



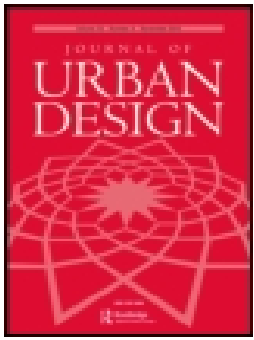
## **Towards a systemic understanding of compact city qualities**

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## Towards a systemic understanding of compact city qualities

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### ABSTRACT

The compact city concept remains a key policy response to multiple societal challenges. Based on theoretical and empirical research, this article seeks to a) develop a systemic understanding of compact city qualities; b) map alleged compact city qualities from the literature onto this framework; c) map qualities mentioned by stakeholders in two European cities onto the same framework; and d) apply the developed framework to analyse how compounded compact city qualities relate to policy challenges, such as carbon neutrality, poverty alleviation, neighbourhood revitalization, or community engagement. It is based on literature reviews and interviews with stakeholders in Barcelona and Rotterdam.

### KEYWORDS

compact cities; urban qualities; systemic framework; Barcelona; Rotterdam

### Introduction

The notion of the compact city has been recurring in urban policy since the 1960s (see, e.g., Jacobs 1965; De Roo 1998; The Urban Task Force 1999). Today, the compact city concept remains a key response in global and national policy for tackling the multiple societal challenges that cities currently are facing, such as climate change, environmental degradation, economic development and social cohesion (Adelfio, Hamiduddin, and Miedema 2020). In 2011, the European Commission argued that compact urban structures are ‘an important basis for efficient and sustainable use of resources’ (European Commission 2011, 42). One year later, the OECD bestowed the compact city with the potential of meeting green growth objectives since ‘it can enhance both the environmental and the economic sustainability of cities’ (2012, 19) and UN-Habitat claimed that ‘housing, employment, accessibility and safety (...) are strongly correlated to urban form’ (2012, 13) and that policies on urban density will bring prosperity and social cohesion, and minimize negative environmental impacts; they will deliver ‘good quality of life at the right price’ (2012, 13). The UNEP affirmed that ‘compact, relatively densely populated cities, with mixed-use urban form, are the most resource-efficient settlement pattern’ (UNEP 2013, 6) and, in 2016, the European Environment Agency (EEA) highlighted ‘compact city planning’ to ‘minimize land consumption, prevent unnecessary conversion of greenfields and natural areas to urban land, and to limit urban sprawl’ (EEA 2016, 18–9). Last but not least, the more recent New Urban Agenda confirmed the global policy concord on promoting urban density and mixed use (United Nations 2017).

Such international policies exert strong influence on how cities and neighbourhoods are planned locally, since the promotion of ideal urban models or ‘referencescapes’ (McCann 2017, 186) tends to ‘shape the global imaginary of urban practitioners and thus have very real effects’ (Rosol, Béal, and Samuel 2017, 1713). In many European cities, the compact city ideal has trickled down into local policy. The City of Barcelona, for example, pursues its Mediterranean version of the compact city (Rueda 2007), ‘improving the quality of life of the neighbourhoods through the adaptation of the housing stock to conditions appropriate for a socially advanced city’ (Ajuntament de Barcelona 2012, 15, translation from Catalan). The City of Rotterdam seeks to densify the housing stock in the inner city to offer ‘a strong and attractive downtown urban residential environment’ (Gemeente Rotterdam 2007, 34, translation from Dutch) with a balance between living and working.

The wide approval of compact cities as a major policy objective is problematic since there is no universal definition of what actually constitutes a compact city (Neuman 2005). In contrast to the relative consensus in global policy, the academic debate on compact cities is a multi-faceted mix of positive, negative and inconclusive accounts where the evidence supporting the policy claims is inconclusive and often contradictory (Breheny 1996; Burton 2001; Cheshire 2006; Arbaci and Rae 2013). Already in 1999, Frey brought together arguments for and against the compact city (Frey 1999). More recently, Boyko and Cooper’s (2011) review of 75 studies presents a comprehensive list of assumed advantages and disadvantages of different types of high urban densities and Ahlfeldt and Pietrostefani (2017) summarize a comprehensive list of primary compact city outcomes drawing on 189 studies.

Compared to urban policy, it is obvious that the research debate is far more divided where Holman et al. (2015) distinguish two opposite mindsets. On the one hand, the *discourse of conviction* emphasizes the role of planning and compact cities are seen as a certain remedy for any urban illness, and especially for economic decay, tracing its origins back to Jane Jacobs’ (1965) work on life and liveability in American cities. On the other hand, the *discourse of suspicion* downplays the importance of built form for urban sustainability. Here, it is argued that a city cannot be reduced into its physical structures and the emphasis is, instead, placed on behaviour, choice and the free market as the real and appropriate drivers of urban development.

