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Multifunctionality of a peri-urban landscape: exploring the diversity of residents' perceptions and preferences

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ABSTRACT

Developing successful policies for sustainable land use requires understanding the perspectives of different actors. This study explored how residents – an often under-represented and unorganized group – vary in their valuation of ecosystem services (ES) and perception of multifunctionality in a peri-urban setting. We conducted 127 interviews in the Kromme Rijn region of the Netherlands guided by an interactive, visual canvas tool (STREAMLINE). We addressed four research questions: (1) Is there variation among residents regarding preferences for ES? (2) Which competing interests do residents see in this landscape? (3) Where are hotspots of perceived multifunctionality? and (4) Can the level of perceived multifunctionality be explained by its location on the rural–urban gradient? Our findings demonstrate that while the majority of ES are important to residents of a peri-urban landscape, there is variation in relative preference towards a subset of ES (mainly provisioning services). A typology of preferences distinguishes three groups: (A)'I want it all' – all ES (very) important; (B)'I want most of it' – majority of ES important; and (C)'I want some' – several ES not important at all. The majority of competing interests identified by respondents were between biodiversity and either a provisioning or cultural service. Universal hotspots of perceived multi-functionality overlapped with the area around residential areas, whereas natural (grassland) areas and water were considered multifunctional by only a small share of respondents. These perceptions and preferences do not necessarily align with current policy and management efforts, it is advised that residents' perceptions and values are better accounted for in landscape governance.

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1. Introduction

Peri-urban areas are emergent, dynamic, and socially heterogeneous territories in between urban and rural areas under preponderant and increasing urban economic and spatial influence (Wandl et al. 2014). This influence is represented by the presence of typical urban forms (e.g. continuous or discontinuous urban fabric) and lifestyles (e.g. teleconnected urban jobs) (Spyra et al. 2020). The changing socio-ecological structure of such areas is characterized by a mixture of old and new residents (Piorr and Ravetz 2011), the latter often being young urban commuters with aspirations for more sustainable lifestyles, requesting access to green infrastructure and close commuting distance, but at the same time aiming for private space and gardens (Metzger et al. 2018). Population and socio-economic projections indicate that peri-urbanization is likely to increase throughout Europe (Shaw et al. 2020), doubling in land area in the next 30–50 years (Piorr and Ravetz 2011; Stürck et al. 2018).

Peri-urban areas are characterized by and valued for high levels of multifunctionality (Ives and Kendal 2013; Sylla et al. 2020), simultaneously providing multiple functions and ecosystem services (ES) along a spatio-temporal gradient from urban cores to rural areas, including but not limited to aesthetics, recreation, air purification, timber and agricultural production (Willemen et al. 2008; Spyra et al. 2020). Multifunctionality can refer to the provision of multiple functions and ES on either the same landscape unit or in different units within the same peri-urban region (Stürck and Verburg 2017). However, there is no clear definition of the specific (set of) ES a landscape needs to provide to be considered multifunctional (Stürck and Verburg 2017). Regardless of the composition, the provision of multiple ES in a limited space often results in competition between different land use practices (Hedblom et al. 2017; Shaw et al. 2020; Spyra et al. 2020), which can lead to conflicts between actors. Therefore, governance in peri-urban areas needs to navigate these complex and often conflicting interests.

Diversity of values assigned to ES (i.e. appreciation/worth of ES (Pascual et al. 2017)) is related to a diversity of actors, which can be roughly divided

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into three groups based on their involvement in the governance process: 1) residents/layman who are affected but largely excluded from land management decision-making; 2) stakeholders in the area who rely economically on the land and are represented in decision-making (incl. farmers); 3) experts, often from outside the region, who inform decision-making (incl. researchers) (Spyra et al. 2020). To develop successful policies to achieve sustainable land use, it is necessary to not only understand and embrace this plurality of actors but also the heterogeneity within a particular group in regard to human-nature relations and their values for ES (Reed 2008; Pascual et al. 2021). The majority of studies looking at peri-urban land-use have focused on specific stakeholder groups that are organized through representative organizations (e.g. Zasada 2011; Palomo-Campesino et al. 2018; Rodríguez-Morales et al. 2020). Several more recent studies, in various landscape types, focus on residents' landscape preferences (e.g. Zhou et al. 2018; Fagerholm et al. 2019; Liski et al. 2019; Zoderer et al. 2019). However, residents in peri-urban landscapes are less represented in existing research while being a very large group of people that are often also poorly represented by formal stakeholder organizations. As a result, the plurality of their values is poorly understood (Spyra et al. 2019, 2020). Considering the many land use pressures in peri-urban areas this is an important and urgent research gap to enhance our understanding of governance of biodiversity and ES (Fagerholm et al. 2012; Tengö et al. 2014).

In this paper, we used a new approach to better understand the diversity of residents' values (specifically perceptions and preferences) towards their peri-urban landscape and the ES it provides. We took up a narrative approach from anthropology called STREAMLINE – a visual tool designed around series of A3 canvas with graphical and textual elements, which are linked with one narrative (De Vries et al. 2018; Metzger et al. 2018). As a case study, we selected a peri-urban landscape in which the majority of the residents is not represented by typical stakeholder organizations. This landscape, the Kromme Rijn region of The Netherlands, is a dynamic cultural landscape facing multiple complex competing land use pressures. By understanding differences in residents' valuation of ES and the spatial perception of landscape multifunctionality, we provide insights to support land use decision making and governance in the region. Specifically, we address four research questions: (1) Are there groups of residents with similar preferences for ES? (2) Which tradeoffs do residents see between competing interests in this landscape? (3) Where are hotspots of perceived multifunctionality in the landscape? (4) Can the level of perceived multifunctionality of an area be explained by its location on the rural–urban gradient?

2. Methods

We adopted a socio-cultural framework, which has been recognized to be useful for capturing and investigating plural values (Martín-López et al. 2012; Scholte et al. 2015; Fagerholm et al. 2019). The framework is designed to understand the values of people towards nature in non-monetary terms to complement biophysical and economic assessments. In this study, we focused on the values (in form of preferences and perceptions) people, as individuals or as a group, assign to ES or their bundles as well as on the spatial perceptions of multifunctionality. Following other applications of the socio-cultural framework (such as Fagerholm et al. (2019)), we examined not only the socio-cultural values but also their potential determinants by including contextual factors, both ecological and social attributes, as separate components. We considered the following contextual factors: a) characteristics of the landscape (a set of rural–urban gradient variables); b) interactions between beneficiaries/respondents and ES (use of the landscape, spatial perceptions of multifunctional areas and knowledge of competing interests in the landscape); and c) personal characteristics of beneficiaries/respondents (age, gender, education level and their relation to the landscape (i.e. place of residence, work, recreation etc.)).

