Revisiting density
The impact of CIAM on Zurich's plans for sustainable urban growth

Herdt, Tanja; Wälty, Sibylle

DOI
10.1016/j.cities.2025.106539

Publication date
2026

Document Version
Final published version

Published in
Cities

Cities 169 (2026) 106539

Contents lists available at ScienceDirect

Cities

journal homepage: www.elsevier.com/locate/cities

Revisiting density: The impact of CIAM on Zurich's plans for sustainable urban growth

Tanja Herdt [a,*], Sibylle Wälty [b]

[a] Department of Urbanism, Section of Urban Design, TU Delft, Faculty of Urbanism, Julianalaan 134, 2628 BL, Delft, the Netherlands
[b] Department of Architecture, ETH Wohnforum - ETH CASE, Wolfgang-Pauli-Strasse 27, 8093, Zürich, Switzerland

ARTICLE INFO

Keywords:
Urban densification
Compact city model
15-minute city
Planning history
CIAM

ABSTRACT

In recent years, the compact city model has gained prominence as a strategy for sustainable urban development, with urban densification at its core. While densification is recognized as a key planning tool, questions remain about how to use it effectively to achieve broader sustainability goals.

This study explores the role of density through the case of Zurich, a global city known for balancing competitiveness with quality of life. Using Campbell's (2007) triangle of conflicts in sustainable urban development, the research evaluates whether built, population, and functional density contribute to balancing the effects of intensified land-use processes, such as the provision of housing, proximity, and mix of uses.

Focusing on Zurich's Aussersihl district, the study analyzes three planning phases: the industrial city, the modernist functional city, and the sustainable city era. By integrating historical and current GIS data with projections for 2040, the findings reveal a transition from mixed-use residential areas to service-based areas. This shift is driven by modernist planning instruments promoting functional separation and de-densification. These approaches may impede sustainability goals, including functional diversity and density of use. The study calls for updated planning instruments and a redefinition of how density is conceptualized and operationalized in urban planning.

1. Introduction

In recent years, the compact city model has emerged as a central strategy for promoting sustainable urban development. Central to this model is the concept of density, defined as the concentration of population within a predefined area. Many cities around the world have adopted this approach, aiming to achieve more sustainable growth through compact urban development and energy-efficient transport systems. In international policy frameworks — such as those of UN-Habitat (2012) and the OECD (2012) — compactness is described as a guiding principle for sustainable urban development. Compactness is typically understood as an increase in housing units per area (Boyko & Cooper, 2011; Broitman & Koomen, 2015) and is associated with benefits such as land conservation (Angelo & Wachsmuth, 2020), infrastructure efficiency (Frey, 2003), improved air quality (Ewing, 1997), and greater walkability and cycling uptake (Squires, 2002). This makes the compact city model the central paradigm of sustainable urbanism (Bibri et al., 2020). As a result, planners and city councils increasingly view urban densification — a core mechanism of the compact city model — as a key instrument for reducing greenhouse gas emissions and overall energy use (Ewing & Cervero, 2010; Jabareen, 2006; Newman & Kenworthy, 1989, 2015). In addition to environmental goals, compactness is also linked to improved housing supply and broader social and economic benefits, such as increased innovation, cultural vibrancy, and economic opportunity (European Commission, 2011; UN, 2015). These theoretical and policy arguments have translated into concrete planning efforts across several European countries. Governments in the Netherlands, Switzerland, Germany, and England have adopted versions of the compact city model to curb land consumption and limit suburbanization (Dembski et al., 2020). Their strategies include increasing built density through the transformation or redevelopment of existing housing stock (Burton, 2000; Searle & Filion, 2011; Touati-Morel, 2015). However, there are also multiple debates about the negative effects of densification concerning sustainable development, and multiple criticisms are emerging around the definition and use of density in the context of the compact city model. This critical scrutiny has focused especially on governance (Bulkeley & Betsill, 2005), environmental outcomes, and resulting inequalities (McClintock, 2018;

* Corresponding author at: OST, Eastern University of Applied Sciences, Oberseestrasse 10, 8640, Rapperswil, Switzerland.
E-mail addresses: t.herdt@tudelft.nl (T. Herdt), waelty@arch.ethz.ch (S. Wälty).

https://doi.org/10.1016/j.cities.2025.106539
Received 28 October 2024; Received in revised form 11 August 2025; Accepted 28 September 2025
Available online 10 October 2025

Sampson, 2017), particularly concerning affordable housing and displacement of residents (Aalbers, 2017; Christophers, 2022). Comparative studies on social sustainability and urban densification suggest that compact cities are not an automatic "win-win" across all dimensions of sustainability. Densification through inward settlement development can also cause negative side effects on achieving sustainable development goals: such as the reduction of open spaces, which may lead to a deterioration in environmental quality, an increase in the cost of housing through the redevelopment of buildings (Burton, 2010; Debrunner, Hengstermann, & Gerber, 2020; Newman & Kenworthy, 1999), and higher CO_2 emissions. One explanation for these observed interdependencies is the need to mitigate the negative effects of high built density on environmental quality and health, for example, air pollution, noise, or urban heat island effects (Caudeville, 2021; Röösli & et al., 2019).

1.1. Criticism and implementation challenges of the compact city model and the use of density for sustainable urban development

The compact city model is particularly criticized for its emphasis on a spatial definition of density (Kjærås, 2020). It assumes that compactness of urban form automatically leads to a higher population density and density of use. For instance, the UN-Habitat (2012: 69) policy recommendation asserts that policy must promote 'compact and moderate' urban development in enclosed city environments, such as neighborhoods, and implement 'high-density development' to realize a sustainable future. As a policy instrument, it is asserted that different density scenarios have wide implications for planning, governance, housing, infrastructure, transport, and energy use. However, there is a lack of a clear definition for the interdependencies among different density concepts in the theory of the compact city model, such as the compactness of the built form and high population density (Habermehl & McFarlane, 2023). Moreover, a purely spatial definition of density fails to acknowledge relations of dependence between places: sustainable practices in one location may be constituted by unsustainable practices elsewhere (Heynen et al., 2006).

