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Review

Challenges and strategies for urban green-space planning in cities undergoing densification: A review

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ABSTRACT

The compact city approach has gained global impact as a planning approach for sustainable development in areas with increasing urban population. Through densification and compact building, the approach aims to counteract negative effects of urban sprawl in terms of ineffective land-use and related environmental problems. In spite of its benefits various problems and challenges are associated with implementing the compact city approach. This review looks at the effects of urban densification and compact city development on urban green space and its planning. It identifies problems, challenges and strategies of urban green space planning during densification processes. Findings confirm that urban densification processes, including consolidation and infill development, can pose a threat to urban green space. However, the literature on the compact city approach often lacks specific suggestions for urban green space conservation and planning. Provision of urban green space in compact city environments and during densification processes is described as a major challenge. Loss of private urban green space rarely seems offset by provision of more public green space. Several ways are identified to deal with these challenges, while also highlighting research gaps, e.g., as to how loss of green space quantity can be offset by increased green space quality.

Introduction

Worldwide, the percentage of people living in urban areas will increase from 50% in 2010 to nearly 70% by 2050 (United Nations, 2013). This will result in expansion and/or densification of urbanised areas. As migration to urban areas is ongoing globally, the need for sustainable urban development is becoming increasingly important. In an urban context this implies creation of both resource efficient systems and good, engaging urban design for attractive cities with good quality of life. Urban sustainability has been related to urban form (Jenks and Jones, 2010a) and alternative, more sustainable urban forms than urban sprawl have been suggested (e.g., Jenks et al., 1996a; Jabareen, 2006; Sonne, 2009). Urban sprawl can be defined as urban development with low-density housing, both residential and commercial, segregated land-use, high level of automobile use combined with lack of public transport, which is in high demand for land (Johnson, 2001). Related problems are non-efficient use of resources e.g., of land and energy causing a larger urban footprint, loss of biodiversity, environmental problems, and social inequalities (Power, 2001). Even urban areas with a declining population (i.e., shrinking cities) can expand in terms of area (Couch et al., 2005). Alternative, more sustainable urban forms include neo-traditional development, urban containment, the compact city and the eco-city (Jabareen, 2006), and in particular compact or dense city form (Jenks et al., 1996b; Burton, 2000; Randolph, 2006; OECD, 2012), since it aims to counteract the negative effects of urban expansion and sprawl. The 'compact city' is characterised by high density housing, mixed use, well-functioning public transport (transit oriented development) and promotion of cycling and walking (Burton, 2000).

Nevertheless, negative effects of certain aspects of city densification are increasingly evident (e.g., crowding, lower living quality) and certain positive characteristics assigned to the dense city are being questioned (less traffic, less environmental problems; Williams, 2000; Neuman, 2005; Howley et al., 2009; Melia et al., 2011; Hofstad, 2012). One issue identified is the lack of urban green space in densified urban areas and the removal of green space when densifying city areas (e.g., Jim, 2004; Fuller and Gaston, 2009; Brunner and Cozens, 2013). This paper reviews research on the challenges to urban green space planning in cities under densification on the one hand, and strategies for sound urban green space planning under these conditions on the other. Urban green space is

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defined here as "any vegetation found in the urban environment, including parks, open spaces, residential gardens, or street trees" (Kabisch and Haase, 2013, p. 113).

Planning and management of urban green space is a crucial issue in the context of the compact city concept, as these spaces provide essential benefits to urban dwellers (e.g., Pauleit, 2003; Tzoulas et al., 2007; James et al., 2009), while also offering crucial habitat for wildlife (Goddard et al., 2010). Green space multifunctionality has often been emphasised as relating to recreation, social interaction, aesthetics, cultural heritage and ecological functions (Pauleit, 2003; Priemus et al., 2004; Mell, 2009). Many of these functions, which are seen as important for sustainable urban development, have to be realised within limited space (Baycan-Levent et al., 2009; James et al., 2009). The concept of ecosystem services (Costanza et al., 1997; Millenium Ecosystem Assessment, 2003), embodying the human benefits derived from ecosystem functions, has also been applied to urban green spaces (Tratalos et al., 2007; Ernstson et al., 2008; Niemelä et al., 2010; Young, 2010; Kabisch, 2015; Hansen et al., 2015). Among the so-called regulating services, air purification (Bell et al., 2011; Tallis et al., 2011; Saebo et al., 2012), water and climate regulation (Bowler et al., 2010; Depietri et al., 2012), carbon storage (Davies et al., 2011; Strohbach et al., 2012) and stormwater regulation (Zhang et al., 2012) are important examples. They are also crucial for biodiversity conservation within urban areas (Goddard et al., 2010; Nielsen et al., 2014).

There is also an increasing interest in the perception of urban nature by humans (Chiesura, 2004; Standish et al., 2013), relationships between biodiversity and health benefits (Fuller et al., 2007; Jorgensen and Gobster, 2010; Dean et al., 2011; Wolch et al., 2014) and generally in human–environment interactions (Kabisch et al., 2015). Cultural ecosystem services such as recreation, aesthetics and cultural heritage, are often prioritised in planning, design and management of urban green spaces. Urban green spaces offer possibilities for restoration (Nordh et al., 2009), physical activity (Hillsdon et al., 2006; Gardsjord et al., 2014), and social interaction and community attachment (Seeland et al., 2009; Arnberger and Eder, 2012; Kaźmierczak, 2013). Because of the considerable health benefits urban green space provide (e.g., Tzoulas et al., 2007), access to green space has been a central issue in green space research in relation to human well-being (e.g., Barbosa et al., 2007).

Provisioning services of urban green space have gained increasing attention over last decade, e.g., concerning urban agriculture (De Bon et al., 2009) and community gardening (Holland, 2004; Guitart et al., 2012). The importance of studying interrelations, especially synergies of ecosystem services or functions has been highlighted (Shmelev and Shmeleva, 2009). Provision of vital multiple ecosystem services makes urban green space a fundamental part of sustainable urban development.

