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RESEARCH



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

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ABSTRACT

Urbanization profoundly transforms ecosystems and the bundles of services they provide to people. The relationship between urbanization and how ecosystem services are produced together to form bundles has received increased research interest. However, there is limited understanding of how people's perceptions of the benefits they receive from ecosystem service bundles change with urbanization, particularly in the Global South. Addressing this research gap is critical given perceptions influence how people relate to, use and manage their environment. We 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. 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. Examining changes in perceived ecosystem service bundles offers a valuable perspective on the implications of social-ecological change for ecosystem service demand and human wellbeing. Our approach presents a novel and simple way to identify and analyse bundles, providing insights into how and where people benefit from nature.

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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. 2010). 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 2005; Rodríguez et al. 2006). For example, Raudsepp-Hearne et al.'s (2010) 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,

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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 paper 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 A.1 in Appendix A). 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. Baró et al. 2017; Yang et al. 2015; see Table A.1), pointing to two blind spots that we address in this paper. First, we 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. Our 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).

We 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). 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, we compared urban and rural dwellers' perceptions of ecosystem services associated with ecosystem type into bundles in two paired coastal urban and rural sites. We 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. 2010; Mouchet et al. 2014), a criterion that was met using multiple study sites in addition to ecosystem service associations being reported by multiple beneficiaries. We 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, we 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. We 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 2×2 design (i.e. urbanization changes or does not change bundle composition; and impacts or does not impact the number of beneficiaries).

2. Methods

2.1. Study sites and sampling design

The Solomon Islands are an archipelago of close to 1000 islands in the South Pacific. The volcanic and coralline islands, as well as the marine environment, host an impressive biodiversity (Ministry of Environment Conservation and Meteorology 2008). About a fifth of the population of 642 000 people lives in urban settings (Solomon Islands National Statistics Office 2015). The rural outmigration of people looking for employment and education results in a very rapid urbanization rate

(4.7%, UN-HABITAT 2012). The Solomon Islands fare relatively low in terms of several developmental indices (e.g. UNDP 2018). In general, people depend heavily on the environment for their wellbeing (Solomon Islands National Statistics Office 2015).

We conducted our research in two provinces, in each of which we paired an urban and a rural site (Figure 1). Both pairs of sites were in coastal locations spanning terrestrial, freshwater, and marine ecosystems. Given the similar location and environmental characteristics between pairs of urban and rural sites, we assumed that the differences between urban and rural areas would mainly be due to urbanization. In Guadalcanal, we paired Honiara, the capital and the largest urban centre, to Tamboko, a village located 20 km away on the same coast. In the Western province, we paired the industrial town of Noro on New Georgia to a village, Nusa Hope, located off the same island 30 km away as the crow flies.

We conducted 50 semi-structured interviews in each of the four sites ($N = 200$) from September to December 2018. We used a systematic random sampling design, selecting every second household in the research sites. We interviewed only one person per household. We maintained a gender balance in each site (respondents were 49% male and 51% female, Table B.1 of Appendix B). Interviews were conducted by trained research assistants from the Solomon Islands mainly in Solomon Islands Pijin and also in Roviana in the village of Nusa Hope.