Holman et al. (2015) see both these discourses as rather dogmatic, where proponents may have little interest in contradictory evidence. The focus is often on using ‘leading paradigms’ (Rosol, Béal, and Samuel 2017, 1710) for marketing urban development solutions rather than providing evidence of their merit. As an example, UN-Habitat delivers normative recipes for sustainable neighbourhood planning – with precise figures for desired population density and mix of land use and tenure types – but based on weak empirical evidence considering the potential impact on local realities (UN-Habitat 2014, n.d). Such policy advice is highly problematic since there is a serious lack of evidence regarding how compact cities actually perform across different urban forms, scales and societies in relation to, e.g., improved health, access to urban green space and mitigation of disasters, and especially how both impacts and interventions unfold on the neighbourhood level (Dempsey and Jenks 2010; Ahlfeldt and Pietrostefani 2017).

At present, the nexus of the compact city discourses of conviction and suspicion has increasingly been focusing on climate change mitigation (e.g., O’Brien and Selboe 2015;

Fujii, Iwata, and Managi 2017; Angel et al. 2020), where cities are seen to play a key role in achieving a zero-carbon society (Arabzadeh et al. 2020; The Global Commission on the Economy and Climate 2014; Dale et al. 2020; Covenant of Mayors for Climate & Energy 2020). Still, the obligation to attain zero-carbon cities is just one out of a plethora of interlinked environmental, social and economic predicaments, forming an entwined global emergency (Asara et al. 2015). Although zero-carbon measures based on urban densification can bring a wide range of important co-benefits linked to, e.g., health, biodiversity and economy (Karlsson, Alfredsson, and Westling 2020), climate change mitigation policies may also lead to serious adverse effects on liveability and well-being (Lehmann 2019). Also, linking, e.g., climate change mitigation too closely to the spatial dimensions of urban compactness disregards the relational nature of the compact city as a constantly reproduced ‘assemblage’ of ‘co-functioning [...] elements’ (Kjørås 2020, 8). All in all, there is a need for an improved understanding of these complexities to provide better support for urban policymaking and planning in the context of urban compaction.

Here, Holman et al. (2015) bring forward a third and more *pragmatist discourse*, arguing for the empirical study of actual benefits or detriments of compact city policies. Instead of being either convinced or suspicious, pragmatists aim to better understand the many complexities inherent in the development of any city, and how these relate to urban compactness when implemented on the ground. In this research context, different types of analytical frameworks have been proposed to better understand the mechanisms and potential benefits of compact cities (e.g., Frey 1999; Boyko and Cooper 2011; Cho, Trivic, and Nasution 2015; Larco 2016; Ahlfeldt and Pietrostefani 2017; Zhang 2017). Although these are very helpful, each one only covers parts of the wide compact city debate and thus only fragments of the abovementioned intricacies of intertwined synergies and trade-offs. Based on a mix of theoretical and empirical research, the aim of the present study is, therefore, to contribute to the pragmatist discourse by meeting the following objectives:

- (1) to develop an analytical framework facilitating a systemic understanding of what urban qualities (both positive and negative) a compact city can (or should) deliver;
- (2) to map alleged compact city qualities (both positive and negative) found in the literature onto such a systemic framework to assess its usefulness for grasping contemporary urban complexity and challenges;
- (3) to map compact city qualities mentioned by urban stakeholders in two European cities onto the same systemic framework to further study its usefulness; and
- (4) to tentatively apply the developed framework to analyse how compounded and interdependent ‘states’ and ‘impacts’ of compact city qualities may act on various contemporary policy challenges, such as carbon neutrality, poverty alleviation, neighbourhood revitalization, or community engagement.

Below, Section 2 presents the methods used to collect data and Section 3 introduces the analytical framework that will support the study in response to the first objective. Section 4 presents the results, subdivided into three parts corresponding to the last three objectives. In Section 5, the results are discussed and some conclusions are drawn.

## Methods

The first objective of the paper – to develop a systemic analytical framework – was addressed through a scoping review of the state of the art, focusing on identifying main characteristics of the compact city debate. A complementary and more systematic review was carried out, focusing on literature with a publication period just before the data collection in the two cities took place (see below), i.e., 2014–2015. The data was collected based on a search in the Scopus database, using the search term ‘compact city’ and 84 articles were identified. The plethora of compact city qualities (both positive and negative) mentioned in the literature were arranged based on systems thinking, specifically by applying the DPSIR (Drivers, Pressures, States, Impacts and Responses) approach promoted by the EEA (1999) onto the urban development context, providing ‘a heuristic framework for the analysis of cause–effect relationships in complex systems’ (Haase and Nuijsl 2007, 3). The framework was verified further through iterations based on the results from the stakeholder interviews (see below).