As urban sprawl can threaten countryside areas, densification processes in town and cities can potentially threaten urban green spaces. There is evidence that urban green space is under pressure due to densification processes such as infill development (Pauleit et al., 2005; Rafiee et al., 2009; Byomkesh et al., 2012). Green space planning and management can be very challenging, especially in city areas under densification, since important ecosystem services are supposed to be delivered by limited green spaces. Therefore existing studies need to be reviewed that have looked at urban green space planning in cities undergoing densification. Questions to be answered by this review are: (1) how do the compact city approach and densification processes affect urban green space planning? (2) Which particular challenges and problems arise from this? And (3) which strategies and solutions are offered for dealing with these challenges and problems?

Table 1
Key word combinations of the systematic literature search (compare methodology to Kabisch et al., 2015).

		Type of urban green		Densification process
Urban	AND	Green space	AND	Compact city
	OR	Green infrastructure	OR	Densification
	OR	Park	OR	Intensification
	OR	Garden	OR	Consolidation
			OR	Infill

Method

Literature was identified by structured and semi-structured searches in selected major scientific databases (Scopus, Web of Knowledge and Google Scholar), with additional cross-referencing. Additional searches were based on the authors own knowledge of potentially relevant work. Structured searches were carried out in November 2012 in Scopus and Web of Knowledge with the keywords *green space* or *park* combined with *compact city*, *densification* or *high-density*, *planning* and additionally on *green space change*. These were complemented and updated during 2013 and 2014, and extended with keywords such as *infill development* and *urban consolidation*. In January and February 2015 structured, quantitative searches were carried out in Scopus using the key words (title, abstract, keywords) *urban*, *green space*, *green infrastructure*, *park*, *garden* combined with *compact city*, *densification*, *intensification*, *consolidation* or *infill* (Table 1). The same searches were carried out in Web of Knowledge (topic). This methodology follows a systematic review approach (Petticrew, 2001; Roy et al., 2012; Kabisch et al., 2015). The literature considered in the quantitative analysis was restricted to publications in English; conference proceedings and other literature difficult to locate were excluded. Focus was on international, peer-reviewed journals. Articles not related or only marginally related to the topic of the review were excluded, while additional relevant articles found via cross references were added. The searches comprised articles published from January 2000 until 10th of February 2015. Due to the fact that snowballing and personal knowledge of the literature were used in addition to the systematic search, the literature search is not entirely replicable, which is a limitation. On the other hand these additions provided highly valuable supplementary information.

Framework and key concepts

As a background, a brief account is given of the compact city concept and the debate on whether compact city development contributes to sustainable urban development. This section provides a brief context rather than a comprehensive review. Next, the quantitative literature search is analysed. Evidence for green space change is summarised in general, but in particular regarding densification processes. Then literature on green space and densification is reviewed. The final section identifies research gaps and directions for future research.

The compact city concept and urban densification

Urban expansion and sprawl have in the past led to degradation of inner-city areas, which lost population and commerce. Moreover they have resulted in destruction and or fragmentation of natural or semi-natural vegetation at the urban periphery and in rural areas (Johnson, 2001). These problems have been recognised and discussed as early as during the 1960s (Jacobs, 1961). The term 'compact city' dates back to the 1970s (Dantzig and Saaty, 1973, cited in Breheny, 1996) and has been increasingly debated since the 1990s (Newman, 1992; Jenks et al., 1996a; De Roo, 2000; Jenks and Jones, 2010a). Rapid urbanisation in e.g., South-East Asia has

led to a wider interest in compact city development (e.g., Jim, 2004; Dave, 2010) which presently can be considered a globally applied planning concept with three main characteristics (OECD, 2012, p. 27):

- dense and proximate development patterns;
- urban areas linked by public transport system; and
- accessibility of local services and jobs.

Dense and proximate development patterns can refer to a variety of building patterns, depending on the context considered. Densification in suburbs can mean enlarging existing buildings or establishing new ones on previous gardens (also called infill development, Brunner and Cozens, 2013). In more central city areas, densification (also named compaction or intensification; Williams, 2000) can be achieved either by establishing new buildings in areas not built-up previously (infill), in built-up areas previously having other purposes (industrial sites, not used for production anymore), or in areas with lower-density buildings which are replaced by high-rise buildings. Densification is also termed consolidation when referring to the compaction of inner city and peripheral areas (Bunker et al., 2002). Densification can thus mean different building forms and processes, depending on the context (e.g., an Australian suburb or an inner-city of Hong Kong).

Compact city development is meant to counteract the negative effects of urban expansion and sprawl, but its own negative effects have been identified (Williams, 2000; Searle, 2004; Neuman, 2005; Jenks and Jones, 2010b; Dempsey et al., 2012; Westerink et al., 2013). The debate on urban sprawl and compaction is only the most recent episode in a discussion of urban form and development between 'centrists' and 'decentrists' which started more than 200 years ago (Breheny, 1996). Boyko and Cooper (2011) have explored the complexity of the density concept in city planning, its definitions and a large range of density measures. They highlight the importance of understanding density not only as a quantitative measure, but as also including other dimension as qualities of the environment and perceptions and needs of for example residents. Challenges of density concepts were emphasised by Bamford (2009) who showed both Copenhagen and Stockholm as past examples of compact city development and garden city tradition. Westerink et al. (2013) provided an overview of both advantages and disadvantages of urban sprawl and compact city development related to environmental, social, economic and resilience factors. Critics of the compact city concept question certain assumptions made on traffic reduction or energy use reduction (e.g., Gray et al., 2010; Melia et al., 2011), how the concept is implemented (Hofstad, 2012), or even whether there is any relationship between sustainability and urban form (Neuman, 2005; Jenks and Jones, 2010b). Despite the ongoing research debate on advantages and disadvantages of the compact city concept, it has had considerable impact in planning practice (Burton, 2000; McCrea and Walters, 2012; OECD, 2012; Brunner and Cozens, 2013).

