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Urban happiness: context-sensitive study of the social sustainability of urban settings

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Abstract. Previous studies have reported multifaceted, controversial social outcomes of densely built urban settings. Social sustainability of urban environments have rarely been studied in a context-sensitive manner, identifying the specific ways urban structural characteristics contribute to the behavioural, experiential and well-being outcomes. In this study, an online public participation geographic information system (GIS) methodology allowed the place-based study of urban and suburban contexts in the metropolitan region of Helsinki, Finland. Respondents (*N* = 3119) located their meaningful places and reported the experiential and well-being outcomes. GIS-based measures of urban structures were calculated within a 500m buffer around their homes. Structural equation modeling was used to assess the contextual variation and the mediational role accessibility and perceived environmental quality play in linking urban structural characteristics with well-being outcomes. Our findings indicated that although increasing urban density was associated with shorter distances to everyday services in both urban and suburban settings, the experiential and well-being outcomes varied. In the urban context, easy access to services contributed to higher perceived environmental quality and positive well-being outcomes, whereas in the suburban setting, the closeness of services decreased the experiential and well-being outcomes. Perceived environmental quality was strongly associated with well-being in both contexts. We concluded that densely built urban neighborhoods can also support social sustainability, but the processes vary between suburban and urban settings. A challenge remains for urban planners on how to improve accessibility and related positive experiential outcomes in suburban contexts.

1 Introduction

Current urban planning strategies favor high densities that can support sustainable modes of transport, efficient energy distribution, and the possibility of directing new buildings to infill and brownfield sites instead of to greenfield sites (Jabareen, 2006; Jenks, 2010; Newman, 2006; Vande Weghe and Kennedy, 2007). Although many of these ecological benefits are undeniable, the social outcomes of dense urban environments seem to be highly complex and even contradictory (Burton, 2003; Dempsey et al., 2009; Yang, 2008). In this study we argue that the seemingly contradictory findings can be explained with a more context-sensitive approach that simultaneously provides planners with new tools to develop both socially and ecologically sustainable urban environments.

In particular, we argue that the social outcomes of urban densification are *moderated* and *mediated* (cf Evans and Lepore, 1992). The former means that we cannot assume any universal relationship between structural variables and social outcomes. For example, density can affect behavior differently in downtown areas compared with suburban areas. We propose that the effects of density on behavior are moderated by context: that is, they are context dependent. In addition, the relationship between structural variables and social outcomes is not direct but mediated. For example, unless density improves the accessibility of services it will not have the assumed beneficial effects on behavior. In this case the effects of density on behavior are mediated by accessibility.

The analysis of whether planning strategies are sustainable only on paper or that they actually encourage sustainable behavior in practice is among the essential questions that we aimed to answer with a context-sensitive approach. The context-sensitive research requires, nevertheless, a methodology that connects social outcomes with urban structure at a fine-grained level. Here, online public participation geographic information system GIS (PPGIS) methodology (Brown and Kyttä, 2014) called softGIS was used. Our data from more than 3100 residents in the Helsinki metropolitan region in Finland offered an opportunity to study the social consequences of density in its different forms. Helsinki is one of the fastest-growing urban regions in Europe (Turok and Mykhnenko, 2007), with documented growth both outward on unbuilt land (see EEA, 2006) and inward within existing built-up areas (see Jaakola and Lönnqvist, 2007). A considerable share of the building stock in the suburbs, including the housing areas dominated by the middle class, consists of apartment blocks built during the postwar era. In terms of density, the city-center neighborhoods and suburban settings under scrutiny vary between 33 and 134 housing units/ha. These density levels are relatively high when compared with the Congress for New Urbanism's recommendation (LEED-ND, 2009) of 17 housing units/ha as the minimum level of density for sustainable neighborhood development.

By studying urban and suburban contexts in the Helsinki metropolitan area, we were able to identify contextual variation in the ways urban density contributed to social sustainability. Our findings revealed intriguing mediational processes and contextual moderation in how the urban structural characteristics were associated with social sustainability. The findings have practical value by providing planners with context-sensitive information, which is not normally available, that can be used to develop unique, local strategies for urban infill projects.

2 Social sustainability of urban settings

Research literature offers an abundance of definitions on social sustainability (Chiu, 2003). Among the most useful for us is the definition by Bramley et al (2009;2010; also Dempsey et al, 2009), who proposed that social sustainability consists of two main dimensions: accessibility (social equity) and experiential outcomes (sustainability of community).(1) According to them, experiential outcomes related to the urban form include several issues: pride in and attachment to the neighborhood; social interaction; safety or security; perceived quality of the local environment; satisfaction with the home; stability; and participation in civic activities. Accessibility refers to the equality of access to services and opportunities: essential local services such as shops, schools, and health centers; recreational opportunities and open space; public transport; job opportunities; and finally, affordable housing. We found these two dimensions proposed by Bramley et al to be very relevant and agree that treating well-being as a mediated outcome is rather more fruitful than treating it as a component of social sustainability. In our study we hypothesized that the two dimensions of social sustainability may also convey a mediating effect on the association between the built environment and well-being. Here, well-being was operationalized as a compound of perceived happiness, quality of life, and health.

(1) Because we found the original labeling of the two dimensions confusing, we renamed them accessibility (corresponding to social equity) and experiential (corresponding to sustainability of community) outcomes.

Following the classification by Chiu (2003), Bramley et al. (2009;2010) represent the people-oriented approach to social sustainability, emphasizing social cohesion and integrity, social stability, and improvement in the quality of life (Chiu, 2003, pages 224 – 225). In our view, the linking of social sustainability with urban form and ecological sustainability as well as the paths towards well-being outcomes could be defined more clearly. For this we found the conceptual frame of Vallance et al. (2011) promising. They distinguish three different ways of defining social sustainability and its connections to sustainable development more generally.

First, the *development sustainability* discourse is interested in how various contexts meet people's basic needs, such as health, clean water, adequate housing, and proper education. The assumption is that, only when people's basic needs are met, can they begin to address biophysical environmental concerns actively. Instead of merely hoping that environmental outcomes will follow after the basic needs have been met, the second approach, *bridge sustainability*, explores active ways to change and promote ecofriendly behavior or stronger environmental ethics. These measures can be both radical reconceptualizations of current lifestyles and human – environment interaction or more modest approaches relying on less fundamental changes in human behavior patterns. Finally, *maintenance sustainability* is interested in the traditions, practices, preferences, and places that people perceive meaningful and worth maintaining or improving. Only if we understand the logic of people's experience and behavior can ecological goals be achieved.

Maintenance sustainability — the main anchor of our work — can be described as rehumanized, context-aware social sustainability that has emerged recently in the literature of social sustainability. In the current study our interest towards inhabitants' experiences of their living environment and everyday life practices clearly represents maintenance sustainability. However, to look only at the maintenance sustainability would be too narrow a perspective. Therefore, our conceptual frame (figure 1) started from the tension between bridge and maintenance sustainability. Here, the core question for us was whether urban structural solutions that have the potential to be ecologically sound really do result in behavior that actualizes this potential. Maintenance sustainability, in turn, stands in tension with development sustainability. What an individual prefers does not always enhance his or her well-being. Inspired by the work of Bramley et al. (2009; 2010), we split maintenance sustainability into two fields: accessibility and experiential outcomes.