Meeting the second objective – to map alleged compact city qualities (both positive and negative) found in the literature onto the systemic framework – was also based on the results from the systematic review of the 84 articles from which terms used to label alleged or contested qualities of compact cities were sifted out and counted. This made it possible to calculate aggregated results based on the number of occurrences of these terms for each one of the fields of the analytical framework. For example, articles were mentioning qualities, such as ‘promote walking’, ‘pedestrian friendliness’, ‘sidewalk attributes’ and ‘design for walking’, and each one of these would tick off one occurrence of the compact city quality ‘walkability’, in turn belonging to the sub-category ‘Built structures/Access’. Note, however, that each occurrence can represent a compact city quality term mentioned briefly as well as more extensive and/or empirically grounded discussions on compact city qualities. Such work is used as a basis to expand on and subsequently gear this work more specifically towards contemporary urban challenges through the fourth objective.

The third objective – to map compact city qualities mentioned by urban stakeholders onto the systemic framework – was addressed by carrying out interviews with a broad range of urban stakeholders in two European cities, 44 in Barcelona (in 2014–2015) and 38 in Rotterdam (in 2015–2016) (see Table 1). Also interviewed researchers, typically engaged

**Table 1.** Number and categorization of interviewees in Barcelona and Rotterdam.

Main category	Sub-category	Barcelona	Rotterdam
Social sector	Residents, neighbourhood associations civil/social movements	6	1
	NGOs	1	1
Institutional sector	Planning officers (technicians)	2	4
	Other professionals working for public administration	5	2
	Managers of public administration sectorial departments	2	1
	Public agencies or foundations	5	7
Urban professionals sector	Development consultants	1	2
	Architects, planning consultants	4	5
Economic sector	Representative of association of entrepreneurs	2	1
	Local business/shop managers	1	
Policy	Politicians	1	
Research/academy sector	Researchers/experts on case studies	14	14
	<b>Total</b>	<b>44</b>	<b>38</b>

in bridging the local science–policy gap, were considered as stakeholders (Hirsch Hadorn et al. 2006; Jacobi et al. 2020). The interviews followed an in-depth, semi-structured interview format (Kvale 1996), where the interviewees were encouraged to approach the topic from their own professional and personal experiences. The interviews were audio recorded and the data was analysed and coded directly from the recordings, thus only partially transcribed. Similar to the data from the literature review, the occurrence for different terms used to describe compact city qualities was registered to facilitate aggregated results. Note that also here each occurrence may represent a compact city quality mentioned briefly as well as in more extensive and/or empirically grounded discussions.

The fourth objective – to tentatively apply the framework to identify and appraise interdependencies, synergies and trade-offs emerging from compact city policies – builds on previous research developed by e.g., Haase et al. (2012), Fertner and Grosse (2016) and Adelfio et al. (2020). This objective was tackled through a qualitative analysis of causal loops as applied in System Dynamics (e.g., Kirkwood 1998) as a way of ‘dancing’ (Meadows 2009, 165) with the systems of compact city qualities. Reinforcing and counteracting links were identified, and subsystems linked to current policy challenges were pinpointed.

## Analytical framework

The analytical framework is based on two components: a) main categories of compact city qualities and b) compact city qualities as states and impacts.

### *Main categories of compact city qualities*

The research literature on compact cities is abundant, representing many different perspectives and objectives depending on the individual research endeavours. Drawing on the literature (where many of the cited references, in turn, draw on multiple sources), compact city qualities can be grouped into main categories.

#### *Intensity (density)*

The self-evident factor of compact cities is their density – or intensity – measured as the quantity of a specified feature within a certain area, usually km<sup>2</sup> or hectare but can also refer to a lot, parcel, block, neighbourhood, city or metropolitan region (Boyko and Cooper 2011). Intensity can be about e.g., residential population (Dantzig and Saaty 1973; Churchman 1999; Burton 2002), employment opportunities (Neuman 2005), impervious surfaces (Neuman 2005; Boyko and Cooper 2011), green space (Rueda 2014), building coverage (Berghauser Pont and Haupt 2009), floor area (Berghauser Pont and Haupt 2009), dwellings or units (Churchman 1999; Burton 2002), and building heights (Berghauser Pont and Haupt 2009) or building volume (Koomen, Rietveld, and Bacao 2009). However, intensity can also refer to qualitative understandings of how intensely urban space is used (Westerink et al. 2013).

#### *Diversity (mixed use, mixed functions, complexity)*

Mixed land use leading to diversity is another key aspect of compact cities (Dantzig and Saaty 1973; Neuman 2005). A ‘varied and plentiful supply of facilities and services’ (Burton 2002, 224) is seen to lead to local self-sufficiency (Dantzig and Saaty 1973; Rueda 2014).

