32	0.25	0.1	0.42	1			
Livelihood	0.86	0.51	0.07	0.32	0.24	1		
MSL	0.74	0.75	0.03	-0.27	0.44	0.66	1	
Time in community	0.53	0.54	0.06	0.6	0.34	0.54	-0.36	1

Figure D.1 Matrix of associations computed between each pair of socio-demographic characteristics using either Pearson's correlation coefficient, multiple correlation coefficient, or Cramer's V depending on the type of variable.

Table D.3 Description of the Generalized Linear Mixed Models (GLMM).

Model description	Model in R
Analysis per wellbeing benefit[a]	glmer(Presence[b] ~ Urbanization level[c] * Ecosystem service[d] + (1|HH[e]), family=binomial(), nAGQ = 0)

[a] Separate model for each of the 15 wellbeing benefits

[b] Presence or absence of a wellbeing benefit

[c] Urbanization: 2 levels (urban and rural)

[d] Ecosystem services: 9 levels

[e] HH=Household (N=200)

Table D.4 Description of the Generalized Linear Mixed Model (GLMM) with socio-demographic characteristics.

Model description	Model in R
Analysis per wellbeing benefit[a]	glmer(Presence[b] ~ ES[c] + Age[d] + Education[e] + MSL[f] + Time[g] + (1|HH[h]), family=binomial(), nAGQ = 0)

[a] Separate model for each of the 15 wellbeing benefits

[b] Presence or absence of a limitation

[c] ES=Ecosystem services: 9 levels

[d] Age: per decade

[e] Education level: 4 levels

[f] MSL= Material Style of Life related to wealth (continuous)

[g] Time= Proportion of time living in the community

[h] HH=Household (N=200)