We used this conceptual frame to test empirically the mediated and the moderated effects of urban density in a context-sensitive way. Context sensitivity refers to the search for contextually varying associations between bridge, maintenance, and development social sustainability. Instead of assuming universal laws that would define these associations,

Figure 1. The conceptual model of social sustainability linking urban structural characteristics with accessibility and the experiential and health outcomes.

we were open to revealing various ways the context, that is, urban versus suburban setting, alters (moderates) the associations between the urban structural characteristics and the experiential and well-being outcomes. We also studied the potential direct and indirect patterns of urban structural characteristics that can be associated with well-being. Here we examined the mediative roles of accessibility and experiential variables: that is, the role of maintenance social sustainability in linking bridge and development social sustainability. To address these aims, descriptive analysis was not enough. Therefore, structural equation modeling was used to reveal the complex social outcomes of urban density.

3 Multifaceted evidence

Existing empirical evidence about the relationships between urban structure, accessibility, and experiential and well-being outcomes are scarce and not straightforward. A study in five medium-sized British cities (Bramley et al., 2009; Bramley and Power, 2009) revealed that accessibility and use of local services were associated with high urban density, whereas most experiential outcomes decreased when density increased. Exceptions were social interaction and group participation, which improved with rising densities up to a medium level, but a further rise in density levels had the social interaction falling again. Also, a nonlinear relationship between density and social or experiential outcomes was found by Raman (2010) while studying six UK neighborhoods, and by Walton et al. (2008) for three different areas in Auckland, New Zealand. In contrast to these studies, Yang's (2008) study did not corroborate the superiority of medium-density housing. In Yang's study, medium density was associated with the lowest neighborhood satisfaction. However, comparing the results from various studies is challenging because the urban structural measures used and the ways they are operationalized vary.

It seems that the associations between urban density and social sustainability are not only nonlinear but also complex in other ways. McCrea and Walters (2012) noticed that, depending on the context, inhabitants associated both positive and negative effects with densification: In addition to the well-known concerns, residents welcomed the potential improvements in infrastructure, local amenities, and public transport services. Residents' concerns, according to the literature, have been related to, for example, loss of livability and environmental quality, social equity issues, and increasing noise and traffic (Breheny, 1997; Burton, 2000; Howley et al., 2009; Neuman, 2005). Yang (2008) found that neighborhood satisfaction differed depending on whether urban growth has been accommodated through infill, transit-oriented projects, or low-density suburban development (lower satisfaction in the latter case). A few studies have explored social sustainability at the individual household level or anchored the local ways of living to the urban structure. An example is a study in four small Finnish cities where perceived environmental quality (PEQ) was studied in relation to urban structural characteristics, which were studied by buffering each home and calculating the urban density within the buffer. In three of the four communities studied, low density was associated with higher perceived quality of the environment, the only exception being the most urban setting, where no significant association between density and perceived quality was found (Kyttä et al., 2011).

Previous studies have reported multifaceted, controversial social outcomes of densely built urban settings. Social sustainability has rarely been studied in a truly context-sensitive manner, identifying the specific ways urban structural characteristics contribute to the accessibility of individually meaningful places and services, or simultaneously attempting to study the potential experiential and well-being outcomes. Our study will fill this gap by building a holistic theoretical model of social sustainability and testing it in two contexts, a city centre and a suburban setting in the Helsinki metropolitan area in Finland.

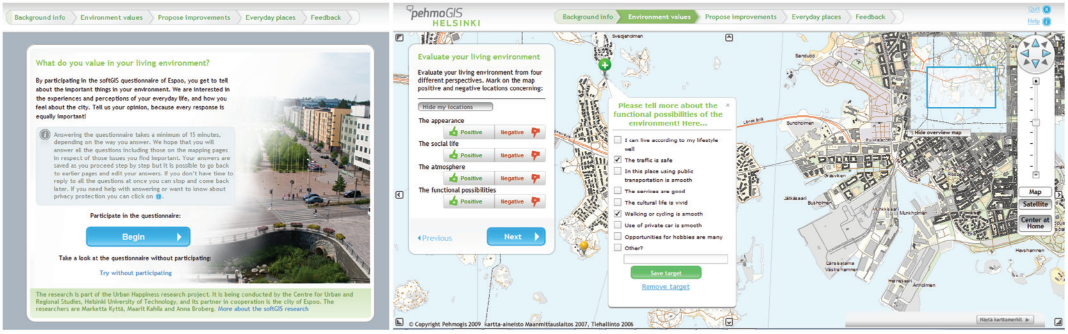


Figure 2. The softGIS application that can be seen at www.softgis.fi/helsinki (user id: pehmogis\happy, password:urbanhappy).

4 Data sources and measures

4.1 Location-based methodology for the study of residents' experiences of an urban environment

The data were collected using the softGIS methodology, a PPGIS method that combines Internet maps with traditional questionnaires (see figure 2). As defined by Brown and Kyttä (2014), PPGIS methods aim to bring the academic practices of GIS and mapping to the local level in order to promote knowledge production, enhance participation, and ultimately improve the quality of land-use decisions. The early examples of online PPGIS methods included argumentation maps, online discussion forums with a mapping possibility (Hall et al., 2010; Rinner and Bird, 2009), and PPGIS applications for reporting mundane environmental problems such as a broken pavement or uncollected refuse (Kingston, 2007). The broad PPGIS literature has been reviewed comprehensively by Sieber (2006) and Craig et al. (2002).

Recently, PPGIS methods have been developed to allow the collection of data that can be subjected to scientific standards of data quality. This level of PPGIS data collection has been performed extensively by Brown et al (Brown and Brabyn, 2012; Brown and Weber, 2011; Raymond and Brown, 2007) in Australia and Canada and by Kyttä et al. (Broberg et al., 2013; Kyttä et al., 2011; 2012; 2013a; 2013b) in Finland.

The softGIS methodology is an advanced example of an Internet-based PPGIS methodology that allows residents to produce localized experiential knowledge that can be analyzed together with the register-based data included in GISs (Kyttä and Kahila, 2011). The softGIS method tailored for the current study gathered information about localized, perceived environmental quality, places of happiness, accessibility of local services and personally meaningful places, perceived well-being of residents, and suggestions for environmental improvements. In this paper we will report only part of the results. The findings related to the analysis of personally meaningful places in relation to various land-use patterns were published separately by Kyttä et al. (2013a).

The web questionnaire proceeded step by step, and the user could choose between address maps and aerial photographs when using the mapping tools. Point, areal, and route information could be marked on the map. When the respondent replied to the background question concerning his or her home neighborhood, the map on the following page automatically centered on it. This helped the respondent to orientate locations on the map.

4.2 Procedure

The statistical offices of the cities of Helsinki and the neighboring city Espoo provided the researchers with addresses of the sample population, that is, inhabitants aged 15 years – 65 years. In seven neighborhoods in Helsinki and in four neighborhoods in Espoo a total of

15 982 persons were contacted by letter by the end of 2009. The respondents were asked to use the Internet to answer the questionnaire within two weeks. No reminder letters were sent. The study did not deal with information covered in the Finnish Data Protection Act.(2) The participation of all residents was voluntary.

4.3 Subjects and communities

Altogether 3119 respondents (2027 from Helsinki and 1092 from Espoo) replied to the questionnaire. The response rates were 20.4% for Helsinki and 18.4% for Espoo. A lottery with five €100 check rewards was arranged for the respondents. The representativeness of the sample with regard to background variables was satisfactory. The age of the respondents followed rather well the age distribution of the base population, although the oldest age group was slightly overrepresented and the youngest age group was slightly underrepresented. Female respondents (60% among respondents; 51% among base population) were overrepresented, and single households were slightly overrepresented in some areas. The aerial representativeness was rather good: the differences in the percentages for respondents and for the base population living in a certain neighborhood were at a maximum of 2.4%.