Diversity can also be seen as the complexity arising from the interactions between 'economic activities, associations, facilities and institutions' (Rueda 2014, 14). The mix of uses can be both horizontal and vertical (layering), and also involve interweaving (combining functions in the same space) or timing (using the same space for different functions over time) (Burton 2002; Haccou et al. 2007). Arguments for increased diversity in already dense urban environments implicitly also tend to argue for a densification of functions other than just housing, such as shops, businesses, offices, services, leisure, open space, and green space. A particular aspect of diversity is that 'the same density can be obtained with radically different building types' (Lozano 1990, here from Berghauser Pont and Haupt 2009, 17).

### *Access (proximity, distance, accessibility, mobility, efficiency, infrastructural connectivity)*

Short distances represent the most significant element of a compact city (Boyko and Cooper 2011; OECD 2012; Kasraian, Maat, and Van Wee. 2017; Hamiduddin 2018). Diversity in combination with fine-grain land use patterns provide a potential for proximity to functions, services and jobs (Burton 2002; Neuman 2005; Rueda 2014), which in turn encourages walking and biking (Næss and Vogel 2012; Boussauw, Neutens, and Witlox 2012). People living close to each other will presumably interact more (Burton 2002), but effective infrastructural/IT connectivity supports intense interaction decoupled from urban density (Porqueddu 2015). In parallel to proximity, improved mobility (e.g., transit-oriented development, Calthorpe 1993), accessibility (Neuman 2005; Ewing and Cervero 2010), and infrastructural connectivity (Zonneveld 2005) are emphasized as key compact city features, also including the infrastructure supporting an efficient urban metabolism (Neuman 2005; Rueda 2014). Short distances to public transport are crucial for multi-modal mobility through local and regional networks (Neuman 2005; Næss and Vogel 2012). Opening hours, income, gender, educational level and vehicle ownership also affect accessibility (Geurs and Van Wee. 2004). All in all, access is a matter of complex relationships with the other main categories of compact city qualities (Boussauw, Neutens, and Witlox 2012).

### *Form (morphology, network connectivity)*

A compact city is clearly contained from its surroundings (Neuman 2005), originally as a monocentric city (Dantzig and Saaty 1973). Today, clustered deconcentration (Westerink et al. 2013) or polycentric configurations (Breheny 1996) are seen as more beneficial, with a multitude of variants, such as the Finger, Star, Linear and Satellite city (Frey 1999). Polycentrism is also reflected in green structure planning, with urban nature shaped as interconnected corridors between built-up areas (Greensurge 2015). Zooming out to the city or metropolitan scale, polycentrism brings a heterogeneity of densities due to the presence of less dense urban functions (Churchman 1999; Berghauser Pont and Haupt 2009). Urban form also links to network connectivity, i.e., the coverage, densities and integration of different types of urban networks (sidewalks, biking lanes, streets, roads, rail, etc.) (Hillier 1996; Berghauser Pont and Haupt 2009), where networks for walking and biking are of particular interest (Dill 2004).



## Size

The above-mentioned proximity is relative to scale, but ‘in the literature on the compact city, often no distinction is made between small towns and metropolises’ (Boussauw, Neutens, and Witlox 2012, 690). Still, to be meaningful, a compact city ‘must be large enough to support the whole range of services and facilities’ (Burton 2002, 220), with an economy large enough to finance its amenities and infrastructure (Neuman 2005). Furthermore, some compact city properties, such as more choice, opportunities and innovations, health issues, and criminality, seem to depend more on size than on compactness (Neuman 2005; Bettencourt et al. 2007).

## Compact city qualities as states and impacts

From an urban economics perspective, Ahlfeldt and Pietrostefani (2017) suggest that compact city qualities can be divided into characteristics (causes) and outcomes (effects), where the characteristics are defined as ‘economic density’, ‘morphological density’, and ‘mixed land use’. Although helpful, a wider categorization of compact city qualities seems useful since Ahlfeldt and Pietrostefani’s framework, for example, largely overlooks the importance of urban nature and all its ecosystem functions and services (TEEB 2011).

Also, since the compact city concept is both contested and poorly defined (Neuman 2005; Boyko and Cooper 2011; Holman et al. 2015), compact city qualities (such as having a socially mixed neighbourhood) need to be disentangled from urban driving forces (Adelfio et al. 2018) (such as gentrification) and urban strategizing (such as promotion of mixed-tenure neighbourhoods). The DPSIR framework (EEA, 1999) is a causal chain model distinguishing between Drivers, Pressures, States, Impacts and Responses that has been widely used in environmental assessment. DPSIR has also proven useful in understanding change in relation to a wider set of urban functions and types of land use (Tscherning et al. 2012; EEA, 2016; Manitiua et al. 2016) and for sustainability assessment of urban neighbourhoods (Zhao and Bottero 2010). It is a straightforward tool, adaptable to new analytical contexts (Spanò et al. 2017). Still, it is important to understand how impacts, in turn, may induce secondary and even tertiary impacts (McDonnell and Zellner 2011; Brown, Moodie, and Carter 2015; see also the literature on evaluation of public policy, e.g., Vedung 2006), for example how a decrease in car use, first leads to less air pollution and then to improved pulmonary health (Cooper 2004).