2.1. Study area

The case study area chosen consists of the Kromme Rijn area and part of the adjacent national park Utrechtse Heuvelrug located in the Central Netherlands, next to the city of Utrecht (Figure 1). This study area has been selected because of its representativeness for peri-urban landscapes in Western European countries. The area is considered representative as it reflects the majority of the processes reported for peri-urban landscapes throughout Europe inventoried by Shaw et al. (2020). The Kromme Rijn area (220 km^2, 86.090 inhabitants) is a dynamic cultural landscape, with differences in size of fields and landscape units (Padt and Westerink 2012), openness and relief, varying from mosaics with patched forests to wide open pastures on the river banks. The name refers to a 28 km long small river that flows through the area. Land use presents a mix of large, dense villages, dispersed houses, farms and farmland, and nature areas. Agriculture is dominated by fruit cultivation and dairy farming. Due to its landscape attractiveness, hosting several estates and castles, it is an important recreation area essential

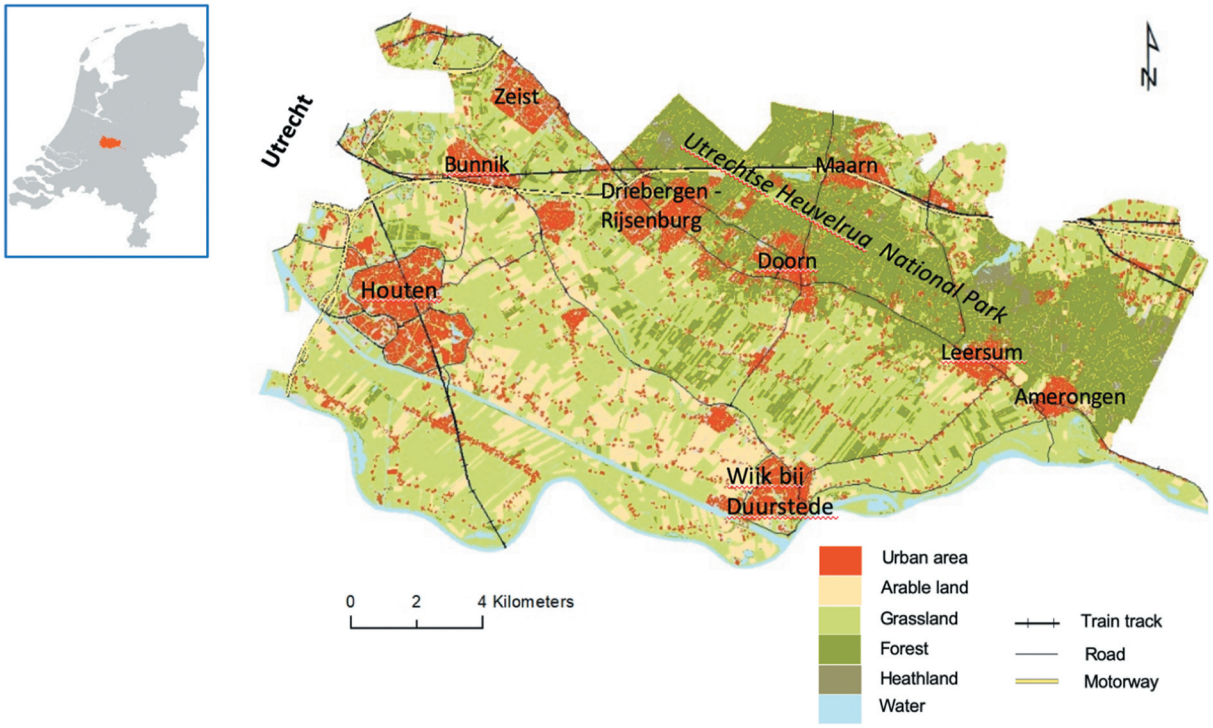

Figure 1. Map of the study area.

to the quality of life of Utrecht's citizens. Utrechtse Heuvelrug National Park covers 10,000 ha of forest, heathlands, grasslands and floodplains. Some 150,000 years ago, ice and water pushed up masses of earth and stones, forming the Utrecht ridge in the middle of the Netherlands. Today, this ridge hosts the second-largest forest in the country, consisting of mostly oak and beech trees, and provides a view of the river and the Kromme Rijn area. The Utrecht ridge has for centuries also been a place for people to relax and recreate, with estates, castles surrounded by nature.

The study landscape is often in the news reporting conflicts between different ES: landscape quality is threatened by expansion of infrastructure, and conflicts arise between intensive agricultural and nature conservation, as well as the increased pressure by recreational use. An example is the planned expansion of the highway A27 bordering the recreational area Amelisweerd in the west of the small town Bunnik that will lead to the loss of natural and recreational area (NOS 2022), while aiming at reducing commuting time for residents. Alongside infrastructure, also the towns and villages in the study area are steadily growing, contributing to further peri-urbanization (Gemeente Utrecht n.d.). Moreover, a large share of residents has occupations outside the region, commuting to nearby cities, thus having a different relationship with the landscape than those that are both residing and working in the area. These typical peri-urban characteristics make residents have relatively little influence on the dynamics and management of the landscape they live in.

2.2. STREAMLINE interviews with PPGIS elements

We conducted semi-structured, questionnaire-based interviews with residents following a narrative approach from anthropology called STREAMLINE – a visual tool designed around a series of A3 canvas with graphical and textual elements, which are linked with one narrative (https://www.streamline-research.com). Respondents answer questions going through the canvases one by one by writing, drawing or picking tiles and thus creating an interactive interview environment. The narrative nature of this series of canvases as well as visual elements such as drawings engage the respondent (De Vries et al. 2018; Metzger et al. 2018). Another advantage of using STREAMLINE canvas format is that it also allows for inclusion of various elements such as public participation GIS (PPGIS), thus providing assessment of ES that is spatially and socially linked. Participatory mapping (such as PPGIS) has become a common and one of the most efficient tools to elicit place-based values of different actors. It allows integration of different voices of the plural society into planning and governance and development of effective management policies (Maes et al. 2012; Brown and Kyttä 2014; Brown et al. 2020).

Our interviews were guided with five laminated A3 canvases (Suppl. material A), each depicting a part of the larger story narrative. They were constructed to

have a simple and interactive layout, by including illustrations, maps and multiple-choice questions. They also have been pre-tested with five respondents prior to the data collection and necessary adjustments have been made. Ethics approval for the project was obtained from the Vrije Universiteit Amsterdam (the Netherlands).