Critics have also noted that implementing density as a planning instrument is complicated by the variety of density types under analysis — e.g., built density, population density, or density of use (Boyko & Cooper, 2011). While density is acknowledged as a useful tool for predicting and controlling land use, concerns have been raised about the vagueness of the term (Churchman, 1999; Matsumoto et al., 2012; Newman & Kenworthy, 1999) and the absence of an agreed-upon definition (Neumann, 2005). There is also no consensus on how best to measure density in cities (Dovey & Pafka, 2017). Some approaches rely on thematic definitions, while others adopt spatial ones (Habermehl & McFarlane, 2023). These inconsistencies pose difficulties for translating density into effective urban planning instruments.

Beyond technical measurement, density has qualitative implications for human perception, behavior, and needs, which must be considered in urban planning (Boyko & Cooper, 2011; Cohen & Gutman, 2007). As Victoria Habermehl notes, the use of different types of urban density reflects differing underlying values, which emerge in debates about the future development of cities. Rather than defining density itself, much of urban research focuses on how density relates to broader problems of city development and quality of life (Habermehl & McFarlane, 2023).

1.2. From CIAM-modernism to sustainable-ism: the historical evolution of density as a planning concept

The current use of density as a tool for sustainable urban development reflects a long and complex history in planning practice. While today it is often framed as a means to promote livability, sustainability, and social wellbeing, its application has traditionally relied on a spatially defined understanding, grounded in the idea that urban form is a key determinant of urban life (Kjærås, 2020:1180). Over time, the concept of density has been aligned with different societal values and evolving notions of "the good life" (Hall, 2014). These shifting associations have shaped the way density is interpreted and operationalized in planning. Most recently, the conflict between social and spatial interpretations of density became apparent with the emergence of New Urbanism, which promoted proximity and diversity as the foundations for economically viable and socially vibrant cities (Fainstein, 2000; Kjærås, 2020). It has been centered around the idea that sustainable urban form, characterized by proximity and diversity, is also conducive to the establishment of healthy economies, sustainable livelihoods, and social wellbeing (Kjærås, 2020). This shift reinforced a growing emphasis on compact urban form as a strategy for sustainability — yet the relationship between built density and broader sustainability outcomes remains contested in both theory and practice.

The term and its use in urban planning have been reinterpreted several times over the past 100 years (Sonne, 2014). Historically, density has been exclusively used as an operative means and quantifiable measure of describing the disadvantages of the industrial city, e.g., lack of hygiene and overcrowding. In urban planning, it was used as an instrument to control the built form and to gain criteria to regulate the number of dwellings per built area during periods of rapid growth in the 19th century (Sonne, 2022). High density was considered "unhealthy," and less densely built areas were seen as a valuable measure against overcrowding. However, built density from the beginning was used to regulate population density. The negative assessment of high-density built-up areas at this time is expressed, for example, in the title of Raymond Unwin's 1912 book 'Nothing Gained by Overcrowding', in which he speaks out against excessive population density in cities. It was only through the writings of sociologists such as Louis Wirth and Émile Durkheim that density began to acquire an implicitly positive connotation, described as the motor of progress and an essential part of city life (Sonne, 2022). City administrations, however, reduced the application of density in urban planning to the control of built density alone (Sonne, 2022).

Limiting population density through the regulation of urban form was a key objective of the Athens Charter — the foundational manifesto of the modernist movement in architecture and urban planning. Developed by the avant-garde Congress International d'Architecture (CIAM) in 1933, the charter promoted the idea that architecture, as a social art, could provide universal principles applicable to all spatial disciplines, including architecture, urban design, and landscape planning. The movement originated in Switzerland, with Siegried Gideon and Le Corbusier as its main organizers. Through a series of international congresses held until 1959, CIAM played a decisive role in disseminating the ideals of modern architecture and functional city planning, particularly during the post-war reconstruction period in Europe.

Building on the functionalist principles advanced by CIAM, many postwar building and zoning laws established strict separations between areas for living, working, and recreation, often promoting low-density housing set within large green spaces. To support this spatial ordering, planning instruments such as the Floor Space Index (FSI) were introduced to regulate built density and shape urban form, while also accommodating increased car traffic. This paradigm of de-densification, combined with functional separation, profoundly influenced major urban expansion projects throughout the 1960s and 70s.

A major shift occurred in 1961, when Jane Jacobs laid the foundation for a change of perspective concerning the understanding of density in cities. In her book 'The Death and Life of Great American Cities', she promotes high density as a central feature of the urban (Jacobs, 1961), by which she meant the presence and movement of people in streets and inner-city squares, and their use as public spaces. This notion of density — as population density, density of use, and mix of functions — has again been regarded as an important characteristic of the urban since the 1980s, particularly in the discussion about the "European city" (Sonne, 2022). The book laid the ground for the idea that compact urban form and high built density could have a positive impact on the social life and urban culture of cities, as measured by parameters such as diversity and proximity. This positive interpretation of density was the starting point for subsequent planning approaches promoting high built density.

A historical analysis of the use of density in urban planning reveals that while its conceptualization has undergone a significant transformation since the 1970s, its practical application in planning has remained largely unchanged since the influence of CIAM. Despite the considerable changes in size and functional composition have cities undergone since industrialization, and their modernist adaptations after WWII, density has continued to be applied in largely unchanged ways (Sonne, 2022).

These historical observations are aligned with the empirical research of Dovey and Pafka (2017), who argue that land use instruments, such as Floor Space Index (FSI) or Ground Space Index (GSI) ratios, reflect a modernist approach based on the separation of functions. Consistent with the vision of a dispersed and car-friendly city, first introduced by CIAM (Dovey & Pafka, 2017), these instruments do not consider functional mixing within a district.