Of the 3119 respondents, 2499 marked some locations on the map pages. The total number of located, personally meaningful places was 10 234. The most common number of markings was four. Of those respondents who marked places, 30% marked four of them. The second most common number of locations marked was eight. Only 9% of the respondents marked nine or more places.

The studied areas of Helsinki and Espoo were picked in accordance with the city planning offices of the cities. The studied neighborhoods included urban densification ('urban renaissance') project areas in eastern and western Helsinki and four areas representing the densification program of Espoo. Out of scientific interest, two Helsinki city-center neighborhoods were also picked for the study. Because the densification projects of both cities were still in a very early phase, the city representatives did not want to inform respondents about them in detail and instead highlighted the need for reliable information on the current experiences of the residents.

All studied areas were dominated by blocks of flats [see figures 3(a) – 3(c)].The average density of suburban settings was 5654 people/km^2 (33 housing units/ha), 4967 people/km^2 in Espoo suburban neighborhoods (27 housing units/ha), and 6396 people/km^2 in Helsinki suburban neighborhoods (38 housing units/ha), and the density of city-center neighborhoods was 18 051 people per square kilometer (134 housing units/ha) on average. We calculated these measures by buffering the homes of respondents with a 500m buffer zone and calculating the individual density measure. It is worth noting that the measured areas were almost exclusively residential areas and, therefore, the density levels appear higher compared with the average density in Helsinki (2785 people/km^2 in 2012; Uusimaa facts 2012, http://tietopalvelu.uudenmaanliito.fi/alue/vaestontiheys/), where all the areas are taken into account.

(2) According to the Finnish Personal Data Act (523/1999) personal data means "any information on a private individual and any information on his/her personal characteristics or personal circumstances, where these are identifiable as concerning him/her or the members of his/her family or household". These have normally been interpreted to mean name, address, or phone number. Because in the softGIS study we asked the respondents to mark their home on the map, there is a question of whether this kind of information is also personal data. We queried this with the Finnish Data Protection Ombudsman and the answer was that map location is not an exact address and therefore it is not personal data. Because some respondents can be worried about their privacy, we added to the application page where the home was localized the text: "If you don't want to locate your home feel free to map it to the nearest street corner."

Figures 3a,b,c. Examples of neighborhoods in the Urban Happiness project: Kontula suburb in eastern Helsinki (2a), Leppävaara suburb in Espoo (2b), and Töölö neighborhood close to the Helsinki city center (2c). Photos: Santtu Pyykkönen (2a,b), Maija Jokela (2c).

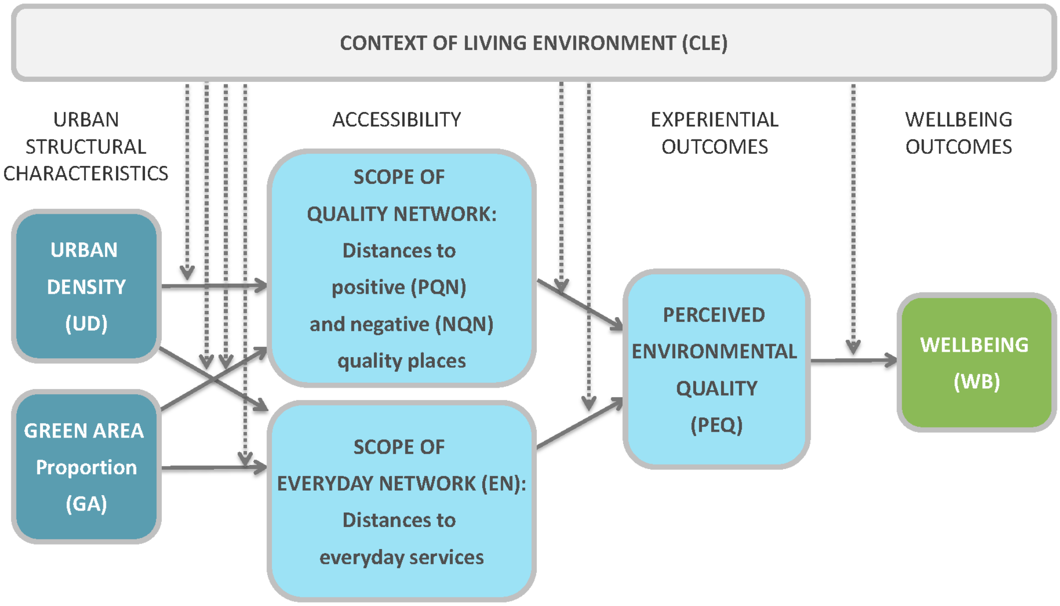


Figure 4. The hypothetical structural model.

4.4 Measures

The theoretical model (figure 1) for social sustainability was operationalized using the measures defined in figure 4. According to this model, the accessibility variables and experiential outcomes mediate the relationship between the urban structure characteristics and wellbeing. Also, we hypothesized that the context of the living environment would moderate the mediation effects of accessibility and experiential variables.

4.4.1 Measures on urban structural characteristics

GIS-based measures were used to study the structural characteristics of the environment. They were calculated within a 500m buffer of each respondent's home (figure 5). The variables of home, floor, and block densities and the e-value (see subsection 4.4.1.1) were calculated using the building centroid dataset obtained from the cities of Helsinki and Espoo. The dataset contains points for each building in the area with information concerning the building volumes and population residing in the building. The following variables were calculated for each respondent's home buffer.

4.4.1.1 Urban density (UD) The latent variable was created using four density measures. (1) *Home density* was measured as the number of housing units within the buffer (or units/ha). (2) *Floor density* refers to the combined floor area of apartments in the buildings within the buffer. (3) *Block density* is an attribute of the combined measure of the convex hull and building footprint ratio. The measure captures the occupation of the block area: how much of the block area has been used for buildings, and how the buildings are distributed within the block area. (4) Finally, *e-value* refers to the combined gross floor area of the buildings within the buffer divided by the area of the buffer.

4.4.1.2 Green area (GA) This was measured as the factor loadings of the proportion of parks, forests, and water within a 500 m buffer. The information concerning land use was calculated from a Separated Land Use/Land Cover Information System (SLICES) dataset: that is, a rasterdata set produced by the Finnish National Land Survey by combining different geographic datasets on land use from various organizations. The dataset offers a hierarchical classification of land use, land cover, soil types, and special use and restricted areas. The SLICES dataset covers the whole of Finland, with a resolution of 10 m.

4.4.2 Measures of accessibility

Accessibility was measured as the distance from home to personally meaningful places and daily services (cf Dave, 2011). (1) The scope of positive quality network (PQN) was operationalized as the average distance to four types of positively experienced places (see next paragraph). (2) The scope of negative quality network (NQN) refers to the average distance to four types of negatively experienced places (see next paragraph). (3) The scope of everyday network (EN) means the average distance to the everyday services of relevance to the respondent. The services that the respondents were asked to mark were workplace, shops, and schools or daycare.

The operationalization of PQN and NQN was based on a series of studies in Italy (Bonaiuto et al., 1999; 2003; 2006; Fornara et al., 2010) and Finland (Kyttä et al., 2011; 2013a) about (PEQ). Respondents were asked to pinpoint on the map places that they found either positive or negative from four different perspectives: (1) functional possibilities; (2) social quality; (3) appearance; or (4) atmosphere of the environment. After respondents had chosen one of the four main dimensions, they marked a place on the map where this criterion was actualized and a further list of eight subdimensions appeared. The subdimensions were different for each theme but always included positive and negative counterparts. Also, a freely defined subcriterion could be named. The contents of these subdimensions were created on the basis of an earlier study by Kyttä et al. (2011), where Finnish inhabitants had freely named personally important quality criteria or affordances. The detailed results concerning the contents of place experiences in relation to various land-use patterns were reported separately by Kyttä et al. (2013a).