DPSIR has not been free of criticism (e.g., Carr et al. 2007) and caution is in place. By applying the DPSIR framework to the analysis of urban transformation it is assumed that different configurations of, e.g., demography, buildings and urban nature are States that subsequently generate diverse types of Impacts. First, it is highly questionable whether it is possible, or even desirable, for planning (i.e., of physical urban space) alone to deliver such States that subsequently have Impacts on the complexities of human societies (Gleeson 2012, see also the discourse of suspicion above). Second, the idea of linear causalities is not easily reconciled with current notions of urban complexity, where we rather should look for multiple and multi-directional correlations (Niemeijer and De Groot 2008; Tscherning et al. 2012). Simplified and naïve application of the DPSIR model may lead to policies with undesirable societal impacts (Rekolainen et al. 2003). Keeping these

**Table 2.** A systemic analytical framework for compact city qualities.

		Main categories			
		Intensity	Diversity	Access	Form
State	<i>Theme A; B; C; ...</i>				
Impact 1 <sup>st</sup>	<i>Theme D; E; F; ...</i>				
Impact 2 <sup>nd</sup>	<i>Theme G; H; I; ...</i>				

**Table 3.** The analytical framework for compact city qualities, with the identified main themes and displaying the number of occurrences of different compact city qualities in the 84 articles.

		Main categories			
		Intensity	Diversity	Access	Form
State	<b>People</b>	80	20	0	5
	<b>Built structures</b>	116	199	303	165
	<b>Nature</b>	76	26	4	18
Impact 1 <sup>st</sup>	<b>Socioculture</b>	4	18	20	4
	<b>Environment</b>	85	48	0	11
	<b>Economy</b>	62	22	28	3
Impact 2 <sup>nd</sup>	<b>Health</b>	19	0	10	0
	<b>Quality of Life</b>	32	28	11	2
	<b>Justice</b>	26	16	28	3
	<b>Adaptability</b>	4	4	0	1

limitations in mind, an analytical framework dividing compact city qualities into states and primary and secondary impacts is still valid as a starting point for a systemic understanding of compact city qualities.

### ***A systemic analytical framework***

Based on the above, our search for a systemic understanding of compact city qualities is based on an analytical framework intersecting states and impacts with the four main categories of compact city qualities: Intensity, Diversity, Access and Form (see Table 2). City size is omitted from this framework since it does not appear to be an essential category of compact cities (as mentioned in Section 3.1). The states and impacts are then broken down into specific themes, further elaborated below (see Table 3).

## **Results and analysis**

### ***The academic discourse on compact city qualities***

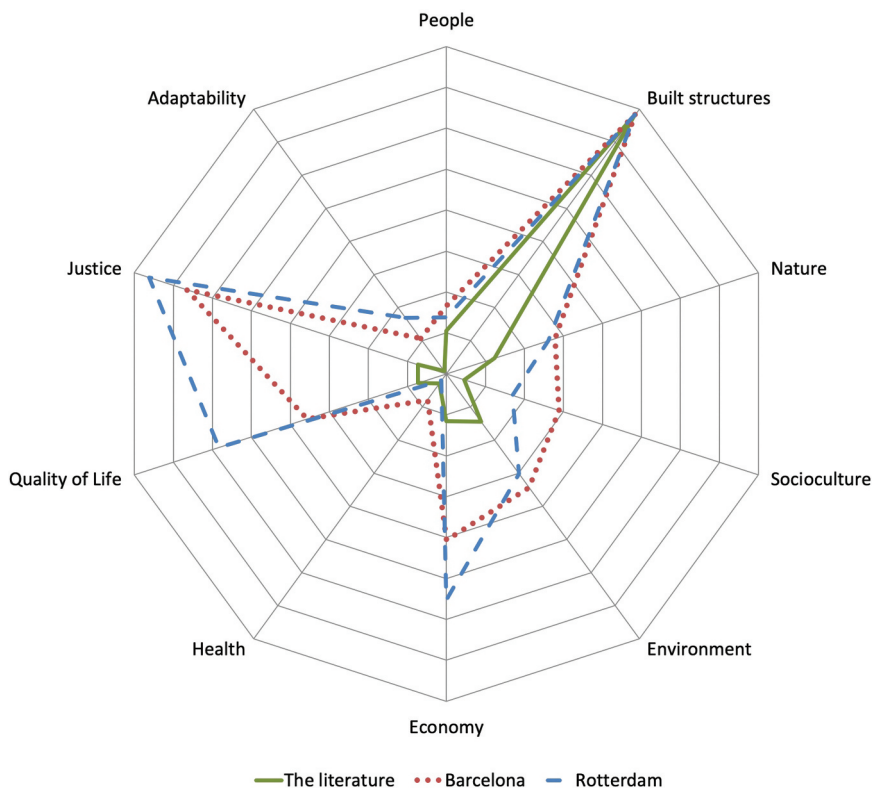
The review of the 84 articles linked to the notion of compact cities inductively identified ten main themes of compact city qualities (both positive and negative), labelled as People, Built structures, Nature, Socioculture, Environment, Economy, Health, Quality of life, Justice, and Adaptability. Building on the DPSIR framework, these ten themes were then subdivided into states and (primary and secondary) impacts of compact city development (see Table 3). The analysis also counted the occurrences of the main themes in the reviewed articles, providing an indication of how the literature placed its emphasis within the compact city discourse.