1.3. Current planning approaches and their use of density

Today, modernist approaches to density — shaped by CIAM and codified in zoning laws until the 1970s — coexist with newer planning paradigms. While some of these continue to focus on built density alone, others embrace an expanded understanding that incorporates population density and density of use. Within the framework of the compact city model, several planning approaches now engage with density as a tool for sustainable development. These include New Urbanism, Smart Growth, "Stadt der kurzen Wege", Transit-Oriented Development (TOD), and the X-Minute City. Although each pursues density differently, they share a broader goal: promoting compact, livable, and resource-efficient urban environments.

New Urbanism emphasizes walkable neighborhoods and traditional town planning to counter suburban sprawl. Its focus lies in creating high built density through compact urban form, fostering community interaction and local identity. However, this approach is often criticized for insufficiently addressing deeper structural issues such as housing affordability and access (Duany et al., 2000).

Smart Growth similarly promotes compactness through infill development and multimodal transport, emphasizing governance and policy tools for sustainable urban expansion (Smart Growth America, 2025).

The concept "Stadt der kurzen Wege" highlights the importance of bringing daily activities close to residential areas, reducing the need for long commutes, and fostering active mobility (Brunsing & Frehn, 1999). The focus of this approach is on public transport to create proximity and high density of use. Transit-oriented development (TOD) combines different density approaches. It focuses on creating dense, mixed-use neighborhoods around public transit hubs, aiming to reduce car dependency and improve access to key urban services (Institute for Transportation and Development Policy, 2020).

The X-minute city (e.g., the 15-minute city, or '10-minute-neighborhoods') integrates these concepts into a citizen-centered framework, ensuring that essential services are accessible within a short walk or bike ride. This model emphasizes spatial and temporal accessibility, social infrastructure, and well-being (Moreno et al., 2021; Allam et al., 2022). The concept incorporates both the definition of built density as well as population density and density of use. The adapted concept of the '10-minute-neighborhoods' aligns with the X-minute city, focusing on the interrelatedness of the factors of proximity and accessibility (Wälty, 2018, 2020), emphasizing the structural prerequisites necessary for a sustainable urban environment. While both concepts share concerns with density, proximity, and livability, the 10-minute-neighborhoods approach is grounded in spatial planning practice and provides model-based tools to operationalize sustainable urban transformation (Wälty, 2018, 2020, 2024).

Taken together, these planning approaches aim to support more sustainable and inclusive urban environments by promoting density, proximity, and a diverse mix of uses, while reducing dependence on private motorized transport. Yet despite their growing influence in policy discourse, most of these approaches have only been partially implemented in practice. The practical implementation of strategies for compact urban growth thus continues to face considerable challenges at the various levels of urban planning and administration.

1.4. Research questions and scope

Although built density is widely acknowledged as a key factor in sustainable urban development, little is known about how it relates to other forms of density — population density and density of use — or how these interact with mixed-use strategies over time. As cities pursue more sustainable trajectories, this transformation often demands complex adjustments to planning frameworks and policy. Yet, few studies systematically assess how such adaptations influence the implementation of the compact city model. This article addresses that gap. It hypothesizes that the benefits of compact cities arise from the interplay of multiple dimensions of density and proximity. Through a historical-analytical approach, it explores the use of density as a planning instrument and points out the differences in its application as an instrument to control urban form.

Based on the development of the concept of density and its application in urban planning, the article takes a historical perspective. The research question is based on the hypothesis that, in Europe, the use of density in land use planning has remained largely unchanged since industrialization and its adaptation in the modernist development model after World War II. Starting from the urban development goals of the compact city model, the article assesses the influence of different approaches to density on the urban form during two key historical periods: the industrial city and the functional city developed by CIAM.

Comparing existing densities in these two historical periods with the urban development goals of the compact city, the study explores the use of density in urban planning, its change over time, and its efficiency in achieving sustainable urban growth. The article draws on empirical case studies and integrates historical analysis of how density has been conceptualized and operationalized in urban planning. Thus, the article aims to:

Firstly, understand the impact of built density and its interplay with population density and density of use in four different planning periods: (1) the industrialized city, before built density became a planning instrument; (2) the modernist functional city, after the introduction of built density as a planning instrument; (3) todays sustainable development model, and (4) the future compact city model with its sustainability goals based on urban densification.

Secondly, analyze the effectiveness of built density in existing land use planning and how structural and functional dependencies affect the implementation of the compact city model. This includes assessing the impact on housing production, built density, functional mix, and basic environmental qualities.

The article aims to demonstrate the potential and limitations of using built density as a planning tool to promote sustainable urban development through compact urban growth. This is of particular interest because values associated with the modernist development model — such as the creation of green spaces and recreational areas in new neighborhoods — closely align with the current quality-of-life and environmental sustainability objectives of the compact city model. While the former were pursued by reducing built density, the latter are now sought through densification. This raises the question of whether built density alone is sufficient to achieve these goals or whether the negative effects of urban densification outweigh its benefits. By doing so, the paper aims to contribute to a better understanding of the connections to the larger issues of urban development currently being discussed, based on the compact city model: Will enough housing be created to ensure affordability? Will there be enough green spaces to ensure quality of life? Will the mix of functions be sufficient for economic viability? Within a broader theoretical framework, this analytical experiment also aims to answer whether, and how, urban sustainability goals can be achieved through compact urban form.

2. Methodology and case selection

This article analyzes the use and impact of different types of density as a planning instrument to achieve selected sustainable development goals, such as mobility and energy consumption, according to the compact city model.

By conducting a comparative case study analysis based on historical and current data the article analyzes the interrelatedness of different densities — spatial density, population density, and functional density — in distinct historical periods. The comparative case study analysis is also used to gain insights on how different types of density and mix of functions have evolved. The analysis of selected historical periods highlights shifts in the functional composition and provides valuable insights into long-term trends and transformations of densities and their regulation.