Canvas 1 sets the scene by introducing the study landscape to the respondent and inquiring into their relationship with the landscape. We prepared a base map of the study area using OpenStreetMap data with various landmarks (e.g. location of castles, hiking paths) to ease readability. Participants were asked to circle familiar areas on the map and list all landscape functions they think it provides. For the purpose of these interviews, we have used the term 'landscape function' to represent ES or Nature's Contributions to People (NCP), as it is more familiar to our target audience. All three terms are referring to the benefits people obtain from nature, however conceptual differences between them exist (de Groot et al. 2002; Kremen 2005; Díaz et al. 2018). The term landscape functions is in the scientific literature also used to describe the internal functioning of the ecosystem (e.g. maintenance of energy fluxes, nutrient (re)cycling, food-web interactions) (de Groot et al. 2002). ES present a set of landscape functions that are directly linked to human well-being and as such are used to translate the ecological complexity into the limited number of ES of interest to human well-being. Finally, NCP, building on the ES framework, present an inclusive approach where different viewpoints exist and recognize not only the positive but also negative contributions to human well-being (de Groot et al. 2002; Díaz et al. 2018). For the purpose of this study the differences between the terms are not significant and with the term used we were best able to link to the respondents understanding. The findings are discussed adopting the perspective of ES using the Common International Classification of Ecosystem Services (CICES) V5.1 18 March 2018 (Haines-Young and Potschin 2018).

Now that the respondents started to consider different landscape functions, on *Canvas 2* they were presented with 14 landscape functions and asked to rate how important they are to them (5-point Likert scale, from not important at all to very important). This question forms the basis analyzing variation in values between residents and, based on that, dividing residents into groups depending on how they value different functions to answer RQ1. The initial set of ES relevant in the study area was compiled based on knowledge from previous projects conducted in the area (i.e. Verhagen et al. 2018; Karner et al. 2019; Hölting et al. 2020). This set included water purification for drinking, landscape aesthetics, outdoor recreation, crop, fruit, dairy and timber production, tranquility, carbon sequestration, pollination. This list was then complemented with suggestions from respondents during the pilot stage (n = 10), including mobility (road construction), energy production (wind and solar) and residential (housing) function. The former and latter are not listed in the CICES ES classification, and represent landscape functions rather than ES. However, since they were added by respondents and are also an essential part of peri-urban landscape experience, we have included them, arbitrarily, into the provisioning ES category in the further analysis. Finally, habitat for biodiversity has also been included in the list of functions for respondents. It is not an ES, but rather an underlying condition for the functioning of the ecosystem and the provision of ES. For respondents, it has been explained as 'the diversity of species (animals, plants)'.

In an open-ended question on *Canvas 3* we asked respondents to name all competing functions in the landscape they could think of. This information presents another dimension of characterizing differences between residents and identifying potential determinants of their socio-cultural values which serve to answer RQ2. This canvas was also meant to make respondents think of potential and existing conflicts between landscape functions as a preparation for next canvas, reflecting existence of competing interests and creating an awareness that all functions at the same time might not be possible.

Canvas 4 presented another PPGIS question, where respondents were asked to first draw (circle) areas on the map that they see as multifunctional (i.e. providing multiple functions) and then those as they see only providing one function (mono-functional). Data from this question were at the core to answering RQ 3.

Finally, *Canvas 5* collected basic socio-demographic data on respondents such as gender, occupation, age and postcode. These have been used to characterize the respondents.

A total of 127 interviews were conducted with residents from both the area itself and towns directly bordering the area (but using the area for activities), who were recruited through purposive stratified sampling based on the following three stratification criteria: 1) location in the landscape, 2) gender, 3) age. The first criterion was based on the geographical balance of respondents within the area. We aimed to cover locations representing different habitats and land cover types along the rural–urban gradient: from forested areas in the National Park, to the central part of the landscape dominated by farms and finally to floodplains next to the river. Respondents were approached at four town markets (n = 63) and at four popular recreation spots in the area (n = 58). Additionally, to cover residents with diverse relationships to the area, we interviewed

representatives of several stakeholder organizations in the area, who are also residing in the area themselves (n = 6). The interviews were spread out in time to cover different seasons (57 in June–September 2019 and 70 in February 2020). An average interview took 20 minutes to complete. Interviews were not audio recorded, but rather, additional notes were written on the canvases for comments given by respondents.

2.3. Data analysis

RQ 1. *Is there variation between residents with regard to preferences for ES*

In Canvas 2, respondents scored the importance of a set of landscape functions using a 5-point Likert scale (from 'not important at all' to 'very important'). To visualize the variation in responses between residents, we initially constructed spider diagram for each respondents' ranking. Visual inspection revealed that respondents could be grouped based on how different functions are perceived in combination with each other (e.g. all ranked equally, or some are ranked distinctly differently from others). Based on this idea we made a typology of the responses, which followed a mix of inductive and deductive grouping of respondents using the shape of their valuation spider diagram (i.e. rules for assigning to one group or the other were developed and being constantly adjusted, whilst being carefully recorded in a log). The purpose of the typology was to create groups with different, but shared, preferences that best capture the variation in the recorded responses, following methods of typology creation as discussed by van der Zanden et al. (2016). Rules included how many functions (min to max) could be ranked differently from all functions and to what extent they differed.

RQ 2. *Which tradeoffs do residents see between competing interests in this landscape*

For each respondent, we recorded which pairs of competing interests they listed. Since data were derived in an open question format, this was done using qualitative thematic analysis. This approach is commonly used to provide a description and understanding of qualitative answers, to discover patterns and develop themes (Braun and Clarke 2006). These pairs were then grouped according to the types of services which are in conflict and for each respondent the number of named pairs and their categories have been calculated. Such breakdown has been calculated for all respondents and for each of three groups of respondents. No further statistical analysis was performed due to the relatively small sample size per group.

RQ 3. *Where are hotspots of perceived multifunctionality in the landscape*

Maps from PPGIS question in Canvas 4 were digitized using ArcGIS 10.4.1. There we created density maps to highlight different levels of perceived multifunctionality for all respondents and for each of the three groups of respondents and placed those maps on the Open Street map to better visualize patterns of different levels of perceived multifunctionality located and identify hotpots (i.e. areas that were considered as multifunctional by a large share of respondents).