### *Local discourses on compact city qualities: Barcelona and Rotterdam*

The analysis of the abundant material from interviews with stakeholders in Barcelona and Rotterdam did not identify any new main themes. Still, the distribution across the analytical framework of the occurrences of compact city qualities showed how urban stakeholder place a different emphasis on which compact city qualities are the most relevant to discuss and address (see Table 4).

Compared to the literature review, the analysis of the interview material provided a richer understanding of what compact city qualities are seen to entail by urban stakeholders (see examples in Table 5). We could also see that new types of qualities – and new dimensions of qualities – emerged that were not represented in the reviewed scientific articles.

The two-tier analysis also made it possible to compare academic and stakeholder discourses on compact city qualities (see Figure 1). A first observation is that neither the literature nor the stakeholders discuss ‘People’ much as an important theme of compact cities, but presumably an increased density, diversity and proximity of people is seen as a self-evident outcome of a higher intensity of ‘Built structures’, such as housing and workplaces. Also, compared to the literature, the stakeholders seem to emphasize ‘Nature’ much more.



**Figure 1.** A comparison between number of occurrences of compact city qualities in the literature and stakeholder interviews in Barcelona and Rotterdam. The theme ‘Built structures’ is set as a common scale reference to facilitate comparison.

**Table 4.** Interview data regarding the number of compact city qualities occurrences from a) Barcelona (BCN) and b) Rotterdam (ROT) inserted into the analytical framework for compact city qualities.

		Main categories							
		Intensity		Diversity		Access		Form	
		a: BCN	b: ROT	a: BCN	b: ROT	a: BCN	b: ROT	a: BCN	b: ROT
State	<b>People</b>	16	6	13	13	1	0	4	8
	<b>Built structures</b>	13	23	21	37	81	64	45	29
	<b>Nature</b>	39	44	3	2	5	2	10	3
Impact 1 <sup>st</sup>	<b>Socioculture</b>	22	12	17	16	15	2	5	3
	<b>Environment</b>	51	36	13	19	2	1	4	3
	<b>Economy</b>	37	55	19	24	6	2	21	27
Impact 2 <sup>nd</sup>	<b>Health</b>	7	4	5	0	3	0	1	0
	<b>Quality of Life</b>	25	41	29	41	8	29	11	3
	<b>Justice</b>	25	22	61	68	42	43	8	16
	<b>Adaptability</b>	5	10	15	23	0	0	2	0

Furthermore, urban stakeholders seem to be much more interested in the impacts of compact city development, where the primary impacts ‘Socioculture’, ‘Environment’ and ‘Economy’ stand out in particular; Barcelona with an emphasis on socioculture and Rotterdam on economy. Interestingly, ‘Health’ is not mentioned much in neither the literature nor the interviews, but is slightly more discussed in Barcelona, compared to both the literature and Rotterdam stakeholders. Another interesting observation is that the two secondary impact qualities ‘Quality of life’ and ‘Justice’ are significantly more mentioned by the interviewees than in the literature, where Rotterdam is almost placing as much focus on justice as on built structures. When it comes to ‘Adaptability’, hardly mentioned at all in the literature, urban stakeholders place somewhat more weight on this aspect.

### *Appraising interdependencies of compact city qualities in relation to contemporary policy challenges*

In the following, Barcelona is used as an example to explore how compounded states and impacts of compact city qualities can be analysed in relation to a certain policy objective, in this case Barcelona as a zero-carbon city (Ajuntament de Barcelona 2018). Out of the full set of compact city qualities identified from the stakeholder interviews, a selection was placed in the analytical framework, displaying synergies and trade-offs of Barcelona compact city qualities with relevance to ambitions for a zero-carbon city.<sup>1</sup> These qualities were then analysed with regard to potential causal interdependencies.

Although representing a simplification, the many identified interdependencies immediately reveal the high degree of complexity and ‘wickedness’ (Churchman 1967; Rittel and Webber 1973) linked to carbon neutrality as a policy objective. To increase the legibility of the analysis, some subsystems were outlined and colour-coded: Mixed use and complexity; Quality of life; Tourism economy; and Inclusive planning and governance<sup>1</sup>. For instance, the branding of Barcelona as a ‘global city’ has significantly boosted the number of tourists, which has benefits for employment and the local economy, but directly increases the carbon footprint from air travel and cruise ships. Extensive tourism also puts pressure on the housing market, where tourist flats and escalating real estate values push low-income households out from several parts of the

**Table 5.** Examples from the literature (with number of hits within brackets) and from the interviews (with city indicated: Barcelona = BCN; Rotterdam = ROT).