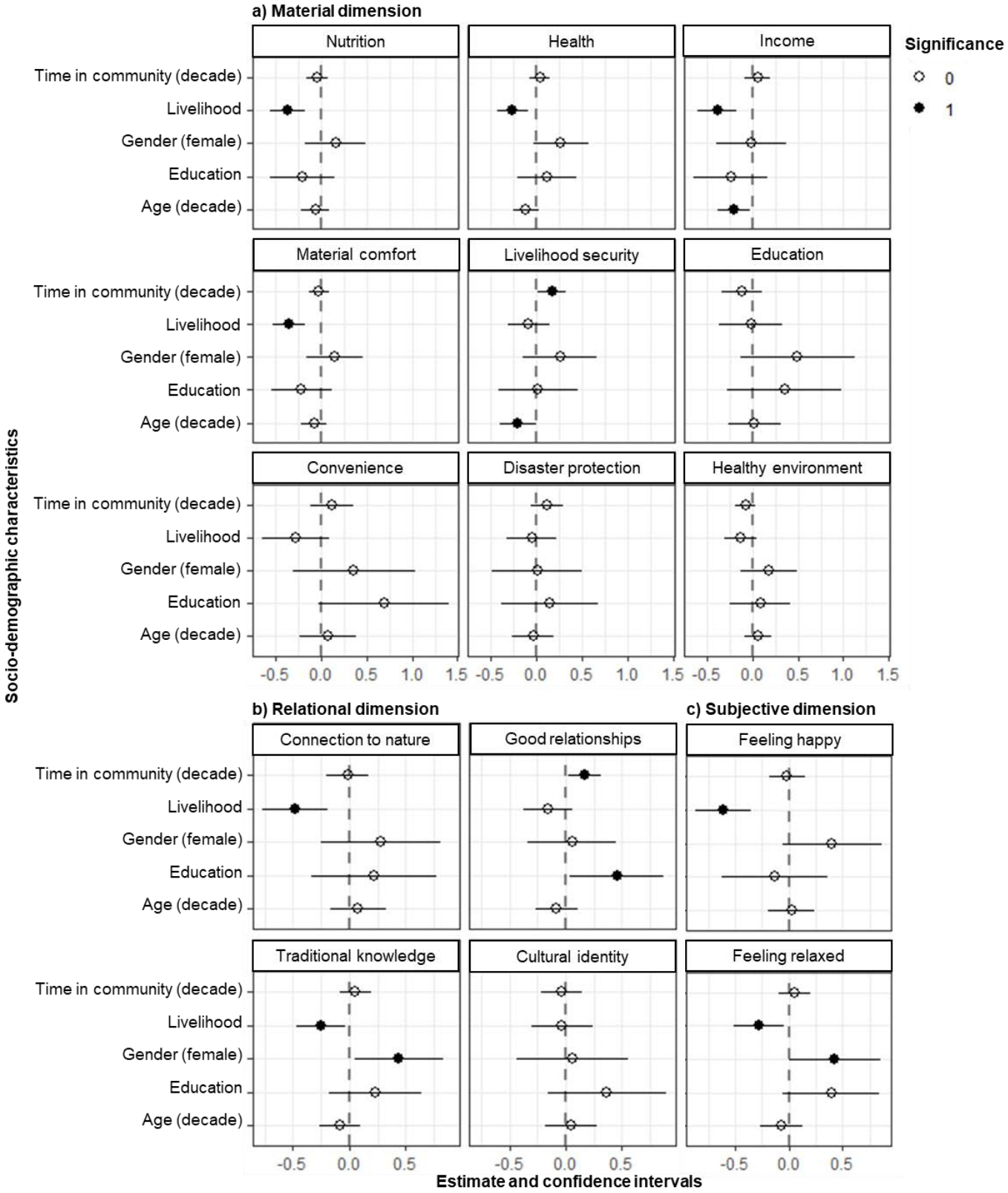


Figure D.2 Probability of identifying a wellbeing benefit obtained from a logistic regression according to socio-demographic characteristics, the type ecosystem service (not shown on the graph), and wellbeing benefits for a) material, b) relational, and c) subjective dimensions of wellbeing. Full circles indicate a significant effect of socio-demographic characteristics ($P \leq 0.05$).

Appendix E. Supplementary material Chapter 6

Table E.1 Description of the articles comparing rural and urban ecosystem service bundles (N=27). Eighteen of the papers reviewed were found in the Saidi and Spray (2018) review on ecosystem service bundles. I kept only those that compared urban and rural areas. I added nine papers following a search in Web of Science with search terms 'ecosystem service', 'urban*', and 'bundle' mentioned in the title, abstract, or keywords (conducted in February 2020). A few additional papers were found that mentioned 'bundle' elsewhere in the text and were also included. The papers that were only conducted in urban areas were rejected.

Source	Study area and scale	Ecosystem or land cover types	Category and number of ecosystem services considered	Supply or demand	Methodology
Bai et al. 2011	Baiyangdian watershed in the North of China	Forest, shrubs, grassland, wetland, agriculture, desert, urban areas	5 regulating	Supply	Spatial analysis with InVEST based on production functions
Balzan et al. 2018	The archipelago of Malta	Urban, cropland, grassland, forest, shrub, unvegetated land, wetland	5 provisioning, 2 regulating, 1 cultural	Supply	Spatial analysis based on proxy data, models, and direct measurements
Baro et al. 2017	164 municipalities of the Barcelona metropolitan region in Spain	Water bodies, forests, shrub and grassland, agriculture, quarries, urban green areas, urban areas	1 provisioning, 3 regulating, 1 cultural	Supply and demand	Spatial analysis based on direct and proxy data at the municipal level
Brown et al. 2015	Sogn and Nordland regions of Norway	Agriculture, forests, shrubs and grassland, sparse vegetation, wetlands, development, bare, water, snow and ice	4 provisioning, 1 supporting, 9 cultural	Demand	Public participation GIS
Depellegrin et al. 2016	Lithuania	About 30 land cover types ranging from urban to forest and sea	14 provisioning, 11 regulating, 5 cultural	Supply	Expert-based ranking approach and a geospatial analysis
Elbakidze et al. 2018	Rift Valley Sidama zone in Ethiopia	25 land cover types from urban to old growth forest	22 provisioning, 19 regulating and supporting, 7 cultural	Demand	Interviews on ecosystem service and land cover preferences, and mapping
Haase et al. 2012	Leipzig-Halle, Germany	18 land use classes from urban fabric to mixed forests	1 provisioning, 2 regulating, 1 cultural, and biodiversity	Supply	Spatio-temporal analysis using published and empirical data
Hamann et al. 2015	South Africa	Wildlands, forested, rangelands, croplands, villages, dense settlements	6 provisioning	Demand	Spatial analysis from census data on ecosystem service use
Kong et al. 2018	Yangtze River Basin, China	Forest, grassland, cropland, desert, shrub, wetland, urban, bare	3 provisioning, 7 regulating	Supply	Spatial analysis based on proxy data and production functions
Marsboom et al. 2018	Near the city of Turnhout, Belgium	Nature, agriculture, grassland, orchard, floriculture, recreation, industrial, built-up, military, other	2 provisioning, 11 regulating, 2 cultural	Supply	Spatial analysis resulting from biophysical and statistical models
Martin-Lopez et al. 2012	Eight sites in the Spain	Rivers and streams, drylands, urban, agroecosystems,	4 provisioning, 4 regulating, 6 cultural	Demand	Interviews on ecosystem service preferences and