RQ 4. *Can the level of perceived multifunctionality of an area be explained by indicators of the rural–urban gradient*

The rural–urban gradient is a characteristics of the transition from built-up to more open and natural landscape, which has commonly been used to study peri-urban landscapes (e.g. Kroll et al. 2012; Larondelle and Haase 2013; Baró et al. 2017; Palomo-Campesino et al. 2018; Zhou et al. 2018). A variety of indicators exists to measure the rural–urban gradient, from demographic to physical and landscape-oriented metrics (Hahs and McDonnell 2006; Andersson et al. 2009). To determine whether the location on the rural–urban gradient is perceived as multifunctional by respondents, we selected several indicators based on a list of potential metrics by Andersson et al. (2009) (for a full list of indicators seen Table 1 in Andersson et al. (2009), also presented in Suppl. Material F). The choice of indicators was based on the potential relevance for this specific area as judged by the authors relying on their previous experience in the area and availability of spatially explicit data for the site. For example, previous study by Komossa et al. (2020) demonstrated that tranquility has been among functions that are highly valued by residents, suggesting that measures of acoustic environment would be important to include as an indicator of the rural–urban gradient. We arrived at the following set of indicators for the gradient: 1) physical variables: land use and land cover classes, proximity to urban areas and acoustic environment (i.e. silent areas); 2) socio-economic variables: density of people and mean household income (Table 1). We purposely did not pre-set value levels of variables to characterize what is multifunctional, as the goal was to find out what levels of perceived multifunctionality (proportion of respondents seeing that as multifunctional) different levels of each indicator variables receive. For example, is silent area (<40 dB) or the one louder than that is perceived multifunctional by larger proportion of respondents?

Table 1. Rural–urban gradient indicators.

Indicators		Description and data used
1. Physical environment	Land use and land cover classes	LGN 6 classes have been reclassified into six main land use classes: agriculture, forest, water, build-up area, infrastructure and nature (i.e. coastal areas, heathland, peatland, moor, and natural grassland) (Hazeu et al. 2010). Sub-classes within each class can be found in Suppl. Material B.
	Proximity to urban areas	Urban areas (Provincie Utrecht 2019a): small patches such as farms and tiny villages manually removed. Distance to urban areas calculated using Euclidean distance function of ESRI ArcGis version 10.4.1 with max distance of 10km.
	Acoustic environment	Areas of silence with noise level of less than or equal to 40dB(A) (Provincie Utrecht 2019b)
2. Socio-economic environment	Density of people	Number of inhabitants per 100m^2 (CBS 2020)
	Mean household income	Mean annual household income on a 25x25 meter grid cell resolution (CBS 2015)

As a preparatory step, we calculated the densities of perceived multifunctionality of various locations in the landscape – share of respondents having identified that location as multifunctional (based on methods used by Komossa et al. (2020)). We then run a multivariate linear regression to relate the levels of perceived multifunctionality to the indicators of both the physical and socio-economic environment. For land use and land cover and acoustic environment, being categorical variables, we calculated the percentage of cells in a 1 km circular neighbourhood (focal mean) where a specific land use land cover or area of silence is present. All variables for rural–urban gradient indicators have also been checked for correlation to avoid multicollinearity in the model.

3. Results

3.1. Variations amongst residents based on differences in preferences for ES

The majority of respondents highly valued cultural (tranquility, recreation and aesthetics) and regulation and maintenance ES, as well as biodiversity. Provisioning services received lower and more diverse scores, of which fruit production has been most appreciated (Figure 2 'All respondents').

Based on the respondents' scores for ES relative to each other (not comparing values of specific ES one by one) we divided them into three groups (Figure 2 and Table 2). Respondents in all three groups provided similar high values to cultural and some of the regulation and maintenance services, and biodiversity. The differences mostly related to the extent of what provisioning services were appreciated. These groups are:

(A) "I want it all": this group consisted of respondents (n = 30) who consider all ES and biodiversity either "very important" or "important" and there are no distinct differences between how they value different ones. This group is dominated by women older than 46 years old, who are residing within the study area.

(B) "I want most of it": this group consists of respondents (n = 63) for whom biodiversity and most ES (such as cultural, regulation and maintenance and some provisioning) are (very) important, while a subset of provisioning ones such as mobility (road network), wood and energy production are less important or not indicated to be important nor unimportant. However, this difference in values assigned to various ES is not always that prominent and services are not often given a score of "not important at all". This is the largest group, comprising almost half of our respondents. Gender distribution is more balanced than in group A. This group also consists of slightly higher proportion of respondents younger than 46 years old. This group also represents most respondents with higher education from applied and normal universities. However, it also consists of a larger share of residents from the nearby big city of Utrecht and small towns around the study area than in group A (around 30%).

(C) "I only want": this group reflects views of respondents (n = 34) with a strong preference for biodiversity, cultural, regulation and maintenance services who find almost all of provisioning services as (very) unimportant. Almost two-thirds are residents of Utrecht or towns around the study area. This group also has the largest share of younger people among all three groups (39% under 46 years old) and a large share of respondents with higher education (67%).

3.2. Competing interests seen by residents in this landscape

The competing interests that were most frequently identified by respondents were between biodiversity and one of provisioning ES (for example, crop or timber production) (52% for all respondents) (Figure 3 and Figure SC1 in Suppl. Material C).