When respondents were asked to pinpoint their home on the map, they could mark instead the closest road intersection on the map if they found the localization of their home too intrusive. The distances from their home to the personally important places were calculated as the crow flies (see figure 5).

4.4.3 Measures of experiential outcomes

The experiential outcomes were operationalized as four measures concerning PEQ. After marking the positive and negative qualities on the map, the respondents were asked to evaluate the quality of their living environment as a whole from the same four perspectives. A slider ranging from 0 to 100 was used to collect evaluations of the quality of the environment in the four dimensions. The average score representing the overall perceived quality of environment was also calculated.

4.4.4 Measures of well-being (WB) outcomes

A slider ranging from 0 to 100 was used to ask about the various dimensions of well-being (WB). In the survey the respondents evaluated (1) their current state of health, (2) how good their life as a whole or their quality of life had been during the past month, and (3) their current level of happiness. An average score representing the overall WB was calculated from these three evaluations. The first two questions were also used in the Finnish national health study (Health, 2000, http://www.terveys2000.fi/indexe.html) and the happiness measure has been used in numerous studies on gross national happiness (Pennock and Ura, 2011).

4.4.5 Measures of background variables

A set of background questions included in the softGIS survey were as follows: *age*, *gender*, *family type*, *tenure*, building type, occupation, *income level*, size of living area, years spent in current neighborhood, type of childhood environment, ownership of cars and bicycles, and number of public transportation tickets in the household. The italicized variables were used

Figure 5. The urban structural characteristics were calculated within a 500-meter buffer of each respondent's home and the distances to the personally important places of inhabitants were calculated as the crow flies from home.

in further analysis because they have been shown to be among the key background variables that correlate with the degree of happiness and WB of people in earlier studies (Ballas, 2013; Blanchflower and Oswald, 2011).

5 Analysis

A structural model was designed to test the mediation effect of the EN and the perceived quality of living in the relationship between urban structural measures and dwellers' WB. In this model we also applied a multilevel analysis to investigate the moderation effects of urban and suburban districts. Structural equation modeling, using the SPSS AMOS 20 (Arbuckle, 2011), was the preferred method of the analysis, and the maximum likelihood was the method of estimation. To test the measurement model, UD, GA, EN, PEQ, and WB were entered in the model as latent variables each of them measured by several indicators. Several nested models were compared using the X^2 change test (Jöreskog and Sörbom, 1986). To indicate the fit of the model, we assessed the root mean square error of approximation (RMSEA) with values of approximately 0.05 or less as the criterion for a close fit, and values around

0.08 or less indicate an acceptable fit (Browne and Cudeck, 1993). The goodness of fit, the comparative fit, and the Tucker – Lewis coefficient indexes with values greater than 0.90 indicate of a good model fit (Hoyle, 1995).

6 Results

6.1 The relationship between urban density and perceived environmental quality: a descriptive analysis

Before the full theoretical model was tested, a descriptive analysis of the covariation between PEQ and UD[(3)] was performed as a first step of the analysis process. The descriptive analysis presented in figure 6 was realized to compare our findings with some earlier findings in the literature especially concerning the curvilinear versus linear association between urban density and perceived environmental quality.

Figure 6(a) reveals that the relationship between density and perceived quality of the living environment (PEQ) appears to be nonlinear. The average PEQ increases until the density level reaches around 100 housing units/ha. After that it decreases but starts to increase again when density is around 190 housing units per hectare. The same general pattern was obtained for all four quality dimensions. Figure 6(b) shows that the above-mentioned patterns of the relationship actually become linear when the data are accounted for by the context of the living environment (city center versus suburb). This result suggests that further inferential and structural analyses on the data should account for the context of the living environment.

Means, standard deviations, and correlations of all study variables are presented in table 1. The overall perceived quality of environment (average PEQ score) was significantly ($t = 9.12$; degrees of freedom = 2081; $p < 0.001$) higher in city center neighborhoods than that in suburban neighborhoods. The significantly superior evaluation of urban settings applied to all four dimensions of PEQ: appearance ($M_{\text{urban}} = 67.8$, $M_{\text{suburban}} = 60.7$), atmosphere ($M_{\text{urban}} = 72.1$, $M_{\text{suburban}} = 63.8$), social quality ($M_{\text{urban}} = 67.7$, $M_{\text{suburban}} = 59.3$), and functional quality ($M_{\text{urban}} = 76.1$, $M_{\text{suburban}} = 68.4$). As also shown in figure 6(a), functional possibilities generally scored higher than other dimensions of PEQ.

6.2 Context-sensitive analysis of the social sustainability of urban settings

According to our theoretical model (figure 1), the social sustainability of urban settings can be a very complex phenomenon. Firstly, we cannot expect universal impacts of urban structural characteristics on social sustainability and should be open to different contextual patterns. Therefore, we hypothesized first that the context of the urban environment would moderate the mediation effects of accessibility and experiential variables (between-context analysis). Secondly, we can not only study the direct associations between urban structural characteristics and wellbeing, but must study the mediational processes as well. For this reason, we studied whether the accessibility variables and experiential outcomes mediate the relationships between the urban structure characteristics and wellbeing (within-contexts analysis). This two-level analysis was operationalized using the measures defined in figure 4. Structural equation modelling was used to reveal the complex social outcomes of urban density.

6.3 Structural equation modelling

To identify the pattern of factor loadings within and between the two contexts, suburban and urban settings, a measurement model was tested. Because the results of a preliminary regression analysis indicated no significant variance explanations from the background variables, they were excluded from the structural model. As shown in table 2, the overall fit

[(3)] In this analysis, it is noteworthy that we measured urban density using a single variable (housing units/ha), but in the later phases of the analysis, we used a more reliable compound measure.