Source	Study area and scale	Ecosystem or land cover types	Category and number of ecosystem services considered	Supply or demand	Methodology
		mountains, wetlands, forests, coastal			capacity of ecosystems to deliver ecosystem services
Muller et al. 2020	Northern Germany	Settlements, agroecosystems, forests, near-nature ecosystems, wetlands, inland waters, coastal ecosystems, marine, etc.	14 provisioning, 11 regulating, 6 cultural, 7 supporting	Supply	Expert data rating and mapping
Plieninger et al. 2019	13 study sites in 10 European countries	Agricultural landscapes	2 provisioning, 2 regulating, 6 cultural	Demand	Interviews, public participation GIS
Queiroz et al. 2015	The Norrstrom drainage basin, Sweden	Cropland, livestock, forests, urban, lakes, built-up areas	6 provisioning, 5 regulating, 6 cultural	Supply	Spatial analysis based on proxy data
Raudsepp-Hearne et al. 2010	137 municipalities across 2 watersheds in a periurban zone close to Montreal, Canada	Agricultural landscape with forests, lakes and built-up areas.	4 provisioning, 3 regulating, 5 cultural	Supply	Spatial analysis at the scale of municipalities using proxy data of ecosystem service use or capacity
Renard et al. 2015	131 municipalities in Montérégie, Quebec, Canada	Agricultural landscape with forests, lakes and built-up areas.	4 provisioning, 2 regulating, 3 cultural	Supply	Spatio-temporal analysis at the scale of municipalities analysis using proxy data of ecosystem service use or capacity
Riechers et al. 2018	Berlin, Germany	Urban green areas	10 cultural	Demand	Interviews on ecosystem service preferences
Riechers et al. 2019	Berlin, Germany	Parks, forests, water bodies, recreational areas, urban surroundings	10 cultural	Demand	Interviews on preferences and use of ecosystem services
Roussel et al. 2017	Peri-urban interface of Paris, France	Agriculture, forest, built-up, waterbodies	1 provisioning, 5 regulating, 1 cultural	Supply	Spatial analysis using proxy-based models and phenomenological models
Tomscha and Gergel 2016	Columbia River, the Wenatchee system floodplain, Washington State, USA	Urban, orchards, fields, shrub, different types of forest, water, and rock/snow.	3 provisioning, 1 regulating, 1 cultural	Supply	Spatio-temporal analysis using combining biophysical attributes into production functions
Turner et al. 2014	Land area of Denmark	Agriculture, forest, coastal, wetlands	3 provisioning, 2 regulating, 5 cultural	Supply	Spatial analysis using proxy data
Vigl et al. 2017	European Alps	Grassland, pasture, forest, agriculture	2 provisioning, 3 regulating, 3 cultural	Supply	Spatio-temporal analysis using proxies
Yang et al. 2015	22 urban–rural complexes across the Yangtze River Delta, China	Cropland, forest, grassland, water, urban	6 provisioning, 3 regulating, 3 cultural	Supply	Spatial analysis using proxies

Source	Study area and scale	Ecosystem or land cover types	Category and number of ecosystem services considered	Supply or demand	Methodology
Yang et al. 2019	Beijing-Tianjin-Hebei Metropolitan Area, China	Forest, grassland, cropland, wetland, built-up land	3 provisioning, 4 regulating	Supply	Spatial analysis using proxies
Yao et al. 2016	Upper Hun River catchment, China	Paddy field, dry field, forest, grassland, water body, built-up, industrial or mining, unused land	1 provisioning, 2 regulating	Supply	Spatial analysis based on direct and proxy data
Zhao et al. 2018	Watershed of the Pearl River Delta, China	Artificial surfaces, bare land, cultivated land, forest, grassland, shrub, waterbody, wetland	2 provisioning, 4 regulating, 2 cultural	Supply	Spatial analysis based on proxy data
Zoderer et al. 2019	South Tyrol, Italy	Coniferous forest, mixed forest, broadleaf forest, agroforestry, alpine grassland, hay meadows, permanent crops, high mountains, standing water, running water	5 provisioning, 5 regulating, 5 cultural	Demand	Interviews on ecosystem service preferences and associations with landscape types