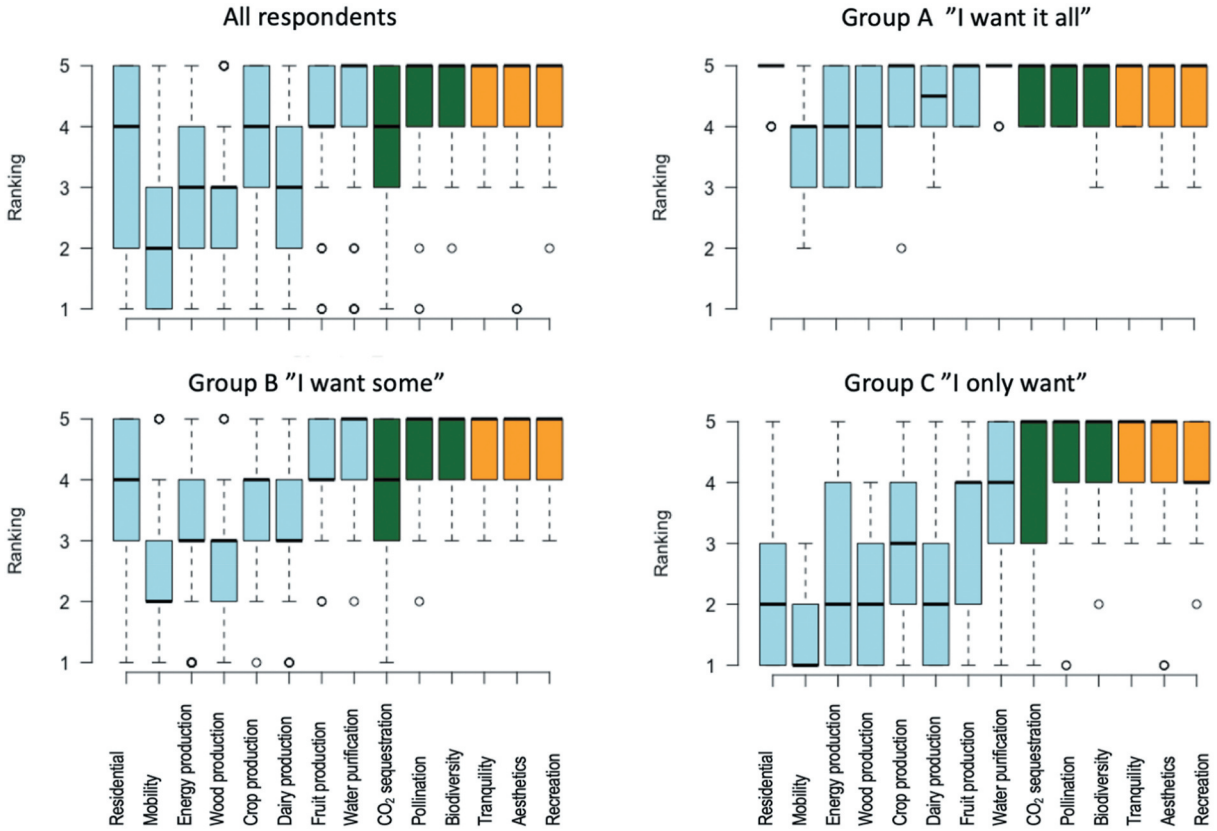

Figure 2. Range of ranking for each ES for all respondents and each group ("1" – not important at all and "5" – very important). Colors of individual boxes represent categories of ES: "blue" – provisioning ("residential" and "mobility" are not ES, but have been arbitrarily placed under this category for analysis as they have been added by respondents during the pilot), "green" – regulation and maintenance and biodiversity, "orange" – cultural.

Table 2. Respondents' composition in each group in percentage from the group's total.

Characteristic	Levels	Group A (n=30)	Group B (n=63)	Group C (n=34)
Gender	Male	23	36	47
	Female	77	58	50
	Unknown*	0	6	3
Age	18 – 30	1	8	15
	31 – 45	19	21	24
	46 – 64	40	51	35
	65 and older	40	17	26
	Unknown*	-	3	-
Highest level of education	None	-	-	3
	Secondary education (High school)	20	8	12
	Professional education (MBO)	23	21	12
	University of Applied Science (HBO)	43	46	32
	University (WO)	6	19	35
	Unknown*	8	6	6
Relationship to the area	Local residents	77	57	32
	Visitors from Utrecht & towns right outside the study area	17	30	65
	Unknown*	6	13	3

*Not provided by the respondent.

Also in all of the individual groups, this was the most frequently identified competing interest. In group A little to no attention was paid to potential conflicts between biodiversity and cultural services as well as between different cultural services (for example, tranquility vs recreation). On the other hand, respondents in this group saw a higher share of competition between different provisioning services (for example, agriculture vs energy production in the form of wind mills). Residents in groups B and C on average had

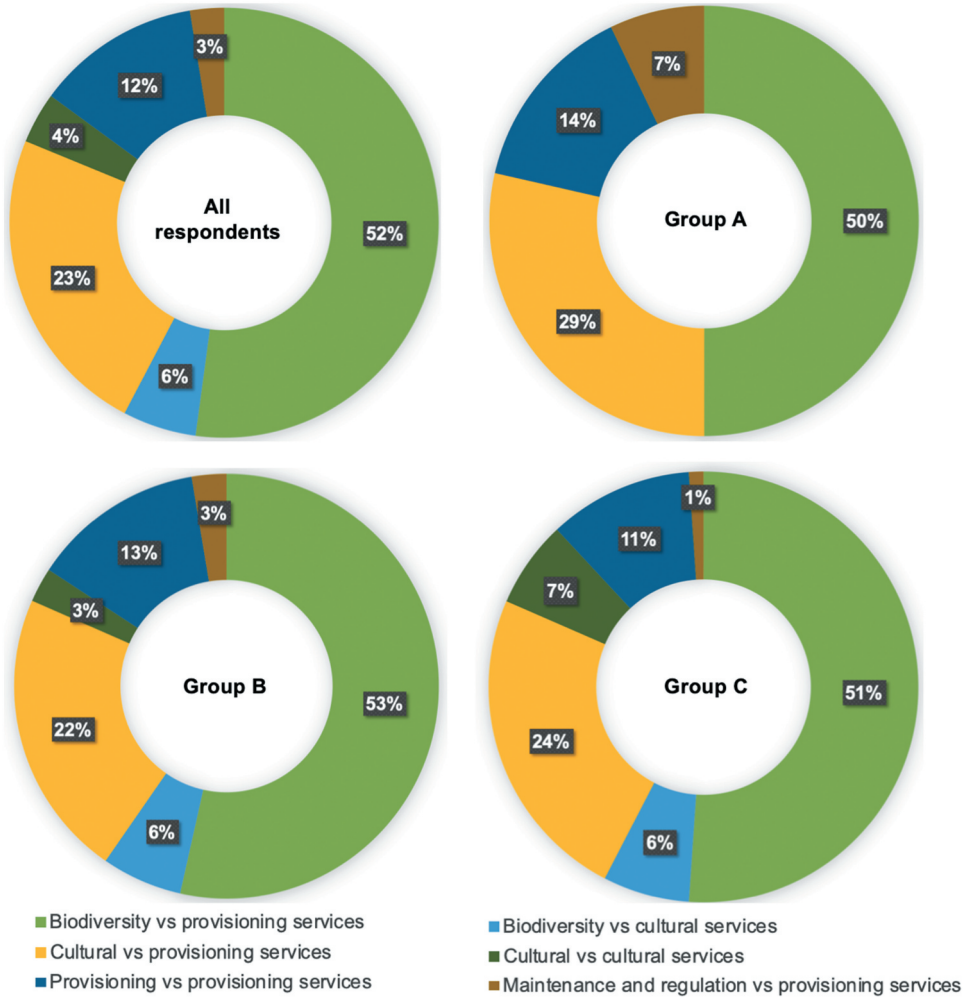

Figure 3. Breakdown of groups of competing services in the landscape known to respondents: for all respondents and for each of three groups. Pie charts present proportions of named competing interests out of the total number of mentioned pairs. They do not correspond to the proportion of respondents, as some respondents named more than one pair of competing interests.