Starting with density as an instrument of urban densification, we compare the three historical periods in which the concept of density was introduced into urban planning: the period of the industrialization of European cities at the beginning of the 20th century, the period of rapid growth and the introduction of functional zoning after WW II, and the period of sustainable urban development from the 1990s to the present day. We then compare our findings with the projected densities based on the municipal structural plan, "Zürich 2040" (Zurich City Council, 2021). The plan is based on the sustainable development goals of the compact city model.

2.1. Case selection: Switzerland and the district of Aussersihl in Zurich as an example case

To understand the role and influence of density as a planning instrument, we use the city of Zurich in Switzerland as a case study. Switzerland has a relatively high average population density and a longstanding awareness of the need for land thrift (Bovet et al., 2019). In 2014 the country revised its federal law on spatial planning, making inward settlement development the primary objective of urban planning (Art. 1, Spatial Planning Act, SPA). Since then, federal and municipal building and zoning regulations have increasingly focused on urban densification to address the effects of urban sprawl alongside steady population growth (up to 22 % by 2045 (Federal Statistical Office, FSO, 2015)). Densification is intended to prevent the overuse of nonrenewable resources from a land-use perspective (Angelo & Wachsmuth, 2020) while simultaneously ensuring "an appropriate quality of housing" (Art. 1, SPA, para. 2) through the effective use of urban form.

In Switzerland, the configuration of land use is dictated by zoning plans and building codes, which determine the type and extent of permissible land use for public authorities and landowners (Verheij et al., 2025). Building applications must comply with the municipal land-use plan and the Floor Space Index (FSI) defined therein and, if applicable, the specifications for residential and commercial use (Linder, 1994).

The city of Zurich is the largest urban area in Switzerland, with about one million residents, including its surrounding suburbs (Statistics City of Zurich, 2020a, 2020b). It is considered a global city and an important center for the international financial industry (Sassen, 2005). Due to its role in the global economy, it is also regarded as Switzerland's economic center (Theurillat & Crevoisier, 2013). Together with Vienna, Austria, Zurich ranks second on the EIU Global Liveability Index 2025 based on quality-of-life scores in areas such as stability, healthcare, culture and environment, education, and infrastructure (The Economist Group, 2025). These factors attract multinational companies and their workforces, leading to steady growth in population and the economy. However, rapid urbanization, increasing individualization, and low interest rates on capital markets have sparked a densification boom (Statistics City of Zurich, 2017). The city faces a tightening housing market and rising rents, while demolition and renovation efforts have caused social exclusion and displacement, especially in rental housing (Debrunner & Hartmann, 2020). These dynamics — rapid urbanization, shrinking inner-city open spaces, rising housing demand, and pressures from global economic integration — place Zurich alongside other global cities such as Copenhagen (Adelfio et al., 2021), Vancouver (Quastel et al., 2012), and Melbourne (Woodcock et al., 2010), which pursue urban densification through the compact city model to remain competitive while maintaining a high quality of life.

According to the structure plan for the Metropolitan Area of Zurich (Canton of Zurich and Federal Office for Spatial Development, 2015), the city is expected to accommodate a 25 % population increase by 2040 (Zurich City Council, 2021). To achieve this goal, the city of Zurich identified designated areas for urban densification in its municipal structure plan "Zürich 2040" (Zurich City Council, 2021). Given the limited availability of land reserves, the municipal government has to realize the required areas for its new inhabitants within the existing urban development of the city.

In line with the guidelines for compact urban growth (Zurich City Council, 2013), these areas were selected for their access to quality public transport and well-placed public infrastructure within walking distance (Zurich City Council, 2021). The municipal structure plan "Zürich 2040" contains a series of accompanying measures to ensure sufficient public infrastructure, such as schools, shops, and recreational areas. However, the plan does not detail how the increase in spatial density will affect the functional and morphological characteristics of the urban densification areas in the future. At the strategic level, the municipal structure plan "Zürich 2040" does not detail any specific measures for achieving compact urban growth through urban densification.

Federal planning legislation requires municipalities to balance social, environmental, and economic objectives when implementing urban densification measures (CSC, Art. 2, 41, 74, SPA 2019, Art. 1). However, case study research on Swiss planning practices suggests that urban redevelopment projects tend to prioritize environmental and economic development objectives, with negative consequences for social sustainability, particularly diversity of land use and housing affordability (Debrunner, Jonkman, & Gerber, 2020). These negative socio-economic impacts of densification are to be expected at the wider metropolitan scale, especially when the production of housing does not meet the demand or the mobility of tenants in the housing market is limited (Ahlfeldt & Pietrostefani, 2019; Gyourko et al., 2013; Phillips, 2020).

Given that the Swiss housing market is predominantly rental, with 61 % of the population renting nationwide (FSO, 2020) and more than 90 % of Zurich residents being tenants (FSO, 2020), current insufficient densification practices have a direct impact on housing prices, threatening the security and stability of housing for current residents (Debrunner et al., 2022, Debrunner & Hartmann, 2020, Herdt & Jonkman, 2022). In particular, the increasing ratio of the number of workplaces (measured by the share of jobs in full-time equivalent (FTE) per land unit) to residential units in the city of Zurich and the resulting decline in residential use between 1990 and 2014 significantly contributed to rising housing prices (Wälty, 2020, 2021). Complementary studies on the intensification of land use in the federal state of Zurich show that densification results in a greater supply of housing on individual plots and a reduction in rents at the city level (Büchel & Lutz, 2021). The reinforcing positive or negative effects of different densities — for example, on social sustainability — thus require a systematic understanding of urban typology and its site-specific characteristics. This makes the city of Zurich an ideal case for analyzing the impact of different types of density on the achievement of sustainable development goals.

2.1.1. Zurich's district of Aussersihl

Zurich is also one point of origin of the CIAM movement, which shaped modernist planning ideas. Its first general secretary, Sigfried Gideon, had been an influential figure among Zurich architects between the 1930s and 60s as client, university teacher, and writer. This made Zurich one of the first cities to be influenced by modernist planning worldwide. The first president of CIAM, the Zurich architect Karl Moser, and member of the Zurich CIAM group conducted one of its first case studies on the application of modernist planning in the Aussersihl district of Zurich (Lampugnani, 2011, 407 ff.).