References

Bai, Y., C. Zhuang, Z. Ouyang, H. Zheng, and B. Jiang. 2011. Spatial characteristics between biodiversity and ecosystem services in a human-dominated watershed. Ecological complexity 8:177-183.

Balzan, M. V., J. Caruana, and A. Zammit. 2018. Assessing the capacity and flow of ecosystem services in multifunctional landscapes: Evidence of a rural-urban gradient in a Mediterranean small island state. Land use policy 75:711-725.

Baró, F., E. Gómez-Baggethun, and D. Haase. 2017. Ecosystem service bundles along the urban-rural gradient: Insights for landscape planning and management. Ecosystem Services 24:147-159.

Brown, G., V. Helene Hausner, and E. Lægreid. 2015. Physical landscape associations with mapped ecosystem values with implications for spatial value transfer: An empirical study from Norway. Ecosystem Services 15:19-34.

Depellegrin, D., P. Pereira, I. Misiunė, and L. Egarter-Vigl. 2016. Mapping ecosystem services potential in Lithuania. International Journal of Sustainable Development & World Ecology 23:441-455.

Elbakidze, M., M. Gebrehiwot, P. Angelstam, T. Yamelynets, and D. Surová. 2018. Defining Priority Land Covers that Secure the Livelihoods of Urban and Rural People in Ethiopia: a Case Study Based on Citizens' Preferences. Sustainability 10:1701.

Haase, D., N. Schwarz, M. Strohbach, F. Kroll, and R. Seppelt. 2012. Synergies, trade-offs, and losses of ecosystem services in urban regions: an integrated multiscale framework applied to the Leipzig-Halle Region, Germany. Ecology and Society 17:22.

Hamann, M., R. Biggs, and B. Reyers. 2015. Mapping social–ecological systems: Identifying 'green-loop'and 'red-loop'dynamics based on characteristic bundles of ecosystem service use. Global Environmental Change 34:218-226.

Kong, L., H. Zheng, Y. Xiao, Z. Ouyang, C. Li, J. Zhang, and B. Huang. 2018. Mapping ecosystem service bundles to detect distinct types of multifunctionality within the diverse landscape of the Yangtze river basin, China. Sustainability 10:857.

Marsboom, C., D. Vrebos, J. Staes, and P. Meire. 2018. Using dimension reduction PCA to identify ecosystem service bundles. Ecological Indicators 87:209-260.

Martín-López, B., I. Iniesta-Arandia, M. García-Llorente, I. Palomo, I. Casado-Arzuaga, D. G. Del Amo, E. Gómez-Baggethun, E. Oteros-Rozas, I. Palacios-Agundez, and B. Willaarts. 2012. Uncovering ecosystem service bundles through social preferences. PloS one 7:e38970.

Müller, F., S. Bicking, K. Ahrendt, D. K. Bac, I. Blindow, C. Fürst, P. Haase, M. Kruse, T. Kruse, and L. Ma. 2020. Assessing ecosystem service potentials to evaluate terrestrial, coastal and marine ecosystem types in Northern Germany–An expert-based matrix approach. Ecological Indicators 112:106116.

Plieninger, T., M. Torralba, T. Hartel, and N. Fagerholm. 2019. Perceived ecosystem services synergies, trade-offs, and bundles in European high nature value farming landscapes. Landscape ecology:1-17.

Queiroz, C., M. Meacham, K. Richter, A. V. Norström, E. Andersson, J. Norberg, and G. Peterson. 2015. Mapping bundles of ecosystem services reveals distinct types of multifunctionality within a Swedish landscape. Ambio 44:89-101.

Raudsepp-Hearne, C., G. D. Peterson, and E. Bennett. 2010. Ecosystem service bundles for analyzing tradeoffs in diverse landscapes. Proceedings of the National Academy of Sciences 107:5242-5247.