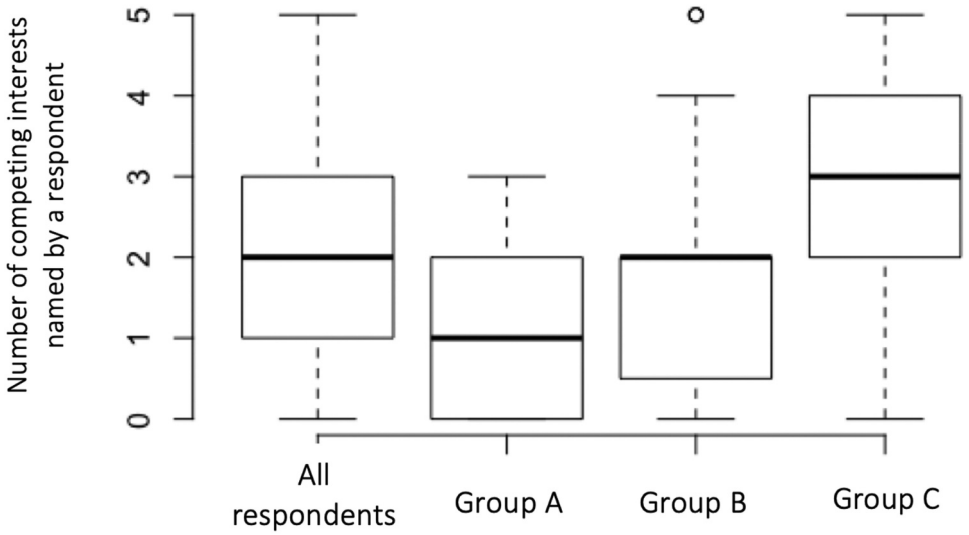

Figure 4. Number of named competing interests in the landscape named per respondent.

a wider knowledge of competing interests in the landscape by mentioning conflicts in more categories (Figure 3). Moreover, in group C, where respondents valued provisioning services distinctively lower, on average, more pairs of competing interests were named by respondents (Figure 4), showing larger and more nuanced knowledge of environmental issues in the area. Overall, half of all respondents

named two pairs of competing interests, and respondents that highly valued all ES (group A) named the lowest number of conflicts on average (Figure 4).

3.3. Location of hotspots of perceived multifunctionality

Visual inspection of density maps of areas seen as multifunctional (Figure 5) showed that hotspots common to all respondents mostly overlap with residential areas (i.e. local towns) and their surroundings. Figure 5 demonstrates differences in how perceptions of multifunctional areas manifest spatially for the three groups of residents. The largest differences are between groups A and B. For respondents in group A hotspots overlapped with the area surrounding the local towns of Houten (to the West), dominated by relatively new residential areas, and Wijk bij Duurstede (to the East), an older town with more elements of cultural heritage. Moreover, respondents in this group mostly circled areas in the south of the study area, where the landscape is flat, composed of agriculture, water, roads and residential areas. For respondents in group B hotspots also overlap with built-up areas but mostly those located in the north of the study area, namely at the border with the Heuvelrug National Park with access to nature/forest areas.

3.4. Link between level of perceived multifunctionality of an area and its location on the rural-urban gradient

Table 3 presents the regression coefficients for all rural–urban gradient indicator variables calculated for all respondents and each of the three group of participants. There was only limited collinearity among the indicator variables. We, however, removed the variable *'number of inhabitants'*, due to a rather high correlation with '*built-up areas*' (see Tables SD1 & SD2 in Suppl. Material D). The models had an overall reasonable, but incomplete, explanation of the areas perceived as multi-functional as shown by the R^2 values (Table 3).

For all respondents, regression outputs confirm that areas perceived as multifunctional are significantly linked to all rural–urban gradient indicators that were included in the model (Table 3). Overall positive associations with perceived multifunctionality are found for forest, agriculture, nature (i.e.