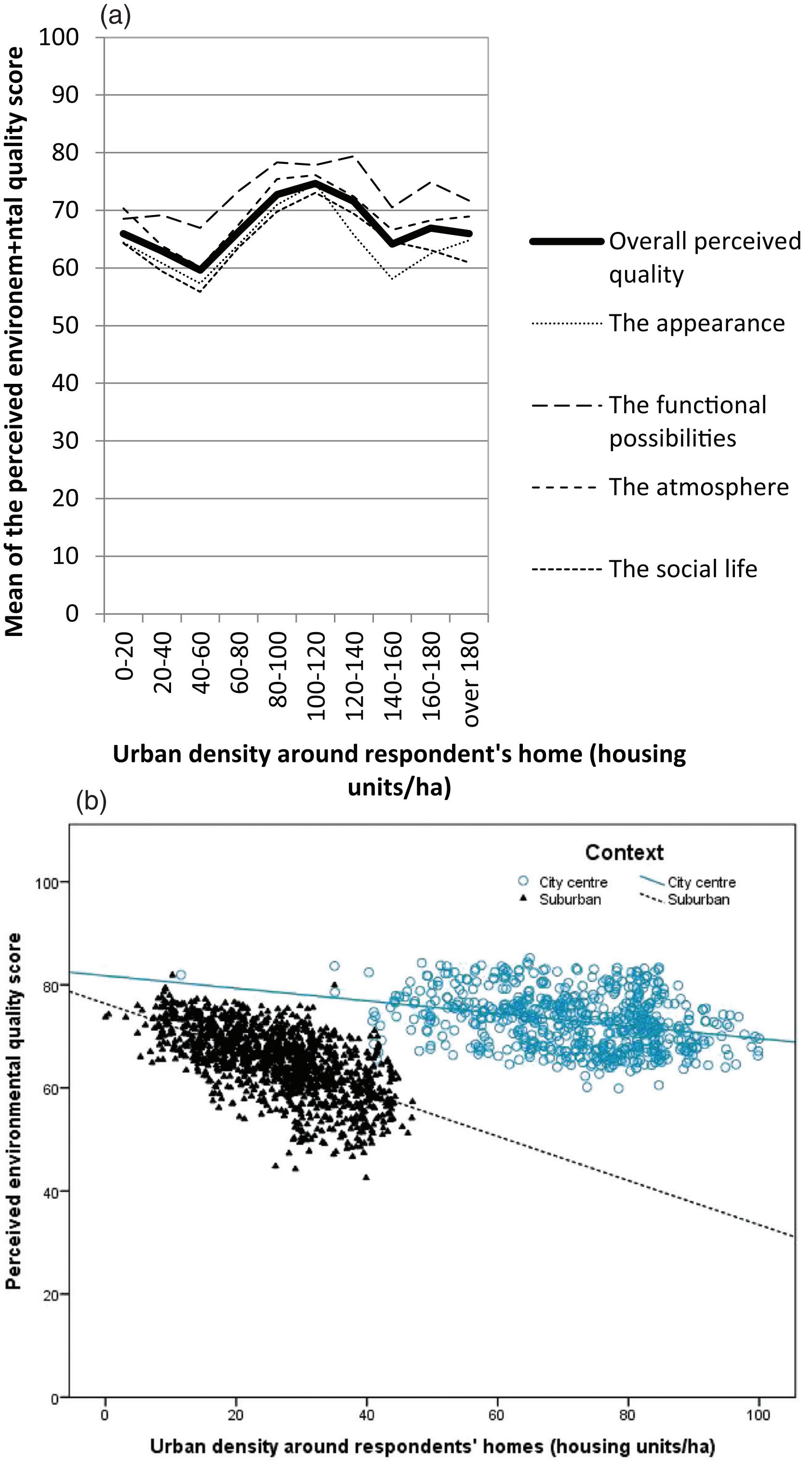


Figure 6. The overall co-variation between urban density and perceived environmental quality (5a) and the same presented in relation to the suburban and city center contexts (5b).

Table 1. Descriptive statistics and inter-correlations among variables under study in two contexts.

	M_{Urban}	$M_{Suburban}$	SD_{Urban}	$SD_{Suburban}$	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Age	37.17	39.91	13.14	14.60	–	.02	.19**	–.03	–.01	–.08**	.07*	.049	–.41**	–.00	.18**	.04	.07*	.04
2. Gender	1[a]	1[a]	*na*	*Na*	.04	–	–.07	–.00	.01	–.01	–.04	–.02	.00	.046	–.05	.02	.04	–.11**
3. Income	3,310[b]	3,486[b]	2,054[c]	1,552[c]	.26**	.09	–	–.15**	–.13**	–.14**	–.01	.09*	–.05	.10*	.06	–.01	.12**	.10**
4. Housing	133.71	32.63	40.82	13.04	–.09*	.00	–.17**	–	.96**	.74**	.43**	–.25**	–.04	–.06	–.14**	–.09**	–.27**	–.06*
5. Floor	498,635.22	153,364.58	96,082.92	52,515.28	–.05	–.06	–.00	.67**	–	.69**	.44**	–.23**	–.04	–.04	–.16**	–.06*	–.24**	–.06*
6. e-Value	1.44	.34	.27	.13	–.04	.01	–.06	.53**	.67**	–	.29**	–.29**	.01	–.04	–.05	–.07*	–.24**	–.05
7. Block	.23	.08	.026	.03	–.04	–.10**	–.02	.31**	.66**	.32**	–	–.11**	–.02	.04	–.01	–.09**	–.11**	–.03
8. Shops	480.77	802.16	744.04	924.33	.06	.00	–.01	–.06	.03	–.01	.03	–	.14*	.15**	.03	.06	.10**	.00
9. School	1,352.33	1,946.40	1,654.57	2,811.15	–.27**	.02	–.07	.23*	.06	.21*	.01	.08	–	.20**	–.14*	–.08	–.12	–.06
10. Work	3,435.56	7,824.27	3,553.00	14,853.05	–.01	.04	.09	.04	–.06	.03	–.12**	.09*	.18	–	–.01	–.07	.05	–.02
11. PEQ	70.28	62.54	17.48	19.16	.05	–.08*	.13**	–.19**	.04	–.04	.04	–.02	–.13	–.04	–	.07*	.15**	.34**
12. PQN	1,509.68	1,428.87	1,086.62	1,062.24	–.05	–.04	.03	–.15**	–.06	–.05	–.01	.13**	.08	–.00	.02	–	.26**	.01
13. NQN	1,195.49	1,157.09	951.97	928.76	.01	.17**	.19**	–.13**	–.09	–.16**	–.05	–.03	.11	.00	.13*	.34**	–	.09**
14. Wellbeing	74.20	71.87	18.24	19.5716	.05	–.08*	.10	.01	.05	.04	.04	.01	–.09	–.01	.27**	.02	.01	–

**P<.05, **P<.01.*

Note: The correlation coefficients are presented below the diagonal for the urban context and above the diagonal for the suburban context:
PEQ = Perceived Environmental Quality, PQN = Positive Quality of Network, NQN= Negative Quality of Network; [a] = Mode, [b] =Median, [c] =Quartile Deviation, and na = not applicable. The values for gender are 1= women and 2= men. Total N= 2618.

Table 2. Fit indices of the structural equation model for the model.

Models	X^2	*df*	χ^2/df	GFI	CFI	TLI	RMSEA
Measurement	3,315.64	512	6.48	.93	.87	.85	.046
Partial Model	3,364.38	520	6.47	.92	.87	.85	.046
Structural Model	3,379.81	530	6.38	.92	.87	.85	.045

statistics indicated a good measurement model for the current study: the RMSEA was 0.046, indicating an acceptable error of approximation,[(4)] and the goodness-of-fit index of 0.93 is an indicator of a good model fit for the measurement model. Regarding the structural model, the results indicated that the model fits the data quite well, as the RMSEA was 0.045 and the fit indices all approached the value of 0.90, an indicator of a good model fit.

We also used a measurement invariance method to test if the measurement model varied across the two contexts. The results showed a measurement invariance among the two districts, $\Delta\chi^2 18 = 896.27$, $p < 0.001$, suggesting a moderation effect for the context of the living environment. To explore the core of the differences between the two contexts, in a first step, all latent variables went through path-by-path analyses separately. We used the X^2 change test to compare a free model with a full constraint model. As indicated by the first two columns in table 3, all latent variables except PQN and WB vary significantly across the two contexts. A path-by-path post hoc procedure was used to compare the free model with a partial constraint model. As indicated by the third and fourth columns in table 3, the X^2 change tests denote that all indicators of UD vary significantly across the two contexts. Regarding GA, the two contexts were partially invariant with a marginal variation in water area. The same pattern of partial invariance was also evident for the other latent variables. The whole measurement invariance analysis indicated that the context of the living environment would greatly affect the measure of the latent variables in the hypothetical model.