Renard, D., J. M. Rhemtulla, and E. M. Bennett. 2015. Historical dynamics in ecosystem service bundles. Proceedings of the National Academy of Sciences 112:13411-13416.

Riechers, M., J. Barkmann, and T. Tscharntke. 2018. Diverging perceptions by social groups on cultural ecosystem services provided by urban green. Landscape and Urban Planning 175:161-168.

Riechers, M., M. Strack, J. Barkmann, and T. Tscharntke. 2019. Cultural Ecosystem Services Provided by Urban Green Change along an Urban-Periurban Gradient. Sustainability 11:645.

Roussel, F., C. J. Schulp, P. H. Verburg, and A. J. van Teeffelen. 2017. Testing the applicability of ecosystem services mapping methods for peri-urban contexts: A case study for Paris. Ecological Indicators 83:504-514.

Tomscha, S., and S. Gergel. 2016. Ecosystem service trade-offs and synergies misunderstood without landscape history. Ecology and Society 21.

Turner, K. G., M. V. Odgaard, P. K. Bøcher, T. Dalgaard, and J.-C. Svenning. 2014. Bundling ecosystem services in Denmark: Trade-offs and synergies in a cultural landscape. Landscape and Urban Planning 125:89-104.

Vigl, L. E., E. Tasser, U. Schirpke, and U. Tappeiner. 2017. Using land use/land cover trajectories to uncover ecosystem service patterns across the Alps. Regional Environmental Change 17:2237-2250.

Yang, G., Y. Ge, H. Xue, W. Yang, Y. Shi, C. Peng, Y. Du, X. Fan, Y. Ren, and J. Chang. 2015. Using ecosystem service bundles to detect trade-offs and synergies across urban–rural complexes. Landscape and Urban Planning 136:110-121.

Yang, Y., H. Zheng, L. Kong, B. Huang, W. Xu, and Z. Ouyang. 2019. Mapping ecosystem services bundles to detect high-and low-value ecosystem services areas for land use management. Journal of Cleaner Production 225:11-17.

Yao, J., X. He, W. Chen, Y. Ye, R. Guo, and L. Yu. 2016. A local-scale spatial analysis of ecosystem services and ecosystem service bundles in the upper Hun River catchment, China. Ecosystem Services 22:104-110.

Zhao, M., J. Peng, Y. Liu, T. Li, and Y. Wang. 2018. Mapping watershed-level ecosystem service bundles in the Pearl River Delta, China. Ecological economics 152:106-117.

Zoderer, B. M., E. Tasser, S. Carver, and U. Tappeiner. 2019. Stakeholder perspectives on ecosystem service supply and ecosystem service demand bundles. Ecosystem Services 37:100938.

Table E.2 Description of the Generalized Linear Mixed Model (GLMM).

Model description	Model in R
Probability of associating an ecosystem service or disservice per ecosystem type between urban and rural dwellers	glmer(Presence[a] ~ Urbanization level[b] * Ecosystem[c] * ES-EDS[d], + (1|HH[e]), family=binomial(), nAGQ = 0)

[a] Presence or absence of an ecosystem service or disservice per ecosystem type

[b] Urbanization: 2 levels (urban and rural)

[c] Ecosystems: 12 levels

[d] ES-EDS=Ecosystem services and disservices: 12 levels

[e] HH=Household (N=200)

Table E.3 Comparison between urban and rural dwellers of the ecosystem service (ES) and disservice (EDS) bundles in terms of: prevalence (proportion of people reporting at least one ES or EDS per ecosystem type); diversity (average number of ES or EDS reported per ecosystem type); relatively high values are highlighted in darker grey and medium in lighter grey while low ones are not highlighted.

Bundle	Urbanization level	Prevalence (%)		Diversity
		ES	EDS	ES
Forest	Rural	100	80	6.39
	Urban	95	64	4.25
River	Rural	98	79	4.83
	Urban	95	60	3.11
Garden	Rural	99	98	2.96
	Urban	67	66	1.8
Backyard	Rural	80	70	2.63
	Urban	87	76	3.73
Beach	Rural	95	36	3.52
	Urban	94	39	2.93
Plantation	Rural	83	67	2.59
	Urban	46	44	0.86
Mangrove	Rural	73	37	2.58
	Urban	71	48	1.99
Ocean	Rural	80	40	1.63
	Urban	81	41	1.64
Wetland	Rural	64	42	1.48
	Urban	41	28	0.66
Coral reef	Rural	85	25	1.72
	Urban	76	29	1.38
Grassland	Rural	42	26	0.96
	Urban	47	23	0.92
Seagrass	Rural	36	6	0.53
	Urban	39	9	0.52
Colour legend	Low	0-49%		0-0.99
	Medium	50-74%		1-2.99
	High	75-100%		3-9

Table E.4 Average number of ecosystems providing each ecosystem (dis)service type reported by rural and urban dwellers.