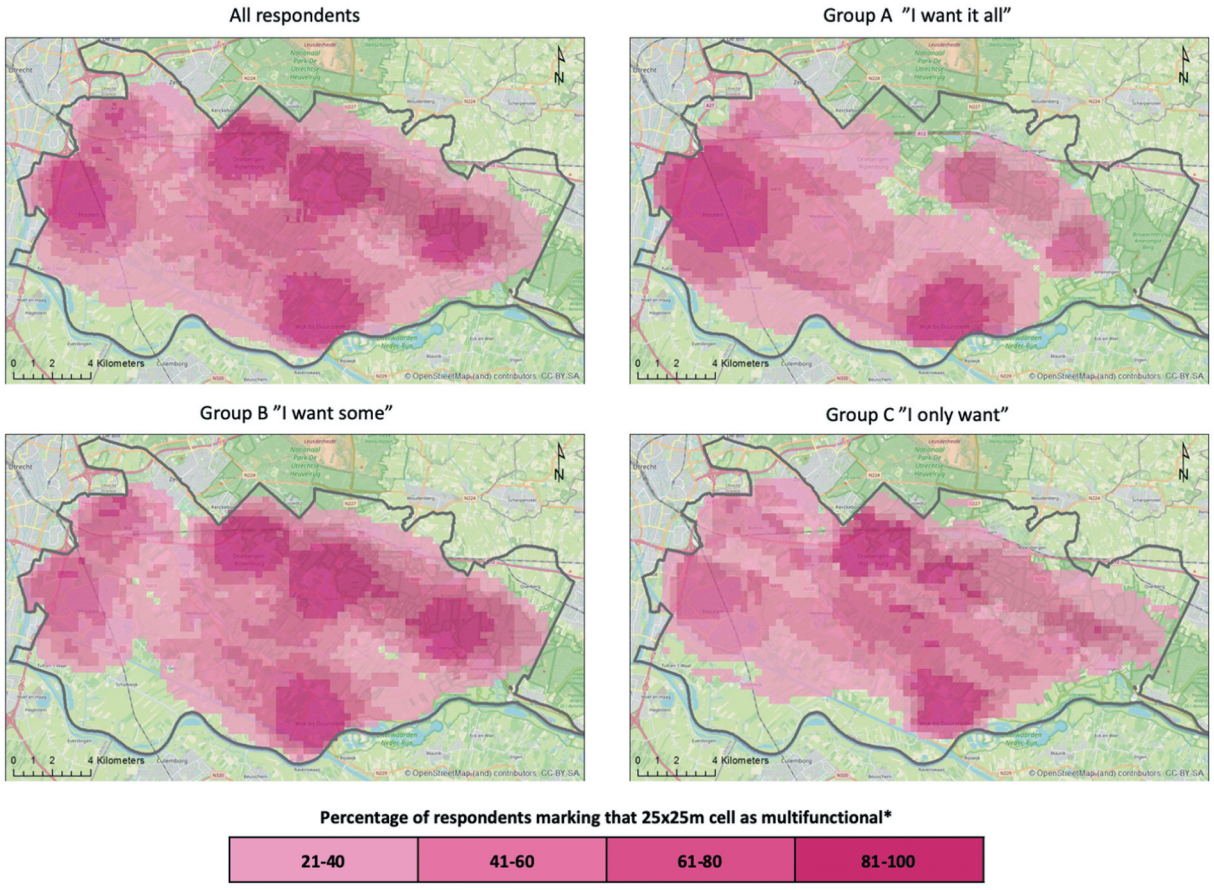

Figure 5. Density maps of areas marked as multifunctional by all respondents and separately for each of the three groups (darker the shade of pink – the larger the share of respondents who have marked that unit as multifunctional). The graphs are not displaying the lowest class of perceived multifunctionality (0–20%), in order to increase readability of the background map.

Table 3. Regression estimates (including R^2 values) for levels of perceived multifunctionality for all respondents and all three groups.

Variables	All respondents	Group A	Group B	Group C
Physical environment				
Forest	37.8989**	6.1625**	−0.0112**	6.8381**
Agriculture	31.0380**	8.0029**	24.9257**	5.4602**
Water	−5.5922*	−1.1253	17.5604	−7.3521**
Built-up area	57.6626**	13.1820**	2.4629**	12.8979**
Infrastructure	−65.7916**	−23.6988**	31.5664**	−12.8962**
Nature	5.1927*	0.5465	−28.7499**	−0.2195
Distance to urban areas	−0.0005**	0.0001**	4.9119**	−0.0001**
Areas of silence	9.2079**	0.6742**	−0.0005**	4.1280**
Socio-economic environment				
Household income	−0.0103**	0.0023**	−0.0009**	−0.0013**
R^2	*Value*	*Value*	*Value*	*Value*
	0.4145	*0.3160*	*0.3604*	*0.4825*

**p<0.01.
*p<0.05.

grasslands), built-up areas and areas of silence. That means that, for example, the higher proportion of built-up areas or agriculture in an area, the larger number of respondents find it multifunctional. Whereas, for water and, infrastructure and distance to urban areas we observed negative relationships with the perceived multifunctionality.

Positive significant association between perceived multifunctionality and built-up areas as well as agriculture are common to all three groups of respondents. Group B differs from the other two with respect to forest (negative association), water (positive association though not significant), infrastructure (positive association), areas of silence (negative relationship) (Table 3). At the same time, forests were marked as multifunctional by a large share of respondents (Figure SE1 in Suppl. Material E). Group A differs from the other two by presenting a positive association between nature (i.e. grasslands) and perceived multifunctionality, though insignificant. In both groups A and B distance to urban areas has a significant positive association with the perceived multifunctionality.

4. Discussion

4.1. Residents vary in relation to the relative importance of ES

Our findings demonstrate that within the actor group of residents of a peri-urban landscape and surrounding areas there is variation in how they value various ES and biodiversity. This is in line with previous studies that indicate that differences in the valuation of ES not only occur between various groups of actors such as stakeholders, experts and residents (e.g. García-Nieto et al. 2015; Hölting et al. 2020; Rodríguez-Morales et al. 2020), but also within these groups (such as farmers) (e.g. Zoderer et al. 2019; Blanco et al. 2020). Our study, however, adds additional insights as it specifically looks at the degree of multifunctionality that is preferred and how interactions between the ES in such multifunctional landscapes are perceived. We distinguished three groups of residents, largely based on the number of ES that are considered important.

4.2. Provisioning ES are the main source of value heterogeneity among residents

When examining which ES were valued as important, we saw that with the exception of provisioning services, all ES and biodiversity are important for all respondents. This is in line with findings of Martín-López et al. (2012), who showed that people value not only provisioning services, but also regulation and cultural, even though they might be harder to recongnize in the landscape. Similar to the findings of the Rodríguez-Morales et al. (2020) in peri-urban communal forests of Mount Xalo (NW Spain), provisioning services were less important for two groups of respondents in our study with a lower proportion of local residents (B and C). Traditional stakeholders representing a specific activity like farming or hunting often have clear stakes in one ES, residents in this peri-urban area value a much broader range of services, and sometimes even less the more traditional provisioning ones. This might be explained by the fact that residents of peri-urban areas do not have a specific dependence on one landscape function for their income, or the conscious choice to live in the area because of its landscape. Moreover, it might be the knowledge of the competing interests between some of these functions that makes residents to clearly value one of these functions as less important.

4.3. Awareness of competing interests in the landscape and importance of multiple ES

Respondents named most competing interests between biodiversity and provisioning or cultural services, as well as between cultural and provisioning services. The awareness of tradeoffs does not necessarily mean that one of the competing ES is less desired. Still, the perception/awareness of a conflict between functions was lower among those that valued all ES equally important. The lower appreciation for some of the provisioning services among residents in groups B and C might, therefore, be linked to the awareness of competition of these services with biodiversity and/or cultural values as knowledge was linked with prediction of perceptions of ES in Spain in the study by Cebrián-Piqueras et al. (2020).

Our groups of respondents were not organized around the geographic profiles of respondents. Still, our findings suggest differences in the relationship of the respondents with the local landscape, knowledge about it and ultimately the extent to which they perceive and value functions provided by it. This corresponds to findings in other studies (e.g. Martín-López et al. 2012; Plieninger et al. 2013; Fagerholm et al. 2019). For instance, in group A, where the majority of respondents were residents within the area, competition between various provisioning services such as mobility (construction of new highway) and residential (building new housing) and energy production (both wind turbines and solar energy parks) was mentioned. This is not surprising since all of them are currently being discussed or part of plans by the provincial government. Groups B and C had a larger share of respondents living just outside the area and visiting it for recreation. These focused less on conflicts between the use of space for provisioning services but rather named a larger number of conflicts between biodiversity and provisioning services, suggesting a deeper awareness of environmental issues. That group also consisted of a larger share of younger people, who tend to prefer more environmentally oriented options (Eriksson et al. 2012; Juutinen et al. 2017). A study of residents of Berlin and its surroundings by Riechers et al. (2018) showed that there are divergent perceptions of green areas in terms of cultural ES: younger inner city dwellers preferring cultural services facilitating social interaction, whereas older peri-urban residents leaned towards the ones providing nature experiences. Moreover, around 5% of our sample were 'wearing double hats', as in addition to being residents they were also representatives of different stakeholder groups such as farmers, policy-makers, etc. They were distributed between different groups. Given the low share of this type of respondents in the total sample, their results cannot have a significant effect on group preferences.