Analysis of the quantitative literature search

Literature searches generated 102 publications (see Appendix). Of these, 69 were selected from 233 titles in Scopus. Through the search in Web of Knowledge three additional publications were identified that did not appear in the Scopus search. Also, 30 publications were added by snowballing from citations in published papers; many being publications dealing with green space change.

Studies are dominated by authors based in China, Europe and Australia (Fig. 1). The country of affiliation is in most cases also the host country of the study with few exceptions, especially work that had an international approach in the choice of case study location.

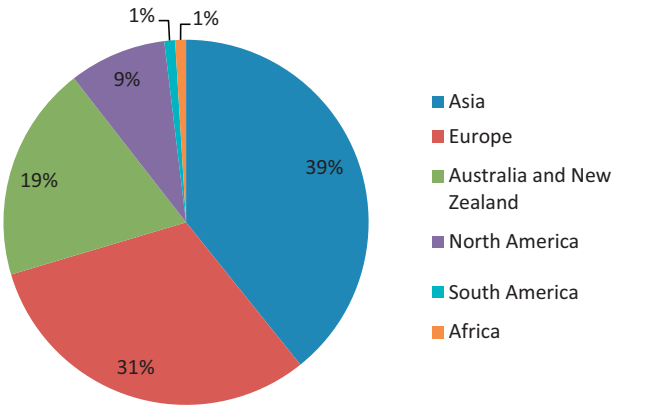

Fig. 1. Origin of studies on urban green space and densification. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

By far the most Asian publications derive from China (63% of Asian publications); in Europe one third were performed in the U.K. Numbers of publications per year increased until 2013; two thirds of all studies were published between 2011 and 2014.

Fifteen different topics were distinguished (Table 2). Major themes of publication were green issues related to green space planning under densification (22%) and green space change (19%). Social factors in relation to densification (resident perception, social equity/social sustainability, recreation, compensation hypothesis) comprised one fourth of the publications (25%). Biodiversity and landscape ecology issues were studied in about 10% of the publications. A case study approach at local, city part or city-wide scale was dominant (86% of all studies); 8% of the studies were on national scale (based on case studies distributed over the respective country) and 2% at continent scale. One study used a theoretical model, 13% used more general conceptual approaches (e.g., on sustainability, urban form, planning strategies, policies).

Publications were published in 52 different journals, which underlines the wide spread of publishing within the topic. Landscape and Urban Planning (17% of all publications), Urban Forestry & Urban Greening (9%) and Urban Ecosystems (5%) were the leading journals.

Urban green space change

There is growing evidence for loss of urban green space due to densification processes worldwide, especially for Asian and Australian cities and to a lesser degree in Europe and North America. Several authors have expressed a need for more knowledge on

Table 2
Major topics of literature on urban green space and densification (n = 102).

Topic	Number of publications
Planning	22
Change	19
Resident perspective	10
Social equity/social sustainability	7
Biodiversity	6
Trees	6
Greening buildings	6
Sustainability	5
Urban form	5
Recreation	4
Compensation hypothesis	4
Landscape ecology	3
Gardens	3
Land use	1
Policy	1

changes in the quantity of urban green space (e.g., Hall, 2010; Brunner and Cozens, 2013; Kabisch and Haase, 2013). Existing studies revealed different trends:

- rapid loss and fragmentation of urban green space in Asian developing countries, e.g., in Hanoi (Vietnam), Mashad (Iran), Karachi (Pakistan), Dhaka (Bangladesh);
- decrease of urban green space particular due to infill development also in suburban areas (Australia, Europe);
- increase of urban green space related to increase of urban area, but loss of undeveloped open areas at the city edge as for example in rapidly growing Chinese cities or Europe;
- increase of urban green space due to strategic plans to enhance urban green space as reported form Singapore and China;
- different trends in different decades as reported for the U.K. (first increase then loss);
- different trends within the same city, but in different areas depending on population density, building time of residential area or social-economic status of inhabitants (examples from the USA or Australia).

In these studies green space was defined differently; some work included private gardens while others did not. Scale also varies, from continents and national level to city and part of a suburb level (which influences the level of detail). Thus not all studies gave information of where (centre, periphery) in the cities green space was lost and what kind of green space (e.g., private, public).

Immense exploitation pressure on green space exists in rapidly expanding cities, especially in industrialising countries. Rapid loss of urban green spaces has been reported in Asian case studies, providing evidence of changes in green space pattern over time (e.g., fragmentation; Hanoi, Vietnam: Uy and Nakagoshi, 2007; Mashad, Iran: Rafiee et al., 2009; Karachi, Pakistan: Qureshi et al., 2010) and dramatic decline also in inner city areas, due to building development (Hong Kong, China: Jim, 2005; Mashad, Iran: Rafiee et al., 2009; Kuala Lumpur, Malaysia: Nor Akmar et al., 2011; Dhaka, Bangladesh: Byomkesh et al., 2012). Losses can be explained by removal of green space such as parks and street trees to make way for housing, industrial areas and grey infrastructure without other greening measures.

In developed countries loss of urban green space is in particular documented for the U.K. and Australia. Pauleit et al. (2005) showed that infill development has led to a decrease in both private and public green space by 5% in an English town area. Gardens and tree cover were lost, while other open space in already more densely-built areas was lost due to redevelopment. Additionally, sealed area increased by paving front gardens. At the national level, one study found an overall increase in green space in 13 English between 1991 and 2001, while after 2001 green space declined (Dallimer et al., 2011). Green space decline was in this study related to densification policies. Infill development on gardens has also been shown to take place at significant levels in certain parts of the U.K. (Sayce et al., 2012). Potential loss of important urban green space sites classified as brown fields has also been mentioned (Lewis, 2005).