Because the results of the measurement invariance analysis had suggested a moderation effect of the context of living environment (CLE), between-context and within-context structural analyses were performed. The between-context analysis was performed to investigate the moderation effect of the CLE, and the within-context structural analysis was performed to investigate the mediation effects of accessibility and experiential factors. Given that the structural model per se presents two mediation effects for the accessibility and experiential factors, a moderated mediation model was established as the result of the between-context and within-context structural analyses. The moderation effect of CLE was assumed to influence the mediation effects of the accessibility and experiential factors (ie, EN, PQN, NQN, and PEQ).

6.4 Does the context moderate the social effects of urban density?

Figure 7 illustrates the results of the structural equation analysis used to test the between-context and within-context structural analyses. To assess the between-context differences, we used the X^2 change test to compare a fully constrained model with a free model.

In line with the results of the measurement invariance test, the between-context analysis indicated that the two models were significantly different, $\Delta\chi^2 11 = 1559.02$, $p < 0.001$. To probe the differences between the two contexts, we performed a follow-up path-by-path analysis. In this set of analyses, we compared a nonconstraint model with several models that had one constraint path, using the X^2 change test ($\Delta\chi^2$). The results indicated that the two contexts were significantly different in the direct effects of UD on both NQN, $\Delta\chi^2 1 = 37.78$, $p < 0.001$, and EN, $\Delta\chi^2 1 = 31.08$, $p < 0.001$, as well as the direct effect of EN on PEQ, $\Delta\chi^2 1 =$

[(4)] A value less than 0.05 is considered an indicator of a good model fit (Browne and Cudeck, 1993)

Table 3. The results of path-by- path analysis for each latent variable separately.

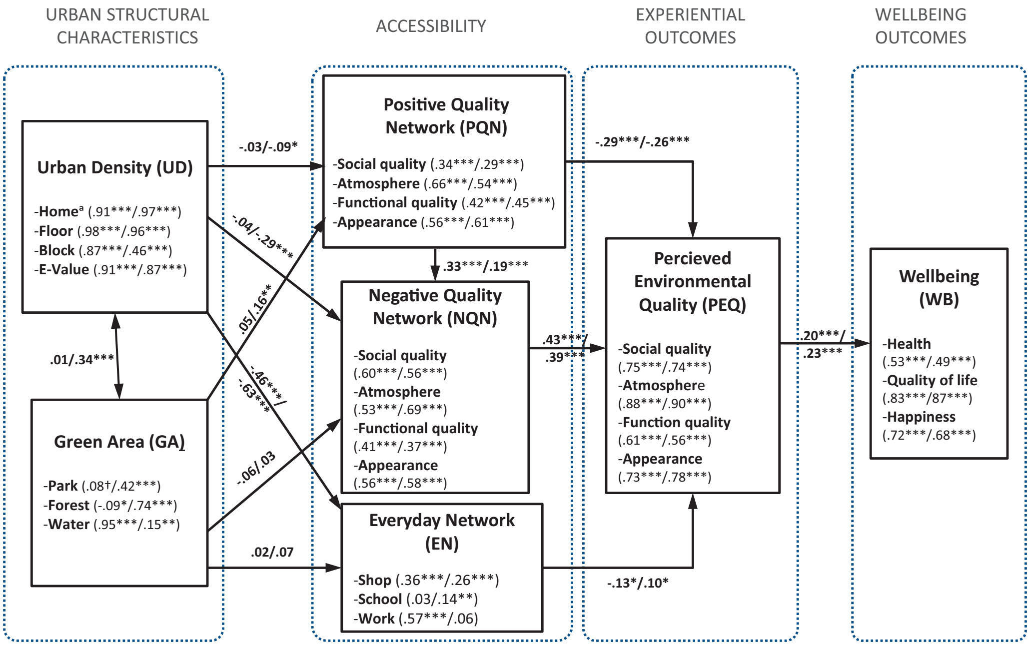
Latent variables	$\Delta\chi 2_{(df)}$	Indicators of the latent variables	$\Delta\chi 2_{(df)}$
UD	$664.43_{(3)}$ ***	H500Huh	$46.45_{(2)}$***
		Floor	$17.64_{(2)}$***
		Block	$604.49_{(2)}$***
		e-Value	$17.43_{(2)}$***
GA	$11.29_{(2)}$**	Park	$2.27_{(1)}$ *ns*
		Forest	$1.6_{(1)}$ *ns*
		Water	$5.6_{(1)}$*
EN	$43.31_{(2)}$***	Store	$-4.62_{(1)}$
		School	$43.21_{(1)}$***
		Work	$-0.11_{(1)}$
PQN	$7.11_{(3)}$ *ns*	Function	-
		Social	-
		Appearance	-
		Atmosphere	-
NQN	$10.22_{(3)}$ *	Function	$9.00_{(2)}$**
		Social	$5.01_{(2)}$*
		Appearance	$1.28_{(2)}$
		Atmosphere	$4.94_{(2)}$
PEQ	$8.20_{(3)}$ *	Function	$4.18_{(2)}$ *ns*
		Social	$6.27_{(2)}$*
		Appearance	$4.28_{(2)}$ *ns*
		Atmosphere	$7.77_{(2)}$*
WB	$.79_{(2)}$ *ns*	Health	-
		Quality of Life	-
		Happiness	-

*p < .05, **p < .01, ***p < .001 and *ns* not significant.

11.18, $p < 0.01$. We did not further analyze the differences between the contexts if the original associations were not significant.

6.5 Do accessibility and experiential factors mediate the effects of urban structural characteristics to well-being?

The within-context analysis revealed different associations in the two contexts among the latent variables in our model. In both urban and suburban contexts, UD was negatively associated with EN ($\beta = -0.46$, $p < 0.001$ and $\beta = -0.67$, $p < 0.001$, respectively). No other associations between urban structural characteristics and accessibility were found in urban contexts. In the suburban context, however, UD was negatively associated with PQN ($\beta = -0.09$, $p < 0.05$) and NQN ($\beta = -0.29$, $p < 0.001$), but the green structure was positively associated with PQN ($\beta = 0.16$, $p < 0.01$). In both contexts, accessibility measures were strongly associated with PEQ: PQN was negatively ($\beta_{urban} = -0.29$, $p < 0.001$; $\beta_{suburban} = -0.26$, $p < 0.001$) and NQN was positively ($\beta_{urban}=0.43$, $p < 0.001$; $\beta_{suburban}=0.39$, $p < 0.001$) associated with PEQ. Also, EN was associated with PEQ significantly and negatively in the urban context ($\beta = -0.13$, $p < 0.05$), but positively in the suburban context ($\beta = 0.10$, $p < 0.05$). In addition, PQN had a significant, positive link with NQN in both contexts ($\beta_{urban}=0.33$, $p < 0.001$; $\beta_{suburban}=0.19$, $p < 0.001$). Finally, high PEQ predicted better WB in both urban and suburban contexts ($\beta = 0.20$, $p < 0.001$; $\beta = 0.23$, $p < 0.001$, respectively).



Note: Parameter estimates are given separately for Urban/Suburban samples
Numbers in the parentheses are factor loadings
† p<.10, * p < .05, **p < .01, ***p < .001.

Figure 7. The model of analysis with the results of structural equation modeling.

In the within-context analysis, we also tested the mediation effects of the accessibility and experiential factors in several nested models using a three-step procedure suggested by Baron and Kenny (1986). In the first step, for each nested model, we detected whether the independent variables predicted the dependent variable significantly. In the second step we calculated the indirect effect of an independent variable on the dependent variable via the mediator. Finally, we tested whether the significant effect of an independent variable on the dependent variable had been reduced (partial mediation) or was no longer significant (full mediation). The standardized direct and indirect effects were calculated using a bootstrap estimate with 2000 samples. Because the distribution of the indirect effect was positively skewed and because the number of cases in some of the measures (such as school) was less than 200, the bootstrap method was applied instead of the Soble test (see Shrout and Bolger, 2002).