4.4. Hotspots of perceived multifunctionality are found around the residential areas

Our findings show that hotspots of areas perceived as multifunctional overlap with built-up areas and the directly surrounding area, a similar finding to that of Fagerholm et al. (2019) for a cross-site study of 13 multifunctional landscapes in Europe (from deep rural to peri-urban landscapes). At the same time, in terms of provision of ES, some studies have reported lower capacity for urban areas in comparison to rural ones (e.g. Balzan et al. 2018), whereas others contested that notion and argued that even the core of cities can provide a wide range of ES (e.g. Larondelle and Haase 2013). Common to all respondents, a large share of agriculture in the area is positively linked to the number of people seeing that area multifunctional. On the other hand, a study by Hölting et al. (2020) conducted an assessment of the multifunctionality of the area without accounting for stakeholder perspectives and found croplands to provide more coldspots than hotspots of multifunctionality. Interestingly, overall water areas have shown a negative association with the perceived multifunctionality and have been marked as multifunctional by only a small share of respondents, contrary to the findings of Fagerholm et al. (2019). A possible explanation is that many of the residents only use the immediate neighborhood of their residence, and hence, only appreciate the multifunctionality of that immediate environment. Some of the towns in the region have been referred to as 'sleeping towns', referring to the disconnect of daily activities of the residents with the surrounding area. This together with awareness of a number of competing interests between biodiversity and ES could present challenges for landscape governance and planning.

4.5. Differences in which areas considered multifunctional

Previous research (e.g. García-Nieto et al. 2015) demonstrated differences in the perception of the spatial distribution of ES between various actor groups. Our findings also show such differences in spatial manifestations of areas that respondents consider as multifunctional in the landscape. Specifically, we observed differences towards perceptions of areas of silence, water, forest and nature (in form of grasslands), as well as infrastructure. Nature was not associated with multifunctionality in most groups. This is most likely the case as these small areas classified as nature are often inaccessible or wetland areas, while the larger forest

areas are classified as forest (but still have natural values). In group B, where respondents were selective about which ES are important to them, interestingly infrastructure returned a positive relationship with perceived multifunctionality, even though on average mobility (roads) were valued low. For respondents who are selective about ES that are important or not (groups C), the most quiet (low noise level) zones in the regions were often perceived as multifunctional, which is in line with the overall high preference for cultural services, including tranquility. Some of these differences in spatial perceptions of multifunctionality and valuation of functions could be linked to the composition of the groups and differences in lifestyles – rural and urban, original inhabitants and newcomers, as described in Shaw et al. (2020), geographical profiles as demonstrated in Rodríguez-Morales et al. (2020), or demographic characteristics as shown in a study of Spanish landscapes by García-Llorente et al. (2020). This has not been explored in our study; however, it presents an important variable for consideration of potential conflicts and trade-offs and how to navigate them.

4.6. Methodological considerations

The interactive and narrative nature of interviews guided by the STREAMLINE canvas was perceived as interesting and engaging by respondents, based on the informal de-briefing and comments provided by them. In their informal feedback respondents often compared these interviews with more traditional ones, indicating that the STREAMLINE ones did not seem overly complicated and boring to them as the other ones often did. At the same time, this interactive nature and A3 format of canvas and the need to draw on them made it more difficult to conduct interviews at spots that did not have a table or at least a bench to lean/prop onto the canvas, limiting sampling opportunities. Another problem associated with paper-based maps is that the same mapping scale is used for all participants even if for some locations a more detailed map would have been beneficial to more accurately identify areas. The sketchy nature of the maps has limited the statistical analysis we could perform on the PPGIS data. In-person surveys using the STREAMLINE approach are not designed to deliver large detailed datasets as web-based PPGIS, but rather to conduct more qualitative explorative studies. A web-based PPGIS survey would have resulted in spatial data of higher accuracy.

4.7. Implications for governance of peri-urban areas

Peri-urban areas are characterized by high levels of multifunctionality, diverse socio-economic profiles and a dynamic mosaic of land uses, which together presents a multi-faceted challenge for planning, policy and governance. Environment and development of peri-urban areas are context specific and often difficult to synthesize into a generic approach to their governance (Shaw et al. 2020). However, in order to improve management and make more sustainability focused policies, the voices of different actors must be included and their interests navigated (Reed 2008). This is further complicated by the heterogeneity in values and demands within each group of actors. Findings of this study demonstrate that this is also the case for the residents. This emphasizes the importance of understanding of variation in values, use and perception assigned to these landscapes by their residents, rather than considering them as a homogenous group of actors. Explicitly addressing the values of residents is essential, as this is a group which often is not represented in policy and decision-making process to the same extent as (more organized) stakeholder groups (such as farmers and hunters), while, in peri-urban regions being the largest group of actors. At the same time, this study has indicated that their perception of multifunctionality is subjective and does not always align with where the focus of current policy efforts is. For example, the majority of respondents saw built-up areas as multifunctional, but water and nature areas were considered multifunctional only by a small share of respondents. Residents might not be aware of the entire range of benefits that such areas provide to them, demonstrating the need for further efforts to increase awareness in that direction, especially since there are considerable policy and management efforts dedicated to ensuring multifunctionality of nature areas. Otherwise, it might indicate the wish for nature areas to be focused on biodiversity protection, while residential areas and the areas surrounding these should be given more attention to manage in ways that they respond to the different needs of the residents. Many of these have moved to live outside the city in this peri-urban environment and expect to benefit from its multiple functions close to home.

Another challenge lies in a fact that while residents are aware of a number of competing interests in the landscape, this does not reduce their desire for high levels of multifunctionality. While competing claims could be resolved by clear societal choices for particular services of the landscape, the high preference for all ES may require more complex ways of navigating the competing interests. Another possible conclusion is that relationships between knowledge and values are not straight-forward. In their study on similar multifunctional landscape in Sweden, Horcea-Milcu et al. (2022) uncovered three modalities of how values and knowledge interact: linked but not necessarily connected, mutually reinforcing and intertwined. They argue that in order to navigate consensus and dissensus

in multifunctional landscapes one needs to plan for collaborative processes which are conductive both to plurality and consensus building. Such processes can support decision-makers in designing context-specific strategies as well as to increase social engagement in environmental governance.

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