To examine how urban planning instruments have historically employed density as a regulatory tool, we selected Zurich's district of Aussersihl as the primary case study. The selection was based on three criteria: data availability across multiple planning regimes, representativeness of key urban development phases, and relevance to contemporary urban densification discourse.

First, Aussersihl is one of the few areas in Zurich with spatial and statistical data available across all major regulatory transitions — spanning from the industrial expansion of the late 19th century through the introduction of modernist zoning laws in the mid-20th century, through to recent planning debates. This long-term data continuity enables a historically grounded spatial analysis of changing density regimes.

Second, the district exemplifies two contrasting models of urban growth: the speculative perimeter block development characteristic of industrialization, and the functionally zoned, lower-density redevelopment schemes proposed by the Zurich group of CIAM during the modernist era. Its morphology thus provides a unique opportunity to assess how different interpretations of density were operationalized in practice.

Third, Aussersihl has become emblematic in current urban policy debates around densification, because of its high spatial density, mixed-use fabric, and central location. As such, it serves as a relevant model for understanding both the constraints and potentials of existing dense urban fabrics in the context of the compact city model.

2.2. Comparative case study: historical and contemporary development of Zurich Aussersihl

The analysis is based on a mixed-methods comparative case study using three historical datasets and one projected scenario for Zurich's district of Aussersihl, each representing a distinct planning period. The comparative case study analysis follows the three different periods identified in the history of planning of Zurich as relevant for the use of density as a planning instrument: the industrial city (1889–1946), the functional city (1946–1999), and the sustainable city (1999–2018), the last following the compact city model represented by the structural plan "Zürich 2040" (see Fig. 1). The study used a mixed-methods approach, incorporating archival materials, geodata, and planning historical documents. We drew on secondary literature on spatial development and the planning history of Zurich to examine the development of Aussersihl during the period of industrialization and the influence of modernist planning on the area. Through the comparative analysis of socio-spatial data from historical planning documents and current geodata, we gained insights into the use of density in different historical periods and their interrelatedness over time. We then projected future densities based on the municipal structure plan "Zürich 2040" — the proposal "Zürich 2040" — to estimate the effects of land use and evaluate the impact of planning instruments.

2.2.1. Data layers and sources

To analyze historical changes and future development scenarios, we use three data sets from Zurich Aussersihl:

- **Historical planning documents** (CIAM surveys, redevelopment plans, zoning regulations)
- **Hectare-based geodata** (Statistics City of Zurich, Federal Statistical Office, datasets for residents, full-time equivalent jobs, retail jobs, building footprints, open spaces)
- **Archival material and secondary literature (urban morphology, planning history, regulatory changes).**

Each of these represent a different historical period and development model, and a projected analysis based on the municipal structural plan

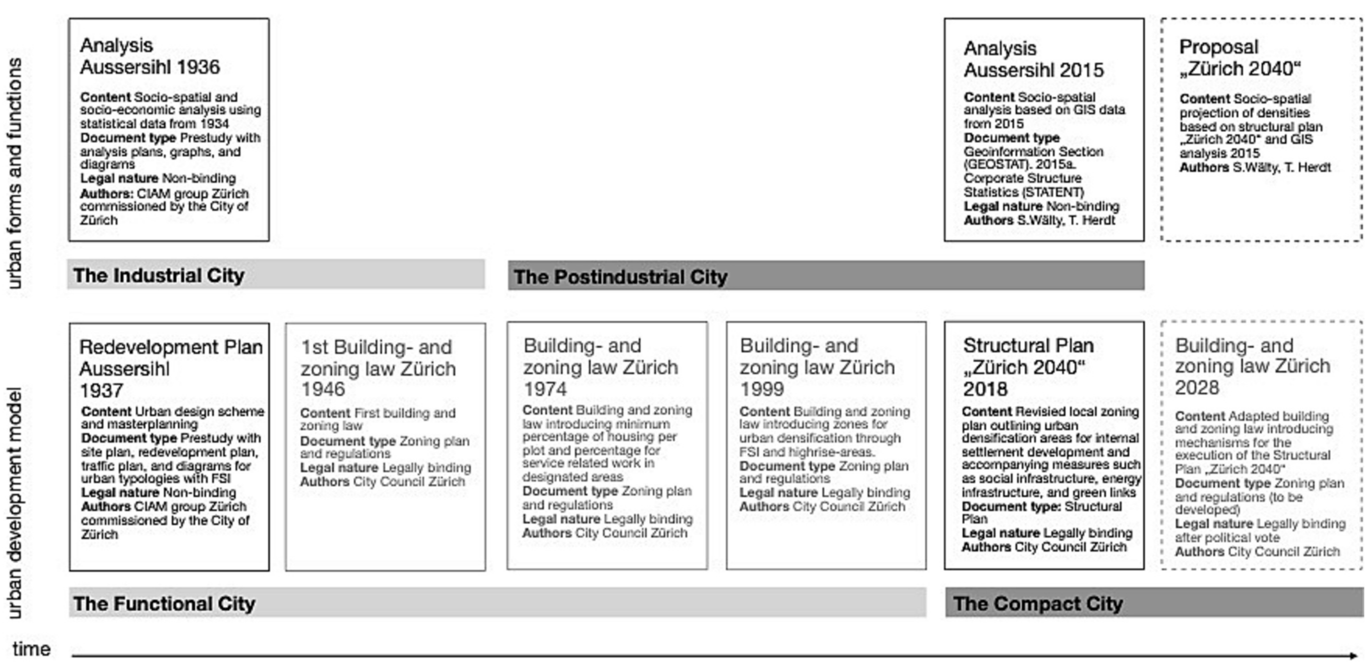


Fig. 1. Overview of the documents and statistical bases used for the comparative analysis, sorted according to periods of development and urban development models, supplemented by central building and zoning regulations (light gray) with changes regarding densification.