		Intensity	Diversity	Access	Form
State	<b>People</b>	Population density in general (38); household size (6) Tourist density (BCN); dog density (BCN)	Population mix: e.g., sex, ethnic, age, marital status (9) Mix rich and poor (BCN); many nationalities (ROT)	-- People stay in their districts (BCN)	Population distribution (5) Continuity of the inhabited city (BCN); empty inner city (ROT)
	<b>Built structures</b>	Density in general (33); multi-family houses, building heights, (21) Small apartments (BCN); highrise housing (ROT)	Mixed land use, diversity, complexity multifunctional (39) Economic activity in ground floor (BCN); mix of social and other housing (ROT)	Distance/access to efficient public transport (47) Proximity of everything (BCN); walkability, bikability (ROT)	Polycentric, nodes, clustering (21); urban sprawl (39) Superblocks (BCN); densify central areas (ROT)
	<b>Nature</b>	Ecosystem services (38); green roofs and walls (6) Amount of green space (BCN); urban agriculture (ROT)	Biodiversity (11); habitat fragmentation (5) Quality of green space (BCN/ROT)	Availability of green space (4) Nature is far away (BCN); green space is lacking (ROT)	Green belts, wedges, corridors (5) The large parks are important (BCN); lack of green fingers (ROT)
	<b>Socioculture</b>	Social in general (3); urban culture (1) Social life outside (BCN/ROT)	Social and cultural diversity (5); heritage (4) A mix of cultures historically (BCN/ROT)	Social capital (13); anonymity, (lack of) privacy (3) Social networks (BCN); lack of social interaction (ROT)	Sustaining (stable) communities (2) Neighbourhood associations and feasts (BCN)
Impact 1 <sup>st</sup>	<b>Environment</b>	Air pollution (NOx, PM10, PM2.5, SO2) (23) Noise from traffic and drunk people (BCN); climate adaptation (ROT)	Consumption of nonrenewables, resource use (16) Green energy, energy efficiency (BCN/ROT); water recycling (BCN)	-- Self-sufficiency (BCN); waste reuse and recycling (ROT)	Heat island effects, extreme heat events (11) Heat island effects (BCN/ROT)
	<b>Economy</b>	Employment density (12); property values (13) Unemployment (BCN/ROT); tourist economy (BCN/ROT); housing costs (ROT)	Innovation (2); vibrancy, economic revitalization (4) Mix of groundfloor activities (BCN); innovation (BCN/ROT); mix of housing (ROT)	Reducing expenditures on infrastructure (14) Real estate prices drive commuting (BCN); PPPs for social issues (ROT)	Competitiveness (2) Clustering for critical mass (BCN); city competitiveness (BCN/ROT)
	<b>Health</b>	Health in general (10); traffic accidents (4) Bad health from overcrowding, air quality, noise, lack of nature (BCN);	-- Social interaction improves health (BCN)	Active commuting: walk and bike (4); healthcare (4) Access to healthy food (BCN); access to green space (BCN)	-- People in poor areas have poor health (BCN)
	<b>Quality of Life</b>	QoL in general, liveability, wellbeing (12) High quality neighbourhoods (BCN); low quality of housing (BCN/ROT)	Functional and attractive open space (8) Quality of public space (for social life)(BCN/ROT); local identity (BCN)	Security, crime rates (6); safety (3) Feeling of safety (BCN/ROT); social conflicts (ROT); crime (ROT)	Feeling of community (1); shared values (1) Neighbourhoodness (BCN); community (BCN/ROT)

(Continued)

Table 5. (Continued).

	Intensity	Diversity	Access	Form
<b>Justice</b>	Equality, equity, justness, rights (10); fairness (2)	Segregation, (negative/positive) gentrification (5)	Social cohesion and inclusion (14); equal access to mobility (4)	Environmental justice across space (3)
	Inequality (BCN); equal opportunities (ROT); social housing (more BCN/less ROT)	Gentrification; ICT open government; citizen participation (BCN/ROT)	Segregation (BCN/ROT); public space as integrator (BCN)	Poor and rich areas (BCN/ROT); barriers between areas (BCN/ROT)
<b>Adaptability</b>	Flexible use (2); resilience (1)	Form as outcome of micro-behaviour (1); manage complexity (1)	– –	Fractal cities (1)
	All space is used up (BCN); free space in harbour = space for innovation (ROT)	Complexity needs local knowledge (BCN); temporary use (BCN/ROT)	– –	Zoning is rigid (BCN)

city. This leads to gentrification, a migration of less affluent households to satellite municipalities in the metropolitan region poorly serviced by public transport, and thus to increased commuting by car or motorbike. Tourist crowds also tend to exclude inhabitants from the local urban spaces vital for quality of life and strong local engagement. A key element of Barcelona's zero-carbon policy is the 'proximity of everything' in a walkable city but this objective is seriously threatened by all these compounded impacts leading to less demographic, social, cultural, political and economic diversity, which affect the offer of local services and amenities and impoverish local life and identity. These are just a few examples. A full account subsystem interdependencies would require a more detailed examination of a wider set of urban qualities and their interdependencies.