Category	Ecosystem (dis)service	Urbanization	Mean	S.D.*
Provisioning	Food	Rural	5.1	1.547236
		Urban	2.25	1.719614
	Materials	Rural	3.24	1.484737
		Urban	2.14	1.456577
	Firewood	Rural	3.23	1.262153
		Urban	1.72	1.356466
Regulating	Clean air	Rural	3.58	1.583883
		Urban	2.69	1.624901
	Clean water	Rural	2.89	1.847165
		Urban	2.7	1.678744
	Soil protection	Rural	3.69	1.606144
		Urban	2.81	1.397653
Cultural	Recreation	Rural	3.22	1.235665
		Urban	2.38	1.331666
	Culture	Rural	3.07	1.430229
		Urban	2.49	1.648354
	Stewardship	Rural	3.8	2.064613
		Urban	4.63	2.572799
Disservice	Dangerous organisms	Rural	3.89	1.780336
		Urban	2.69	1.624901
	Pests and diseases	Rural	2.65	1.225775
		Urban	2.24	1.311334
	Natural disasters	Rural	3.24	2.287957
		Urban	2.89	2.635787

* Standard deviation

Appendix F. Supplementary material for Chapter 7

Table F.1 Comparisons of socio-demographic characteristics between urban and rural dwellers.

Socio-demographic characteristics			Urbanization level	
Variable	**Description**	**Category**	**Urban**	**Rural**
Gender	Recorded as male or female.	Female	49	53
		Male	51	47
Age	Recorded in years. Divided into 9 categories for analyses (18-24; 25-29; 30-34; 35-39; 40-44; 45-49; 50-54; 55-59; 60+)	Mean	36.4	44.1
		SD	12.1	15.2
Education level	What level of school respondents had completed: 1) None to elementary; 2) junior secondary and professional, e.g., carpentry; 3) senior secondary; and 4) tertiary.	1	26%	50%
		2	17%	24%
		3	32%	12%
		4	25%	14%
Time in community	Number of years living in the community divided by the person's age.	Mean	14.0	34.3
		SD	11.9	20.0
Material style of life	PCA loading for one factor-based grouping scores of presence of more modern types of amenities (Table A.2).	Mean	0.73	-0.73
		SD	0.83	0.49

Table F.2 Description of the Generalized Linear Mixed Model (GLMM).

Model description	Model in R
Probability of identifying a limitation per ecosystem service between urban and rural dwellers	glmer(Presence[a] ~ Urbanization[b] * ES[c] * Limitation[d] + (1|HH[e]), family=binomial(), nAGQ = 0)

[a] Presence or absence of a limitation

[b] Urbanization: 2 levels (urban and rural)

[c] ES=Ecosystem services: 9 levels

[d] Limitations: 14 levels

[e] HH=Household (N=200)

Table F.3 Description of the Generalized Linear Mixed Model (GLMM) with socio-demographic characteristics.

Model description	Model in R
Analysis per ecosystem service within urban or rural areas	glmer(Presence[a] ~ Limitation[b] + Gender[c] + Age[d] + Education[e] + Time[f] + MSL[g] + (1|HH[h]), family=binomial(), nAGQ = 0)
Analysis per limitation within urban or rural areas	glmer(Presence ~ ES[i] + Gender + Age + MSL + Education + Time + (1|HH), family=binomial(), nAGQ = 0)

[a] Presence or absence of a limitation

[b] Limitations: 14 levels

[c] Gender: 2 levels (male and female)

[d] Age: per decade

[e] Education level: 4 levels

[f] Time= Proportion of time living in the community

[g] MSL= Material Style of Life related to wealth (continuous)

[h] HH=Household (N=200)

[i] ES=Ecosystem services: 9 levels