"Zürich 2040":

(1) Representing the industrial city (1936 CIAM survey), the "Analysis of Aussersihl 1936" is based on the survey conducted by the Zürich CIAM group. The socio-spatial analysis shows the 1936 situation of the industrial city perimeter block development (Figs. 4.1 and 6.1). The area is characterized by a high population density. It serves as a residential neighborhood for the city's industrial workers and temporary residents.
(2) For the functional city (1934–1937 CIAM redevelopment plan), we rely on the "Redevelopment Plan Aussersihl" (GTA archive), which was designed by the Zurich CIAM group between 1934 and 1937 (Fig. 2). It shows the new urban layout of the area according to the CIAM guidelines of the functional city applying a radical reduction of density and separation of functions with areas for living, recreation, and working.
(3) *Postindustrial city* (2015 hectare-based geodata), the "Analysis of Aussersihl 2015" shows the socio-spatial situation of the area as part of the postindustrial city. The hectare-based geodata from 2015 (Fig. 4.2) was analyzed to compare densities and ratios of residents and jobs through the analysis of morphological and socio-spatial characteristics of the area and the modernist redevelopment plan with contemporary growth scenarios (FSO, 2015a, 2015b, Zurich City Council, 2015). The area is now under heritage protection. In addition to the original residential uses for the working class from the period of the industrial city, it is now home to services and workplaces. It has become a nightlife district and also houses part of the red-light district.
(4) The proposal "Zürich 2040" (projection based on Zurich's municipal structural plan), is a projection of densities and ratios needed to implement the municipal structural plan "Zürich 2040". The plan uses the compact city model as a vision for Zurich's future growth. The hectare-based geodata projection is based on the analysis of intensification and balance of land use according to the analytical framework of the '10-minute-neighborhoods' framework (Wälty, 2020, 2024).

As secondary literature we used Harbusch et al. (2014), Hildebrand (2007), and Lampugnani (2011), and the planning history of Zurich (Zurich City Council, 2013) to examine the influence of modernist planning on the development of planning instruments.

Fig. 2. Redevelopment plan proposed by CIAM, "Gesamtplan," Quartierssanierung Aussersihl, undated, not standardized. no scale.
Source: GTA archives.

2.3. Analytical framework: the compact city and the '10-minute-neighborhoods'

This study applies the '10-minute-neighborhoods' framework developed by Wälty (2018, 2020, 2024) as an analytical framework to assess sustainable land use and its effects on mobility and energy consumption. While developed in the Swiss context, it offers clearly defined objective spatial thresholds and quantifiable ratios (further discussed in Section 2.4) that enable the systematic assessment of urban structure and functional mix. Its parameters can be universally applied. The framework thus allows for the assessment of existing urban structures as well as the formulation of quantitative target values for potential transformations.

Compared to broader concepts like the 15-minute city, it emphasizes measurability and spatial specificity, such as the relation of spatial density, density of inhabitants and density of employees, necessary for achieving sustainable development goals within a given area, making it particularly suitable for evaluating the alignment between existing urban typologies and densification targets. It supports the identification of thresholds where density may begin to impact environmental quality or social inclusiveness and allows for the formulation of locally relevant transformation scenarios.

Two key aspects are central to the analytical framework of the '10-minute-neighborhoods'. First, the model is based on behavioral assumptions regarding density and mobility: Since people typically only walk to everyday destinations or public transport stations when they are within approximately ten minutes of walking distance, the 500-meter-radius forms the basis for estimating the potential reduction of car traffic and CO_2 emissions through compactness and the spatial proximity of housing and jobs (co-location). Second, the framework requires a functional density within this radius, ideally including at least 10,000 residents, with a targeted ratio of two residents per one full-time equivalent (FTE) job. This setting allows for a diverse range of goods, services, and public transport to be sufficiently locally supported.

Limitations arise primarily from two methodological simplifications: First, there is no differentiation between types of residents or employees, which leaves out differences in mobility needs or daily commuting rhythms. Second, the model focuses solely on the 500-meter radius, excluding potential benefits beyond this distance such as bike infrastructure or public transport connections over greater distances. However, public transport stops within walking distance are central to this analysis, as their accessibility is crucial for the connectivity of an area. Additionally, the 500-m radius can be understood as a moving window of analysis for a more granular, location-specific assessment. These intentional limitations facilitate a standardized, data-driven quantitative analysis of local transformation potential in the context of sustainable urban development.

2.4. Indicators for measuring density and proximity

Our comparative analysis is based on selected criteria for compact city development: intensity, proximity and accessibility, and diversity or functional mix (Kain et al., 2021). We use three metrics to define intensity: built density, population density, and density of use (i.e., the ratio of residents to employees in an area). Accessibility is measured by the ratio of surface area dedicated to open and green spaces relative to built areas. Diversity is assessed by examining the functional mix through the following indicators: the ratio of residents to employees, floor area per person, and the share and distribution of public ground floor use.

2.4.1. Spatial resolution

Given the systemic impact of urban densification measures, we analyze and compare various densification criteria on a neighborhood scale. All quantitative analyses are conducted at the neighborhood scale, defined as a 500 m radius (≈100 ha) — the walking distance underpinning the 10-minute-neighborhoods analytical framework. This includes evaluating the intensity and balance of land use — measured as sums and ratios of residents and jobs within a predefined spatial perimeter [a] of approximately 100 ha, equivalent to a 500 m radius or a 10-minute walking distance (Figs. 2–4.1/4.2). These measures align with the quantitative criteria for '10-minute-neighborhoods', such as proximity to essential services and balanced residential, commercial, and recreational green and open spaces (Wälty, 2018, 2020, 2024). Additionally, gross FAR is considered for built density at the neighborhood scale, and net FAR on the parcel scale.