Loss of private open space in older residential areas was observed in Australian suburbs (Hall, 2010; Sivam et al., 2012; Brunner and Cozens, 2013), which is problematic since these areas have comparatively little public green space. Hall (2010) points out that small backyards of new developed areas might not only be negative from an individual perspective, but also result in a loss of several ecosystem services provided by private gardens (air quality, temperature regulation, biodiversity). Infill development often causes clearance of all vegetation on exploited sites (Brunner and Cozens, 2013). This development seems rooted in a lack of interest or economic incentive for developers to preserve green space and a lack of regulations to prevent its removal (Brunner and Cozens, 2013).

Kabisch and Haase (2013) studied changes in urban green space in 202 European cities between the years 1990 and 2006. The authors found an overall increase of urban green areas in Western European cities between 2000 and 2006, but a decline in Eastern Europe. Interestingly, they also discovered that residential areas increase independently of population increase or decrease. This is probably due to the numbers of households increasing even when the population declines (Kabisch and Haase, 2013). Urban green space area was found to be positively related to city size, but no relationship was found between population density and per capita urban green spaces. However, Fuller and Gaston (2009) – analysing the same database as Kabisch and Haase (2013) – found that compact cities have low per capita green space.

Increase of urban green space can be related to increase of city area, but also to greening measures (Zhou and Wang, 2011; Tan et al., 2013). In China several studies have documented landscape changes around urban areas (Xu et al., 2011) as well as green space dynamics within cities (Kong and Nakagoshi, 2006; Zhou and Wang, 2011; Zhao et al., 2013). Due to rapid urbanisation, open space in city surroundings, especially agricultural areas, decreases (Xu et al., 2011), while built-up areas and also urban green space increase (Zhou and Wang, 2011; Zhao et al., 2013). Zhao et al. (2013) analysed data from 286 Chinese cities and found that cities which historically had a high percentage of green space also kept this during recent development. Cities of the same geographical region showed similar trends in green space change and per capita GDP (gross domestic product) was the most important factor explaining green space cover (positive correlation).

While studies on quantitative change of green spaces have increased, little work has been done on the quality changes of urban green space (Kabisch and Haase, 2013). One exception is the work by Wilson and Huges (2011) who analysed effects of urban green space policies by the New Labour government in England between 1997 and 2010. Green space quality was perceived to decline due to lack of management until the middle of the 1990s. A series of policies tried to reverse this process, attempting to raise awareness and involve a larger number of stakeholders in improving urban green space quality. Green space quality was not defined in important policy documents.

Gupta et al. (2012) have highlighted the importance of analysing the quality of urban green space in addition to quantitative aspects, suggesting an "Urban Neighbourhood Green Index" comprising both quantitative and qualitative measures, yielding information on a more relevant spatial level and including attention for proximity to green space. Thus, distinct differences in green space quality and quantity were shown for different neighbourhoods with varying densities in Delhi, India (Gupta et al., 2012). Neighbourhoods are the most suitable spatial unit to analyse green space as this unit matters most to residents' living quality. Neighbourhood is defined as an urban unit which is homogenous in terms of housing and development (e.g., low-rise, high-rise, high density, low density).

Challenges in current planning and implementation practice in the context of densification

The literature on green space planning in urban areas undergoing densification identifies a number of challenges:

- green space provision in areas undergoing densification
- counteracting social inequalities
- consideration of resident perspectives
- avoidance of deteriorating recreation experience and compensation travels

- prevention of biodiversity loss
- institutional constraints related to e.g., planning and regulations.

Green space provision

An overall problem in already dense city environments is the development of new green space (Jim, 2004). How lack of space in already compact cities can challenge green space planning is well illustrated by for example Ng et al. (2012) in Hong Kong who describe narrow footpaths, high pedestrian flow, traffic constraints and the lack of sunlight (shade) caused by high buildings as difficulties in the path of green space enhancement in streets. Tian et al. (2012) concur, also emphasising problems below ground, such as poor and heavily compacted soils, as well as cables and pipes. These factors are also constraints for cities in general, but for compact cities in particular.

Provision of new green space seems to be a genuine problem also in less dense urban environments. For example, Sivam et al. (2012), studying infill development in suburbs in Adelaide (Australia), found a considerable loss of private green space, while no new public green space was provided. The authors argue that infill development without planning for more public green space can decrease living standards in an entire neighbourhood. Smith et al. (2009) note the almost total absence of tree plantings in green space and monotonous, poorly diversified other plantings on redeveloped sites in England, and ask for better quality in the green space provided. Reasons for poor quality greening were low maintenance efforts, fear of or experienced vandalism by tenants or providing what was expected by tenants. Also in a European context new high-rise schemes have been described as having little or no green space, and then of low quality (Beer et al., 2003).

Byrne et al. (2010) are amongst the few who discuss the challenges of green space planning in cities under densification in depth, highlighting integration of existing green space in the new built environment, provision of green space to different user groups and guaranteed access to green space of high quality. The authors also stress the importance of using open space standards, arguing that applying quantitative criteria without quality criteria has been shown to lead to green space of poor quality that is not used. Nevertheless, even quantitative open space standards are often not reached. For the Brisbane case study it was observed that even the low standard of 1 ha public green space per 1000 residents had not been achieved for certain consolidation areas (Byrne et al., 2010).

Since private green space is lost in certain forms of densification processes (e.g., infill), questions arise about the different functions of private and public green space and if and how the loss of private green space can be compensated. Loss of private green space might be a problem at both individual level and neighbourhood level, if certain ecosystem services as for example water retention or temperature regulation are not provided anymore (Hall, 2010). According to Coolen and Meesters (2012) private and public green space have different functions and meanings and thus public green space cannot substitute private green space in general. The authors see a discrepancy between government policies for compact living and consumers' preference for dwellings providing green space in the Netherlands. A need to acknowledge the difference would be necessary to address challenges in green space planning under densification processes.