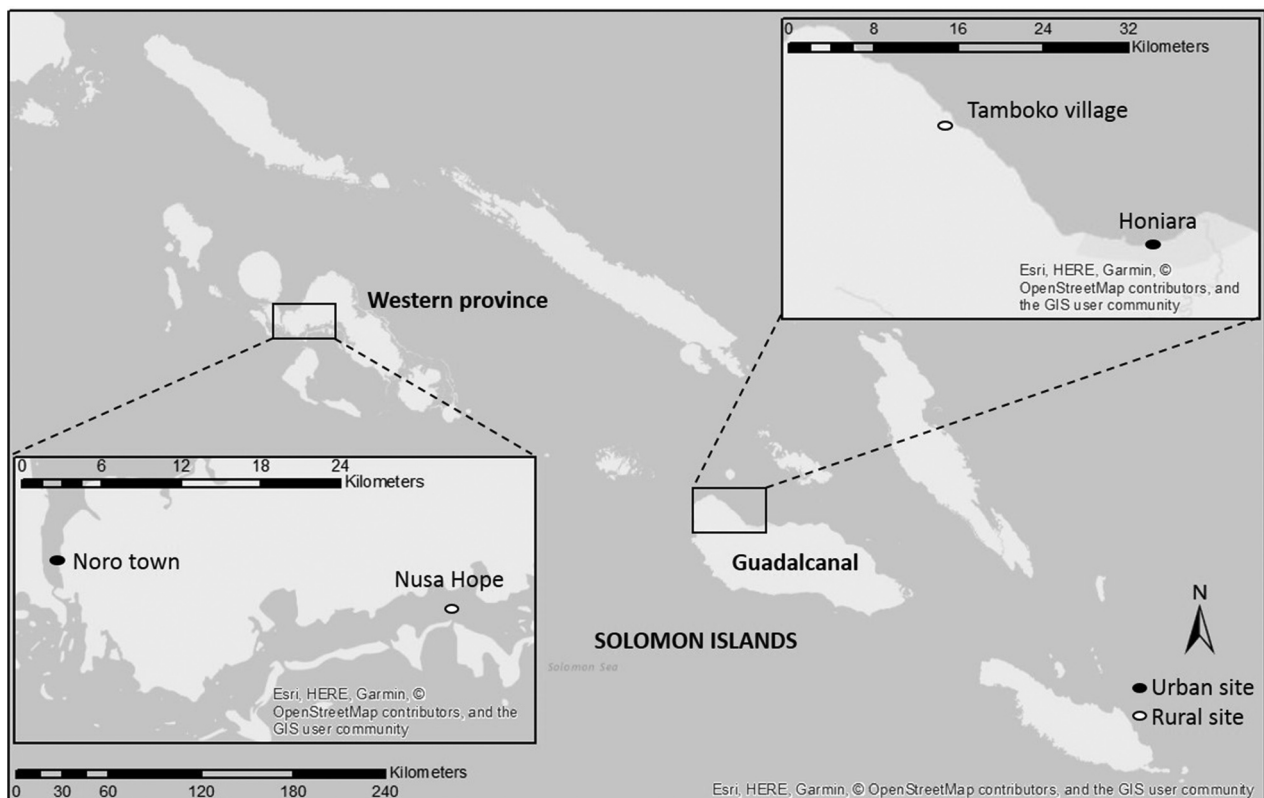


Figure 1. Map of the study sites.

2.2. Identification of ecosystems, ecosystem services and disservices, and bundles

In the household interviews, we presented respondents with 14 ecosystems, 9 ecosystem services and 3 ecosystem disservices, 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. We 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 field, (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. We 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, we 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.

The 12 ecosystem services and disservices were described to respondents as things from nature that result in positive, or negative, impacts on their life, respectively. We selected nine ecosystem services, with three ecosystem services from the provisioning (food, materials, and firewood), regulating (air filtration, water filtration, and soil protection), and cultural (recreation, culture, and stewardship) categories, and three ecosystem disservices (dangerous plants and animals, pests and diseases, and natural disasters) through a process of expert interviews and focus group discussions in the study sites (Table B.2, Appendix B; for more details, refer to Lapointe et al. 2020b). We defined ecosystem services according to the Common International Classification of Ecosystem Services at the class level (CICES, Haines-Young and Potschin 2018).

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. We do not present bundles determined from multivariate statistical analyses (e.g. ordination or clustering techniques) as recommended in Mouchet et al. (2014) because, considering our research design, these methods did not provide additional insights to the findings presented here.

2.3. Statistical analyses

To test whether the probability of identifying ecosystem services and disservices associated with ecosystem types differed between urban and rural respondents, we 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 disservice per ecosystem type per respondent, which we coded as a presence-absence binary variable. We 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. We 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 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, we 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).

3. Results

We identified 12 bundles of ecosystem services and disservices in both urban and rural areas according to ecosystem type (Figure 2). 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 C.1, Appendix C). However, significantly fewer urban dwellers perceived benefiting from at least one ecosystem service in all bundles (Figure 3). 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 our first hypothesis that living in urban areas compared to rural areas changes both the composition of perceived bundles and the number of