Because the between-context analysis indicated the existence of a significant potential moderation effect of the context on living environment, we decided to include this moderation effect while testing the mediation effects of accessibility and experiential variables. Therefore, we found four mediation models nested in the main structural model (figure 8). As depicted in figure 8a, there was a full mediation effect by PEQ over the effects of UD on WB. A bootstrap confidence estimate indicated a significant indirect effect of UD on WE ($p < 0.01$). This mediating effect was only evident in the suburban context. The variation in the mediating effect of PEQ supported a moderated mediation model in which the mediation effect of PEQ was moderated by the CLE. There was another mediation model, shown in figure 8(b), where PQN partially mediated the effect of GA on PEQ. A bootstrap confidence estimate indicated a significant indirect effect of GA on PEQ (p <0 .01). In addition, this mediation was found to be moderated by the CLE; the effect was found only in the suburban context.

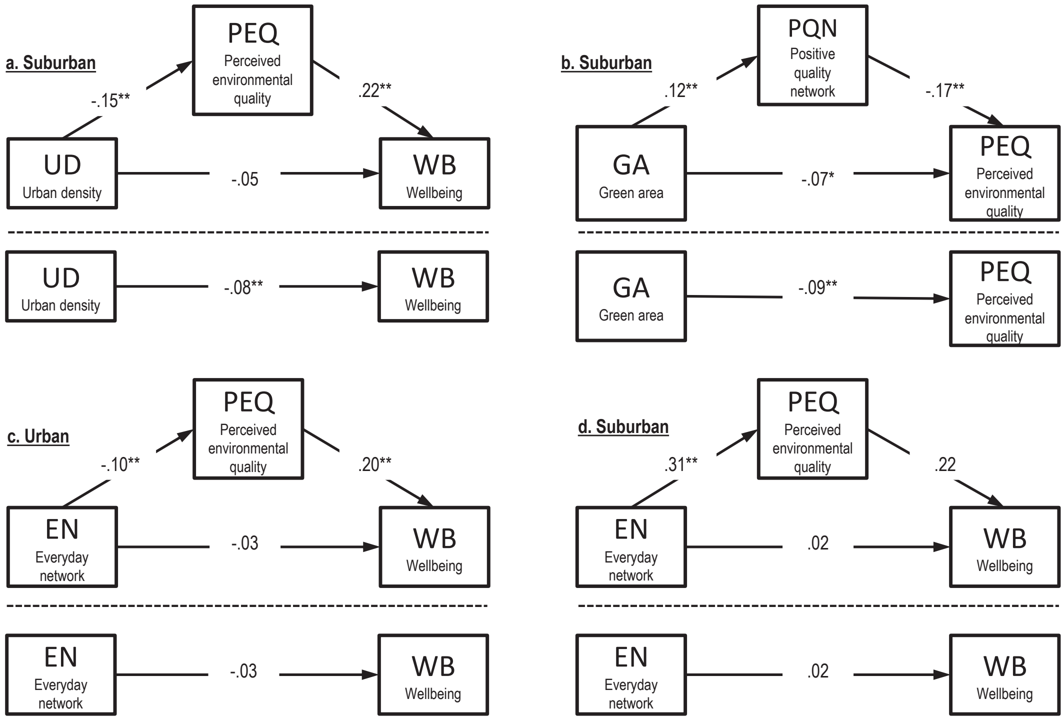


Figure 8. The four significant mediation effects. Underneath of each model a direct effect path is provided**.** (a) denotes a full mediation, (b) shows a partial mediation, (c) and (d) denote indirect effects (potential mediating effects) as there never was any significant direct path.
*p < .05, **p < .01

Finally, figures 8(c) and 8(d) show that there are two identical indirect effects of EN on WB through PEQ; the bootstrap confidence estimates for both urban and suburban were significant ($p < 0.05$ and $p < 0.01$, respectively). Because the direct effect of EN on WB was not significant, the indirect effect was not to be considered typical of a mediating effect (cf Baron and Kenny, 1986). However, because the necessity of testing a direct association between the independent and the dependent variables has been questioned (Collins et al., 1998; MacKinnon et al., 2002; Shrout and Bolger, 2002), we suggest a 'potential mediating effect' for PEQ. This potential mediating effect was not found to be moderated by the CLE.

6.6 The summary of results

Altogether, the results of between-context and within-context analyses indicated that the context of living environment poses a significant effect in the study model. In terms of a context-specific pattern of social sustainability, the results supported the existence of a moderation effect of the context of living environment such that (1) in the urban context, perceived environmental quality mediated the effects of the scope of the everyday network, that is, the effect of the distances to everyday services on well-being, leading to improved well-being if the distance to everyday services was shorter; (2) in the suburban context, perceived environmental quality mediated the effects of urban density on well-being so that a lower urban density led to improved well-being; and (3) in the suburban context, a higher proportion of green areas resulted in lower perceived environmental quality, the association of which was mediated by distance to personally meaningful positive quality places.

7 Conclusions

Our findings indicate that the social sustainability of densely built urban neighborhoods is a highly complex and context-dependent issue. The simultaneous study of bridge, maintenance, and development social sustainability (Vallance et al., 2011) helps to reconnect the social and environmental sustainability discourses (Davidson, 2010) but demands both individually and contextually sensitive research strategies. In this study, a place-based PPGIS methodology was applied, which allowed the study of residents' urban networks in an individually sensitive manner and anchored findings on the urban fabric in a contextually sensitive manner.

Our results suggested that densely built urban neighborhoods can also include characteristics that support social sustainability. Residents living in the Helsinki metropolitan area in Finland generally evaluated the quality of their environment higher in urban than in suburban neighborhoods in terms of appearance, atmosphere, and social and functional quality. The functional quality scored highest in both urban and suburban settings, which is in contrast to the findings in the study by Walton et al. (2008) in New Zealand, where functional quality generally scored the lowest. Our finding can be related at least partly to the strong functionalistic tradition in Finnish architecture and urban planning.

The descriptive analysis of the association between urban density and perceived environmental quality revealed at first a curvilinear association, where the perceived quality peaked at a rather high level of urban density (around 100 housing units/ha). A similar curvilinear pattern had been found in some earlier studies (Raman, 2010; Walton et al., 2008). In our study, further analysis suggested that the curvilinearity was actually an illusion that hid the two different linear processes of the two contexts. These initial analyses were not sufficient to test our conceptual model of social sustainability that linked urban structural characteristics with accessibility and the experiential and health outcomes.

Further steps of analysis applying structural equation modeling uncovered significantly differing patterns of the way social sustainability evolved in two contexts: that is, urban and suburban settings. Urban density promoted easy access to everyday services in both urban and suburban contexts, which is in line with British studies indicating the service accessibility benefits of urban density (Bramley et al., 2009; Bramley and Power, 2009). However, the experiential outcomes varied. In the urban context, easy access to services contributed to higher perceived environmental quality, whereas in the suburban setting, the closeness of services as well as the increasing density decreased perceived environmental quality. Closeness to services even had association with well being, but again these were opposite in the two contexts. In the urban context, closeness to services had positive outcomes, whereas in the suburban context, it had negative outcomes. In both contexts, perceived environmental quality mediated these outcomes. The closeness of daily services and easy access for errands has been shown to include positive physical health outcomes by promoting active travel modes (Durand et al., 2011). Perhaps in the urban settings of our study, services were reached more often by walking or by bicycle and, therefore, entailed positive experiential and well-being outcomes. Unfortunately, this could not be verified because the information about the travel mode was not available.