Social equity

The uneven distribution of urban green space over cities has been acknowledged and urban areas with low green space cover have been related to residents with lower socio–economic status (e.g., Milwaukee, USA: Heynen et al., 2006; five cities in the U.K.: Dempsey et al., 2012; Delhi, India: Gupta et al., 2012; Johannesburg, South Africa: Schäffler and Swilling, 2013; Berlin, Germany: Kabisch and Haase, 2014; Santiago, Chile: Aquino and Gainza, 2014). This is seen as a general challenge for future green space planning, as a more even distribution and thus more equal accessibility of urban green space is desirable (e.g., Dai, 2011; Cohen et al., 2012; Dempsey et al., 2012; Romero et al., 2012; Tian et al., 2012; Schäffler and Swilling, 2013; Senanayake et al., 2013).

Distribution of green space can often be related to geographical position, where the most central parts have less green space than areas nearer the periphery (Tian et al., 2012; Aquino and Gainza, 2014). These differences in geographical location often overlap with socio–economic status; in Berlin, certain inner-city parts with low percentage of green space are inhabited predominantly by immigrants (Kabisch and Haase, 2014). Also time of development influences green space distribution. The oldest parts of Singapore have the least green space even when redeveloped (Tan et al., 2013) and also here an observed link between the social status of inhabitants and the amount of green space in city quarters.

One challenge to balancing these inequalities by greening disadvantaged areas is the risk that increasing green space area in neighbourhoods can lead to higher housing prices and thus a shift to residents with higher income (Wolch et al., 2014). Dale and Newman (2009) confirm this in their study from Toronto, Vancouver and Victoria (Canada), where densification projects on brown field sites with green neighbourhoods led to less affordable housing for lower income groups.

The complex social challenges faced regarding urban green space preservation in rapidly growing towns like Mumbai in India have been analysed in the context of social equality in the case of the Sanjay Gandhi National Park by Zérah (2007). While the forest in the national park is continuously threatened by development and policy decisions on the one hand, residents in slum settlements are moved from the park to the city periphery without any possibility of compensation or better future living standards.

Resident perspectives

Only recently closer attention has been paid to the way in which residents perceive living in compact city environments also in regard to green space access (e.g., Howley, 2009; Howley et al., 2009; Kyttä et al., 2011; Buys and Miller, 2012; Dempsey et al., 2012). The quality of children's lives in dense city environments has been related to provision of outdoor space in general (Easthope and Tice, 2011, Sydney, Australia; Carroll et al., 2011, Auckland, New Zealand). There is evidence of lack of outdoor space provision especially for children in new developed dense urban areas, traditionally associated with young or elderly people living in apartments in these areas (Easthope and Tice, 2011). However, the number of families with children from lower income classes is increasing in apartments with needs regarding outdoor space, needs which have been little considered in certain consolidation projects (Easthope and Tice, 2011). The authors emphasise the importance of acknowledging the needs of this resident group in all planning stages. The perceived lack of green space provision has also been reported by McCrea and Walters (2012), who interviewed 70 residents in Brisbane (Australia) about their experiences of urban consolidation in two areas. The two study areas were representing an inner and an outer suburb, which had experienced densification. One interviewee pointed out that the consolidation project did not have any plans for more public green space or other services, which would be needed.

Lo and Jim (2010a) found different attitudes to green space provision in different residential communities in Hong Kong. Urban green in old core area quarters has an important function for socialising and are highly appreciated by residents. In new developed areas at the periphery, green space cover is much larger,

but less used and valued. The authors explain these differences amongst others by the difference in age structure of residents in the different residential areas (young people living in the new developed areas using green space less), weak social cohesion and low integration of immigrants. Highly valued aspects were microclimate and amenity (Lo and Jim, 2012). Residents expressed wishes regarding more greenery, tree plantings, but also sport facilities.

The importance of green space for residents has been also investigated in economic terms in form of residential prices for dwellings near green space. Higher housing prices for flats with views of water bodies or green space and which are situated in the vicinity of accessible green space have been documented from e.g., China (Jim and Chen, 2006a, 2007, 2010) and for property values in Adelaide, Australia (Mahmoudi et al., 2013).

Recreation

Three different aspects were emphasised in studies on recreation in compact city green space: provision of high quality green space (Jim and Chen, 2006b; Lo and Jim, 2010b), importance of small pocket parks (Peschardt et al., 2012) and the problem of crowding (Arnberger and Eder, 2012). Jim and Chen (2006b) found that there is a high willingness to pay for use of high quality green space in compact Guangzhou, China. Here entrance fees to certain parks already have to be paid, but willingness to pay is strongly correlated to a person's income. Residents would also be willing to pay to recover losses of urban green space (Hong Kong, Lo and Jim, 2010b). However, to pay for access to urban green space might not be seen as acceptable in those parts of the world where access is expected to be free.

But not only high quality large green spaces are important in compact cities, also small pocket parks have important functions according to Peschardt et al. (2012), who studied the use of these parks in Copenhagen. The parks were an important asset in everyday life for the users, who mostly come for resting or socializing and primarily visited when passing by. Where the city environment is densified, people can also be expected to use attractive green spaces, thus increasing higher pressure on these recreation areas. Arnberger and Eder (2012) investigated the Wienerberg area in southern Vienna, Austria, and found that visitors perceived crowding of urban green space due to housing densification in the surrounding areas as a problem.

Compensation hypothesis

The risk of increased numbers of leisure travels according to the compensation hypothesis has also been discussed (Byrne et al., 2010). This hypothesis implicates that residents living in dense built environments to a larger extend travel to visit green space further from home (Maat and de Vries, 2006). This has also been studied in the context of second home establishment. Different results have been obtained, for example, for Spain where Módenes and Lópes-Colás (2007) found a greater tendency towards second home establishment in Spain among people living in denser urban environments, while Muñiz et al. (2013) could not prove any such relationship for Barcelona. In Finland, second homes were used the more the denser the city environment of the primary home was (Strandell and Hall, 2015). In Oslo the access to private gardens reduced the number of leisure trips (Holden and Norland, 2003). The possibility for compensation travelling is certainly influenced by economic means and regarding second homes also by tradition; with for example Scandinavia having a strong second home tradition. Thus there is evidence that living in compact urban environment can favour compensation travelling depending on factors as traditions and economic means.