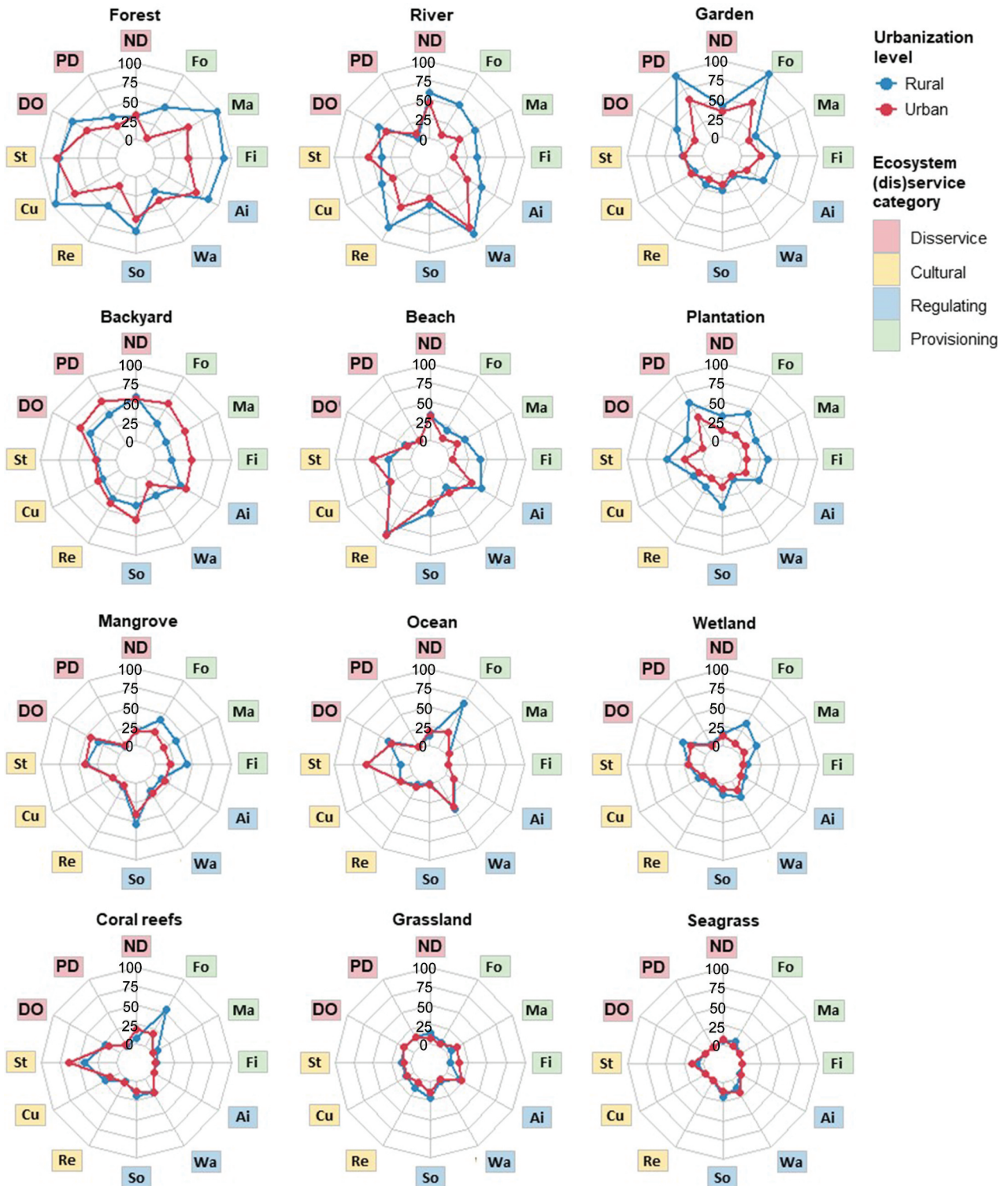


Figure 2. Radar charts showing the percentage of urban (in red) and rural (in blue) dwellers reporting ecosystem service and disservice associations per bundle (ecosystem type). Ecosystem service and disservice types: Fo: Food, Ma: Materials, Fi: Firewood, Ai: Clean air, Wa: Clean water, So: Soil protection, Re: Recreation, Cu: Culture, St: Stewardship, DO: Dangerous organisms, PD: Pests and diseases, and ND: Natural disasters.

people benefiting from different ecosystem services within a bundle.

Less than half of urban and rural dwellers reported disservices in most bundles (Table C.1, Appendix C). Further, urban and rural dwellers did not significantly differ for most associations between ecosystems and ecosystem disservices (Figures 2 and 3). 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