Only in the suburban context, was higher urban density associated with shorter distances to both positive and negative personally meaningful quality places. Higher green area proportion around residents' homes was associated with longer trips to meaningful positive places only in the suburban settings. Experientially, this was a problem in the suburbs: a high green area proportion decreased the perceived environmental quality, and a long distance to positive places even mediated this association. The finding might be unexpected considering the large body of literature showing the strong experiential value of green areas for residents (Hu et al., 2008; Maas et al., 2006) and the related (mental) health outcomes (Korpela et al., 2010). Because the suburbs of our study represent the Finnish suburban concept — a block of flats surrounded by forests — our finding may suggest that for Finnish residents the quality of green settings is more important than the quantity. Arnberger and Eder (2012) came to this conclusion when comparing the perceptions of green settings between urban and suburban dwellers.

According to the above-mentioned findings, bridge and maintenance social sustainability stand not necessarily in conflict. Urban density can both meet the ecological goals for efficient urban structure and support social sustainability by providing good everyday service accessibility and the resulting positive experiential and wellbeing outcomes. In the urban context of our study, this happy situation held true. In the suburban context, conflict existed partly because the two dimensions of maintenance sustainability, that is, accessibility and experiential outcomes, did not support each other. These findings may suggest that only in a setting that is sufficiently urban can the benefits of service accessibility bloom, which would give some support to optimal centrality theory (Cicerchia, 1999; McCrea and Walters, 2012). According to this theory, an optimal level of urban density can be found where access to services and facilities can be guaranteed without overwhelming urban problems such as pollution and traffic congestion. A challenge remains for urban planners on how to improve positive quality place and service accessibility and related experiential outcomes in suburban contexts as well. Possible measures can include investments in accessibility by walking and cycling as well as a careful consideration of those services that best facilitate smooth everyday life. One possibility of increasing understanding of why good service accessibility does not always receive positive feedback from residents would be to typologize urban form based on not only the degree of urban density and the green structure proportion but also the social structure of the neighborhoods (Miles and Song, 2009).

Perceived environmental quality was strongly associated with well-being in both contexts but no direct associations were found between well-being and urban structural characteristics or accessibility. Future studies should also take into account that social neighborhood characteristics such as socioeconomic factors can contribute to individual well-being. In addition to the individual-level or household-level socioeconomic status, also neighbourhood status can be associated with individual well-being. Especially interesting would be the analysis of whether relative socioeconomic position would be associated with an individual's well-being in the way that Luttmer (2006) suggested. He was able to show that higher earnings of neighbors are associated with lower levels of self-reported well-being and happiness.

When people are happy about their living environment, this supports their perceived health, happiness, and well-being. Hence, according to our study, maintenance sustainability did not stand in tension with development sustainability. Nevertheless, future studies should elaborate more clearly the spesific health outcomes related to various environmental experiences because they are likely to be supported by different contextual processes and differing urban structural solutions (Kyttä and Broberg, 2014). While our study generally revealed rather positive experiential outcomes of urban density, the same dataset also exposed inhabitants' strong affection for green settings. In a separately reported analysis, we found that positive places were located more often in green areas than in areas representing other land-use patterns (Kyttä et al., 2013a).

The two examples of urban contexts studied here, urban and suburban settings, were already able to reveal the complexity of the processes towards social sustainability. Our findings highlighted the contextual variation instead of a socioeconomic or attitudinal one (Lewis and Baldassare, 2010). In both urban contexts studied the living environment was the 'block of flats' type of development, and further variation in urban typology could provide prolific understanding of the spectrum of local notions of urban livability, in both developed and developing countries (Arifwidodo and Perera, 2011; McCrea and Walters, 2012).

An important concern, nevertheless, when using Internet-based methodologies, is that this approach can limit the pool of participants to those who have access to computers, are technologically competent, and have the physical and mental ability to use them. Although Finland is among the top European countries in the prevalence of Internet usage, this concern is relevant. According to Räsänen (2008) the socioeconomic (education, income, and class identity) differences related to ICT use had already evened out in Finland between 1999 and 2004. Age seems to define Internet usage more than social status, while over 80% of Finns aged 16 – 54 years used the Internet daily or nearly daily in 2012, the share of daily users aged 55 – 64 years was only 62% (Statistics Finland, 2012). In our study the older age groups were, however, well represented.

Low respondent rate can be another limitation of a PPGIS study. Although our respondent rate was not high (about 20%), it is satisfactory when compared with studies utilizing a similar methodology (Brown and Weber, 2011) and in comparison with standard respondent rates in surveys arranged by city planning offices. Improvements in the usability of PPGIS applications and feedback to residents about how of how the ‘soft’ knowledge produced is actually used in urban planning practice can be among the ways that can help to increase the motivation of residents to participate in PPGIS studies in the future.

Future studies should also improve substantially the ways in which accessibility is operationalized. Although our approach made it possible to define the individual, behavioral intentions to access certain everyday services and personally meaningful places, it still reduced accessibility to a mere measurement of physical distance. Rather, accessibility should be examined as an integrated, multidimensional construct that also recognizes nonspatial factors and social barriers, such as the potential influence of safety concerns, lack of information, or social exclusion (Wang et al., 2013). The GIS analysis used in this study enabled the measurement of urban structural characteristics in an individually sensitive way within a 500m buffer of each resident’s home and in relation to the distance to personally meaningful places and daily services. The next steps towards even deeper recognition of the individual variation in the ways of using the urban environment will be the individual definition of the boundaries of activity spaces (cf Perchoux et al., 2013; Rainham et al., 2010) and the calculation of urban structural characteristics within these dynamic boundaries. Another step towards higher quality PPGIS data relates to the amount of spatial data each individual provides. In our study respondents located clearly, on average, fewer places than participants in some other PPGIS studies (Brown and Weber, 2011). This was probably because we collected quite a lot of further information after each localization.

The results of this study support Bronfenbrenner’s (1993) suggestion that whenever people – environment transactions are studied, finding universal patterns should not be expected, and similar solutions can be associated with different outcomes in various contexts. Context-sensitive planning has already been advocated by planning practitioners (Goltsman and Iacofano, 2007). Our study offered further empirical evidence of the need to develop these strategies. If urban planning strives to be more than merely pseudoscientific (Marshall, 2012), empirical evidence should not only inform practitioners but also help with testing existing urban planning theories and eventually perhaps contribute in creating new theoretical stances.

The type of context-sensitive approach realized in this study can help a planner to find potential locations for infill projects without high experiential costs (Kyttä et al., 2013a; 2013b). According to architects (Hartiala, 2012; Ikonen, 2010) who tested the usefulness of the collected localized experiential knowledge in the Helsinki metropolitan area, the softGIS data provides the planner with context-sensitive information that is not normally available. Currently, the city of Helsinki is using a new softGIS survey in the master plan process.[5] The large-scale user knowledge produced has also been reflected in the phases of participation processes using more traditional methods such as public hearings and focus-group meetings. Together, these steps can pave the way toward diminishing social resistance to urban densification and enhance an understanding that the same recipes for the health and happiness of residents do not apply everywhere.

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[5] The city planning office of Helsinki designed a new softGIS survey that was used in the master plan process, Helsinki 2050. In this survey, residents were, for example, profiled according their attitudes toward Helsinki's densification policy and were asked to map locations suitable for new buildings and green areas that should be protected. The survey attracted more than 4700 respondents who made more than 33 000 localizations (see http://www.yleiskaava.fi/en/).

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