Biodiversity

Studies investigating the effect of densification on biodiversity found everything from negative to positive impacts of densification. Increasing residential numbers reduced the number of bird species in pocket parks in a compact city environment in Canberra, Australia (Ikin et al., 2013). The amount of green space in the neighbourhood influenced bird species numbers and abundances positively, while green space configuration was less important (Ikin et al., 2013). Higher housing density and reduced garden complexity was found to influence density of native bird species in gardens negatively (van Heezik and Adams, in press). Additionally, left over spaces caused considerable spill-over into gardens, which could not have taken place when these green spaces were removed due to densification.

In Rennes, France, Varet et al. (2014) could not relate species composition of carabid beetles and spiders to urban form (compact–conventional/not compact). However, newly developed housing areas had a higher percentage of public green space (private green space was not mentioned) and the difference in landscape factors between compact and conventional urban form was not as distinct as one could have expected. The effect of densification on biodiversity thus depends on the species group and type and quality of green space studied, at which scale the study is carried out and how much green space is in the surroundings.

The importance of scale in studies on biodiversity in the context of urban densification is underlined by Sushinsky et al. (2013) who applied bird surveys in Brisbane, Australia, to two different urban development scenarios, compact and sprawl development. Compact development was pronounced better for conservation of species compared with sprawl development. In both scenarios development took place within the city boundaries, in the compact development through division of single-dwelling properties, in the sprawl development on developable urban green space (not parks, gardens, nature reserves). The authors point out the importance of city wide/regional analysis of urban development forms on biodiversity since local effects (often negative effects of compaction) are different from effects at city level (often positive effect of compact building due to land preservation at the fringe). The negative effects of densification at local level are often due to habitat loss (loss of green space including private gardens), and dense building forms have been found to be related to negative biodiversity potential (Tratalos et al., 2007). The urgent need for studies of biodiversity in relation to urban growth at the city scale is shared by other authors (e.g., Lin and Fuller, 2013).

Institutional constraints

Institutional constraints impeding the development of urban green space are widely acknowledged and often mentioned as one major challenge to green space planning. Crucial is the fact that green space provision is non-statutory in many countries. The lack of comprehensive green space planning that takes a strategic, longer-term perspective on urban green spaces and their developments, is seen as a major problem (Byomkesh et al., 2012; Tian et al., 2012). Not implementing existing green space plans is another (Nor Akmar et al., 2011; Byomkesh et al., 2012). Additionally problematic is illegal building on green space, which is not always prevented (Byomkesh et al., 2012). Schäffler and Swilling (2013) mention the lack of available data and knowledge on existing green space (e.g., how much green space of different types exists? In what state is it? How is it used?) because it makes well-informed decision making and prioritisation of goals and resources difficult. This can result from a lack of interest (Tian et al., 2012) or of policy, or be due to low political motivation in addition to limited resources (Byomkesh et al., 2012). The way in which green space planning is

organised within the administration also influences its outcome, as illustrated by Baycan-Levent and Nijkamp (2009) who showed that European cities where green space responsibilities were divided between different units had less successful green space planning than cities with only one unit responsible. The lack of participation of stakeholders and the public is another challenge to successful green space planning (Nor Akmar et al., 2011). For example, lack of green space planning in Hong Kong partly resulted in lack of public awareness of the important values of urban green space (Tian et al., 2012).

Strategies for green space provision in compact city environments

Saving and providing green space of high quality

Suggestions how to facilitate green space provision in compact city environments include:

- Preserving green space;
- enhancing quality of existing green space;
- providing green space on redeveloped sites;
- greening difficult sites lacking green space (narrow streets);
- smart allocation to increase visibility and visual quality.

Saving existing urban green space is often suggested as the first option for effective green space planning, especially in already compact cities (e.g., Jim, 2013). This is particularly true regarding remnant semi-natural vegetation, which is often more species-rich and varied than planted vegetation (Jim, 2013). Examples show that careful planning of development sites (here forest) for compact building can keep 91% of the original carbon sequestration and 82% of the carbon storage (Vaughn et al., 2014). Enhancing the quality of existing green space, both from a recreational and a biodiversity perspective, is seen as another important aspect (Bolleter and Ramalho, 2014). Enhancing quality is particular important when no further public green space can be provided (Byrne and Sipe, 2010).

Jim (2013) recommends the application of ecological principles when choosing vegetation type; for example a more natural species composition and efforts to augment biodiversity. Areas with low biodiversity and a simple design could be converted into more natural areas (Jim, 2004). Generally Jim (2013) calls for more innovative greening ideas, realised through an interdisciplinary approach. These innovative greenings comprise especially sites that have been sub-optimal exploited as green roofs, green walls, street sites, river renaturation and sites needing amelioration for plantings (Jim, 2013). Green space should be provided on redeveloped sites, for example by green space plans for developments sites elaborated before the building plan (Jim, 2004). It also should be better handled during the construction phase, trees could be saved and if no other option is possible should be transplanted (Jim, 2013). After redevelopment, green space in private residential areas often needs improvement in order to better fulfil various functions, aesthetics among them (Smith et al., 2009).

Sites without green space, such as narrow streets, can be greened if the necessary effort is taken (Ng et al., 2012). Visibility and visual quality of green space can be increased by smart allocation (Tan et al., 2013). Based on experiences from Singapore, the authors report that it is not only the quantity of green space that influences the perception of a green city, but also how green space is distributed and placed within the city. Thus Singapore is perceived as a green city even with little space for greenery (Tan et al., 2013). Smith et al. (2009) show several interesting European examples on how greenery can be qualitatively enhanced even on a small scale. This can be reached for example by housing integrating systems for surface water retaining, which varies the design of yards in inner city housing blocks (for example Copenhagen). Also the use of various shrub species planted at door steps improves the greenery of city streets even when using very little space and causing low maintenance costs (example from Berlin). Although many suggested solutions for sufficient green space provision seem obvious, realising these seems less clear.