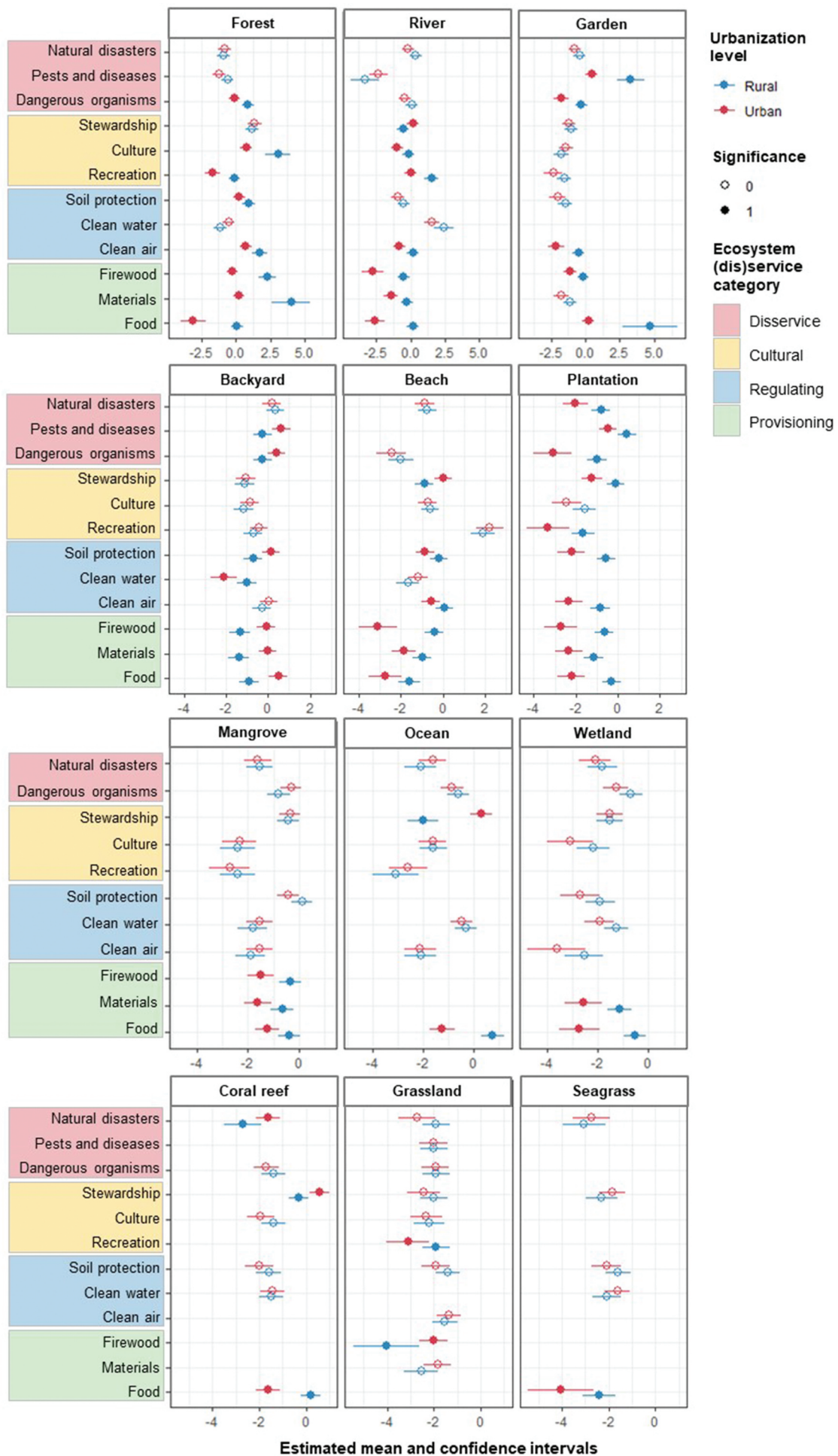


Figure 3. Coefficient plots from a logistic regression comparing the probability of associating ecosystem services and disservices to ecosystem types between urban (in red) and rural (in blue) areas.

and seagrass beds (Table C.1, Appendix C). Rural dwellers reported a greater number of ecosystems providing each ecosystem service type compared to urban dwellers, with the exception of stewardship in which case urban dwellers mentioned, on average, a higher number of ecosystems (Table C.2, Appendix C).

4. Discussion

We 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, we found strong support for our 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 we 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.

Our 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). We 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 over-exploitation and pollution of ecosystems (Ministry of Environment Conservation and Meteorology 2008; Toki et al. 2017b). 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. 2017a). 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. 2010; 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 A.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). We 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).

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). 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, Martín-López 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). 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 us 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, we 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). An 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. 2010). 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. (2010) also found that higher levels of urbanization led to a decrease in ecosystem service bundle multifunctionality. We 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, our 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. 2017a). 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, our approach presents a novel and simple way to identify and analyse bundles. We 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, we 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, our method provides information on the distribution of locally relevant ecosystem services in land and sea-scapes. The approach that we 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). Our 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.

4.1. Limitations and future research needs

We limited our 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 we were 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 our findings. Locating our 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. We 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, we would need information on people's needs and expectations or satisfaction levels towards ecosystem service bundles.

5. Conclusions

To understand how urbanization affects people's relationships with nature, we compared rural and urban dwellers' perceptions of ecosystem services and disservices bundles in terrestrial, marine, and freshwater ecosystems of the Solomon Islands. We 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.

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Disclosure statement

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Ethics approval

The research protocol was reviewed and approved by the Human Research Ethics Committee of James Cook University (Ethics Approval Number H7201).

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