For our quantitative analysis, we derive the following primary indicators:

- **Intensity of land use**: Total number of residents (R), full-time equivalent non-retail jobs (J), and retail jobs (J_R) within the area [a] (Wälty, 2018, 2021).
- **Jobs-housing balance** (R/J): The ideal ratio of about 2 residents per non-retail job ensures local employment opportunities and reduced commuting (Wälty, 2021).
- **Retail job ratio** (R/J_R): Ideally around 30 residents per retail job, supporting local retail services (Wälty, 2021).
- **Open space**: Calculated as the total area [a] minus the area covered by building footprints, thus including streets, courtyards, and green spaces.

3. The historical development of Aussersihl

3.1. Urban form and planning history

Aussersihl was the first district to be built as a perimeter block development in the 1890s. After it was incorporated into Zurich in 1893 (Zurich City Council, 2013), It grew into a densely populated district while retaining many features of its former village structure, such as small plot sizes and street layouts. This growth was influenced by the cantonal building code and speculative land use, leading to high spatial density, close building distances, and overcrowding due to insufficient open space.

Following a short period of rapid growth that lasted until the 1930s, the district then served as a model for modernist planning. In 1934, the city of Zurich commissioned a study on the redevelopment of the district, in which the Zurich CIAM group, led by A.W. Moser, tested the just-developed functionalist ideas of the Athens Charter. In their proposal, "Quartierssanierung Langstrasse 1935–1937" (Fig. 2), they suggested a

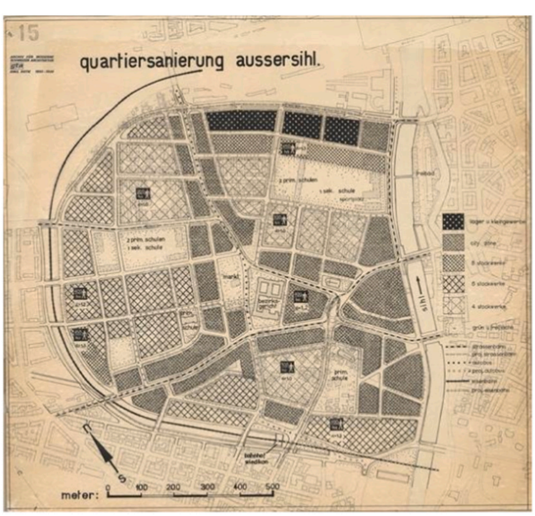


Fig. 3. Zoning plan proposed by CIAM, "Zonenplan," Quartierssanierung Aussersihl, undated, not standardized.
Source: GTA archives.

Fig. 4.1. As-built plan, Zurich Aussersihl, 1936, standardized, no scale.
Source: Swiss Topo.

Fig. 4.2. Aerial photo, Zurich Aussersihl, 2015, standardized, no scale.
Source: Swiss Topo.

radical concept of redevelopment that introduced new planning tools to manage spatial density and open space. The group developed a zoning plan (Fig. 3) based on a strategy for gradual "de-densification", which the group later presented at the 5th CIAM Congress "Living and Recreation," in Paris in 1937, as a model of modernist planning (Hildebrand, 2007, p. 65). The study was based on a detailed socio-spatial analysis of the district. Following the empirical statistical method proposed by van Eesteren, the mapping provided important information on aspects such as population density, spatial density, property value, and functions of the neighborhood (Lampugnani, 2011), which were used to evaluate the scheme's economic potential.

Today, Aussersihl is designated as a protected area, and its relatively high spatial density limits its development potential. However, given its central location and diverse mix of functions, it is currently being rediscovered as a vibrant working and residential area. It is considered a potential model for future urban densification schemes, as noted in the municipal structure plan "Zürich 2040" (Zurich City Council, 2021).

3.2. Continuities and shifts in regulatory logic

CIAM's redevelopment concept proposed expanding the city's transportation network and introducing a "CITY zone" with eight-story buildings to create a central shopping and business district.

Additionally, the adjacent perimeter block developments were to be converted into low-density housing estates with up to four-story line or L-type buildings (Fig. 2). Both interventions were based on a consideration of the newly introduced net floor space index (FSI), defined as the ratio of total space of all floors to the plot area. The group sought to limit the net FSI to 1.1 for public infrastructure to ensure "the necessary open and green spaces" and advocated for new planning instruments to control spatial density and land use. They assumed that the costs of de-densification would be offset by the revenues generated by the "CITY zone" (CIAM Gruppe Zürich, 1937).

Although the zoning plan was not implemented, it significantly influenced the development of Zurich's first building regulation and zoning law in 1946 (Fig. 3), which codified the ideas of modern functionalism (Zurich City Council, 2013). It limited the net FSI to 1.0 to support low-density housing and required larger distances between buildings to facilitate open spaces. It also introduced no-build zones for open and green space while permitting large-scale developments (over 6000 sqm) to create high-revenue areas (CIAM Gruppe Zürich, 1937).

The CIAM group utilized case studies to demonstrate possible improvements that could be achieved through new specifications in the city's building regulations. They illustrated these potential advantages using exemplary drawings that enabled a direct comparison between the impacts of the existing building regulations on urban typology and the new rules proposed by the group (Fig. 5). this would have resulted in the de-densification of the perimeter and the development into a residential area, as suggested in the CIAM redevelopment plan.

The introduction of these basic instruments to regulate the intensity of land use and spatial proximity proved to be highly influential for the city's second growth period, especially in the districts of Altstetten and Schwamendingen (Zurich City Council, 2013). Housing schemes in these areas were based on developments that applied the 6000 sqm rule to implement various urban planning models, such as garden cities and high-rise housing estates. While these measures provided much-needed flexibility in designing new urban districts, they limited the city's ability to systematically address the relationship between urban morphological features and the criteria of density and proximity in urban planning.

4. Findings

This chapter compares the results of the historical-comparative analysis and quantitative analysis.

4.1. Quantitative comparison: 1936, 2015, 2040

4.1.1. Functional transformation and land use intensity

To evaluate the intensity of land use in our perimeter, we compared the number of residents with the number of full-time equivalent (FTE) jobs and the number of FTE retail jobs.