Using standards

The application of green space standards has been discussed as one strategy to ensure sufficient green space in cities. However standards seem to be controversial and difficult to apply (Byrne et al., 2010). Critics argue that it would be more important to focus on green space quality and accessibility than on quantity standards (e.g., Ståhle, 2008). To provide high accessibility of public urban green space is already a principal goal in urban green space planning and also in compact cities (Ståhle, 2008; Jim, 2013; Tan et al., 2013), but as demonstrated, is far from being reached. A key question is whether the application of urban green space standards that comprise quantitative, qualitative and access aspects could improve high quality green space provision. Recommendations for standards for natural green space access and size exist already in for example the U.K. (Accessible Natural Greenspace Standards; Natural England, 2010) and could be used as a model. Gupta's et al. (2012) neighbourhood index is an another example. Pure quantitative standards without consideration of access and quality are not meaningful especially when applied at city scale, where green space provision per inhabitant might be high overall masking local scale scarcity.

Landscape ecological approach

Several authors advocate applying landscape ecological principals when planning for, or establishing, green space in compact cities (Jim and Chen, 2003; Li et al., 2005; Oh et al., 2011; Tian et al., 2011, 2012, 2014; Jim, 2013). Applying landscape ecological principals can mean optimising green space geometry for example by increasing connectivity (Jim, 2013) or network planning (Oh et al., 2011). The latter includes working with core areas, buffer zones and connecting corridors – such as greenways – between green areas (Oh et al., 2011). The application of landscape ecological principals considers content (patch structure and function), context (patch location in relation to surrounding), connectivity and dynamics of, for example, heterogeneity (Oh et al., 2011 citing Zipper et al., 2000). One example is the preservation or planning of 'green fingers', which provide high connectivity of urban green space from city centre to the periphery (Jim, 2004; Caspersen et al., 2006; Caspersen and Olafsson, 2010). Also older concepts as green belt strategies are discussed again in the context of city densification (Kühn, 2003; Hill et al., 2009; Shi et al., 2012). The green finger concept comprises several advantages (accessibility, connectivity and linking central urban areas with peripheral/rural landscapes), which should make it attractive especially to green space planning in compact city environment as it gives access to large connected green areas from the centre to the periphery.

Improving green space planning processes

Several authors underline the crucial importance of effective green space planning, especially in already compact cities, due to the many constraints and particularly the scarcity of space (e.g., Nor Akmar et al., 2011; Schäffler and Swilling, 2013; Tan et al., 2013), and the need for strategic and holistic plans that comprise the entire region (Jim, 2013). Legal frameworks to designate urban green space planning are essential for reaching this goal. Successes

with strategic green space plans have, for example, been described by Tan et al. (2013) for Singapore and by Zhou and Wang (2011) for Kunming, China. Both cases illustrate how greening strategies have resulted in significant increases in green space in large and at least partly very compact cities. Another example of greening plans implemented and of further development recommended for them is given by Ng et al. (2012) for Hong Kong. As a basis for successful green space planning, a good data base of existing green space including gap sites etc., is seen as essential (Jim, 2004; Schäffler and Swilling, 2013). Important would also be to acknowledge the significant role of informal green space residents in green space planning (Rupprecht and Byrne, 2014).

How to counteract the loss of trees and other valuable vegetation in private gardens due to infill development is an unanswered question. Pauleit et al. (2005) call for more efficient green space policies that address the changes due to infill development in private gardens concerning individual, small-scale developments. Brunner and Cozens (2013) see the answer rather in informing about benefits than implementing restrictions.

The growing influence of the ecosystem service approach, also concerning urban planning issues, potentially facilitates better urban green space planning (Niemelä et al., 2010). It offers the consideration of multiple functions and their relation to human health and wellbeing, increasingly also translated into monetary valuation. In particular there is potential for better communication green space benefits in a planning context (Kabisch, 2015). The ecosystem service approach will likely have increased impact on the urban planning literature, but studies focusing particularly on compact cities have so far been limited (e.g., Schäffler and Swilling, 2013; Byrne et al., 2015; Kabisch, 2015; Hansen et al., 2015).

Public participation

Stakeholder involvement and encouraging public participation are seen as crucial to the planning of green space according to user and resident needs (e.g., Tian et al., 2012; Hordijk, 2013; Jim, 2013). A needs-based approach – as distinct from green space provision according to quantitative standards – is elaborated in Byrne and Sipe (2010) and involves extensive work on questioning residents on their preferences. Existing green space would be changed to adapt to the needs identified by residents, such as areas for youth, playgrounds, barbeque areas etc. Such need-based approaches would have to be repeated when necessary. The importance of including residents in the process of densifying their neighbourhood is underlined by Smith and Billig (2012) who found that residents also became more supportive of compaction of their neighbourhood when informed about regional sustainability goals. Ruming (2014) came to similar conclusions studying attitudes to urban densification beyond the own neighbourhood at city scale in Sydney, Australia. The analysis of an online survey with 721 respondents showed lack of knowledge about densification strategies. With half of the respondents being reluctant to further densification, Ruming (2014) sees important needs for resident information on policies and strategies and citizen involvement beyond ad hoc information at a concrete planning level.