## Discussion and conclusions

The analysis of the combined empirical material – academic literature and stakeholder interviews – seems to confirm the relevance and usefulness of a systemic analytical approach. The systemic approach provided a more wide-ranging as well as a more detailed understanding of compact city qualities. Such a systemic understanding is essential for an effective and transparent approach to sustainable urban transformation (Coral and Bokelmann 2017) and can function as a platform for identifying, understanding, discussing and negotiating what compact city qualities should be prioritized in specific urban contexts. The presented analysis of qualities focuses more on qualitative concepts rather than on the quantitative measurement of compact city qualities through metrics. By doing so, this paper takes the distance from the 'institutionalized concept of the compact city – focused on establishing minimum thresholds of residential density' (Górgolas 2018, 58) and also embraces the relativeness of the compactness and density concepts as described by Lehmann (2016).

There are many ways to cut a cake, and the elements of our main compact city quality categories (Intensity, Diversity, Access, Form) can obviously be arranged differently, with slightly different boundaries between the categories. For example, there are arguments for dividing the category access in two: e.g., labelled as Proximity (Boussauw, Neutens, and Witlox 2012) and Accessibility (Rode et al. 2014) where the first deals with distance

(Hamiduddin 2018) and the second to connectivity (Peponis, Bafna, and Zhang 2008). Also, there is a certain overlap between infrastructural connectivity (now part of Access) and connectivity resulting from urban Form, e.g., when it comes to network density and integration. There may also be strong arguments for bringing city size back into a compact city quality framework (Echenique et al. 2012).

Also, even if the content of most of the boxes in the compact city quality framework was straightforward to fit into the systemic format, there were some glitches that suggest that the systemic approach needs further work. Fitting the empirical data into the framework was at times a bit forced. For example, the content of the intersections of People/Access and Adaptability/Form did not come out as self-evident and may well be debated further, and for one intersection neither the literature nor the interviews provided any content and it remained empty, i.e., Adaptability/Access.

At times, the notion of cause-and-effect dependencies – from state to primary and then to secondary impacts – proved difficult to pinpoint. For example, attractive public space (Quality of life/Diversity) is categorized as a secondary impact, e.g., from social and cultural diversity (Socioculture/Diversity) but one may as well argue that rich outdoor social life depends on high quality outdoor space. This confirms the arguments by several authors already highlighted in Section 3.2 that there are seldom any linear linkages but instead multidirectional and complex interdependencies (Rekolainen et al. 2003; Boussauw, Neutens, and Witlox 2012; Gleeson 2012; Tscherning et al. 2012). Moreover, ‘the interconnectedness of urban features, urban systems and related flows (...) may create a cascade (or “domino” effect) of impacts’ (Wamsler and Brink 2015, 5).

To conclude, the proposed systemic framework has proven useful for meeting the four objectives of this article. Complementary to the earlier compact city frameworks mentioned above, it has been helpful for structuring the diversity of compact city qualities brought forward in the literature, as well as discussed among urban professionals and stakeholders. The systemic framework has also facilitated a more nuanced understanding of how different aspects associated with the diverse states of compact cities correlate to – and potentially cause (or are caused by) – different types of impacts, where positive impacts are to be strengthened and negative impacts tackled.

Our findings suggest that any policy measure or analytical effort linked to urban compactness needs to respect the prevailing complexity and bear in mind the iterative movement between different types of states and impacts as highlighted above. The proposed framework provides an improved understanding of the multiple factors that need to be taken into account by urban planners and decision makers who advocate for compact city development as a response to multiple urban policy challenges, such as carbon neutrality, poverty alleviation, neighbourhood revitalization, or community engagement. Furthermore, previous research (Adelfio et al. 2018; Adelfio, Hamiduddin, and Miedema 2020) has shown the significant influence of local specificities and complexities on the implementation of compact city policies. Here, the qualitative focus of the proposed framework, rather than providing metrics or thresholds, allows for a much-needed flexibility and adaptability to local contexts in urban analysis and policy making.

## Note

1. see [https://research.chalmers.se/publication/524157/file/524157\\_AdditionalFile\\_cbafca7c.pdf](https://research.chalmers.se/publication/524157/file/524157_AdditionalFile_cbafca7c.pdf)

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