Greening strategies for buildings and private properties

When space is scarce to provide greens space on the ground other greening strategies as green roofs and vertical green infrastructure such as green façades are put forward as an option for greening compact city environments (Tian and Jim, 2012; Jim, 2013; Tan et al., 2013). Also spontaneous vegetation can contribute to greening buildings (Jim and Chen, 2011). Green roofs and façades can fulfil different functions as cooling (Ng et al., 2012), amenity (Tan et al., 2013), food production (Bayley et al., 2011) and biodiversity conservation (Ishimatsu and Ito, 2013). Tan et al. (2013) point out that so-called sky gardens can be very important assets for residents by improving living quality and contribute to a city's greenery. However, these do not fulfil the functions of public open green space at ground level, e.g., in terms of public access and cooling effects at ground level (Ng et al., 2012). Thus sky gardens can fulfil important functions for certain user groups or can provide important ecosystem services, but not necessarily the same as ground level urban green space and not necessarily for the same user-groups. According to Tian and Jim (2011, 2012) there is major potential for the development of a much larger amount sky gardens in a compact city as Hong Kong. Tsang and Jim (2011) suggest various tax-exemption schemes to enhance this. Besides economic incentives, aesthetics and level of environmental knowledge influence the willingness to implement greening measures (for storm water control) on private properties in Syracuse, New York, USA (Baptiste et al., 2015).

Discussion and conclusion

Despite different contexts in different regions regarding urban density, population growth, societal conditions and preconditions for urban green space planning, several recurring challenges and problems resulting from the impact of the compact city approach and densification processes are evident, including:

- Loss of public and private urban green space due to densification measures;
- risk for insufficient green space provision in areas under densification;
- risk for quality loss of existing green space and for provision of green space with low quality;
- risk for low priority of green space planning in the context of exploitation;
- risk for cementing social inequalities even when greening measure are performed; and
- uncertainty on how to keep or improve green space quality on private properties.

These can lead to lower living quality in consolidation areas, worsened recreation possibilities, loss of biodiversity, lack of provision of ecosystem services and lack of coherent green space.

While the importance of urban green space for human health and wellbeing and biodiversity is uncontroversial, it is a major challenge to provide sufficient and well-functioning green space in areas under densification and to counteract the above described risks. Certain literature in favour of densification strategies and urban consolidation does not address urban green space issues (Byrne et al., 2010).

Further analysis, evaluation and discussion are needed of the effects of city compaction on urban green space and ways to deal with these. By acknowledging the challenges to green space planning and development in compact cities and cities undergoing densification, attempts can be made to solve rather than ignore them, and rather than advocating the compact city as *the* solution of sustainable city development especially in comparison to urban sprawl. Such analysis would not only involve renewed discussion of quantitative public green space standards, but also of qualitative objectives.

Several authors identified the problem of loss of green space quality on private land, both in private gardens and on land belonging to residential housing (e.g., Smith et al., 2009; Hall, 2010; Brunner and Cozens, 2013). Measures are needed to prevent or minimise this type of degradation as a consequence of compaction. Moreover, analysis is needed of which legislative frameworks or

policies exist to counteract this negative development. The existing literature pays limited attention to the success or failure of legislation which forbids owners of private gardens to pave large parts of their front garden or to remove trees of a certain size without permission of the authorities.

The influential concept of ecosystem services might offer new analytic and evaluation tools which can help to plan, develop and manage urban green space (Niemelä et al., 2010; Kabisch, 2015), also in compact cities. Since many crucial ecosystem services are provided by urban green space, these will have to be better considered and planned for to ensure a high living standard in urban areas. In regard to urban green space management, the concept offers several advantages, e.g., that of comprising both natural and cultural aspects and requiring far greater consideration of qualitative aspects with respect to multiple functions. The shift from seeing green space as a measure of city beautification to seeing it as an essential part of the urban infrastructure (Nor Akmar et al., 2011) has partly taken place already. However, Beer et al. (2003) criticised green space planning and management for still far too often being based on aesthetic and economic reasons and lacking an understanding of its multiple functions and services.

The crucial importance of green space development plans for the entire urban region (Jim, 2013; Lin and Fuller, 2013) should be emphasised. On this scale the spatial organisation of green space elements, for example from a landscape ecological perspective, can be considered. The concepts of green fingers, parkways, greenways and networks can be implemented to allow for better green space access, meaning not only access to the nearest parks but also provision of a green network for recreation. Where there is a need of city wide planning recognition of the importance of the neighbourhood or local scale could help address issues regarding social equity and access to green space (Gupta et al., 2012). This is especially important as certain urban development beneficial at city scale can have negative impact at the local scale, e.g., traffic-based emission (generally higher in urban sprawl cities, but individual exposures are highest in compact areas; Schindler and Caruso, 2014).

Research regarding urban green space planning in cities under densification will need to include (partly based on Brunner and Cozens, 2013):

- Analysis of effects on urban green space (private and public) in quantitative and qualitative terms. Need of cases studies from local to city scale in areas less researched so far.
- Analysis of synergies and trade-offs of densification processes in relation to urban green space at different scales.
- Studies on the quantitative and qualitative requirements for multiple ecosystem service provision of urban green space in compact cities/cities under densification.
- Identification of successful policies, legislation and practices that prevent green space degradation during compaction and enable development of well-functioning urban green space.
- Frameworks and tools that enable successful public participation and resident perspective in cases of densification.
- Research on how to develop highly functional green space under compact conditions, e.g., using technical innovation such as roof and vertical greening including their implementation on private properties.

Compact city form is often justified as a way to save land on the city periphery from exploitation. How much land is actually saved by densification and compaction has been little explored. Almost all studies that deal with city compaction deal with residential areas, while industrial and commercial areas seem to sprawl on the periphery, apparently without any limitations of space. So why are mainly residential areas compacted, whereas other building types seem not to be under the same pressure to handle space more efficiently.

In the light of rapid urbanisation and major environmental challenges, sustainable urban development is needed more than ever. The compact city concept addresses some important aspects of this, but far from all. Other concepts should also be considered, especially in relation to urban green space. To green the compact city is possible to a certain degree, but requires careful planning and a sound knowledge base on how essential ecosystem services can be provided within the compact city's limited green space area. The creation of unsustainable city areas that lack green space is difficult to reverse. Therefore compaction must be done together with high-quality green space planning and implementation.

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Appendix A. Supplementary data

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