The 1936 CIAM urban analysis reported a population of nearly 30,000 residents and nearly 15,000 FTE jobs. This yields a ratio of two inhabitants per full-time job, aligning with what is considered ideal in the 10-minute-neighborhood concept.

The CIAM group's redevelopment proposal aimed to reduce the intensity of land use and built area by half while maintaining the total number of inhabitants. Had this plan been realized, it would have halved the number of jobs (Table 1).

The 2015 analysis shows significant changes in the functional composition of the perimeter. The ratio of residents to the number of jobs (measured in FTEs) was more than reversed compared to 1936. The number of jobs almost doubled, while the resident population decreased by two-thirds from 1936. Additionally, the number of FTE jobs in the retail sector was also halved during this period. The comparison reveals a significant change in land use within an almost unchanged development. Between 1936 and 2015, the area transitioned from a mixed-use, densely populated residential neighborhood to a service-oriented workplace district with significantly fewer residents (Table 1).

Achieving the population increase projected in the municipal structure plan "Zürich 2040" while maintaining a high level of commercial activity will require accommodating a significantly larger population. To align with the ideal ratio outlined in the '10-minute-neighborhoods' framework of two residents per full-time job, the resident population would need to increase by 400 % from 2015 to 2040. Accordingly, the number of FTE retail jobs would have to increase proportionally (Table 1). The analysis of the 2040 proposal shows accommodating both the existing number of workplaces and the projected increase in the number of residents in the perimeter would require an extreme increase in spatial density. At the same time, the number of workplaces within the perimeter would have to be significantly reduced to achieve a balanced ratio of residents to employees that aligns with '10-minute-neighborhoods' framework. The quantitative and qualitative growth targets outlined in the municipal structure plan "Zürich 2040" do not adequately account for the current ratio and distribution of functions within the perimeter. Therefore, the targeted increase in residents can only be achieved if the number of jobs (FTEs) in the perimeter is reduced, in addition to an increase in spatial density.

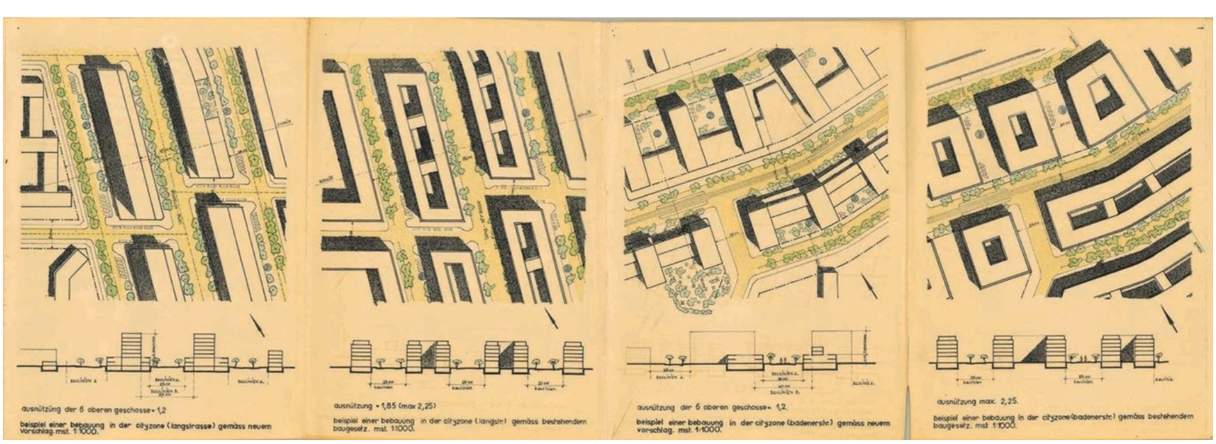
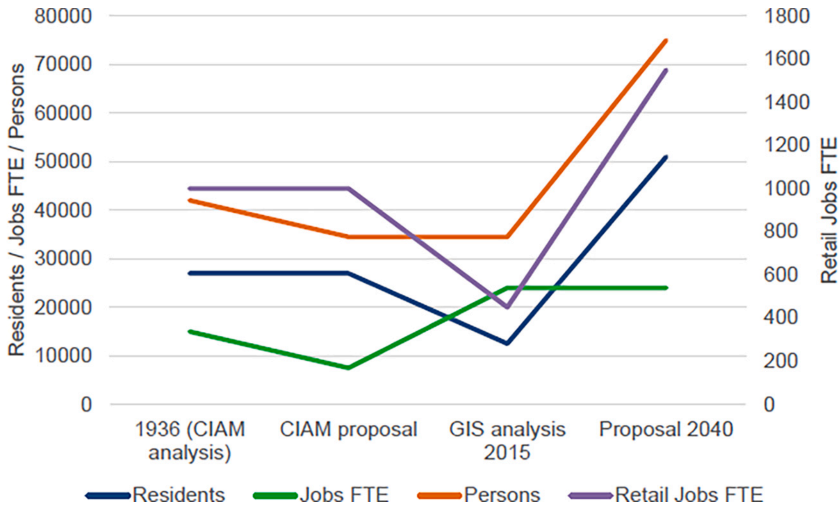


Fig. 5. Examples of development with the existing building code and the adapted building code proposed by CIAM, "beispiel einer bebauung in der city zone, gemäss neuem vorschlag / gemäss bestehendem baugesetz " Quartierssanierung Aussersihl, not standardized, original scale 1:1000.
Source: GTA archive.

Table 1
Functional transformation and land use intensity. Comparison of the number of residents, jobs full-time equivalent (FTE), persons (sum of residents and jobs FTE), and jobs retail FTE in 1936 CIAM analysis and proposal, GIS analysis 2015, and proposal "Zürich 2040".



Sources; CIAM (1936) analysis, GEOSTAT STATENT (2015a) & STATPOP (2015b).

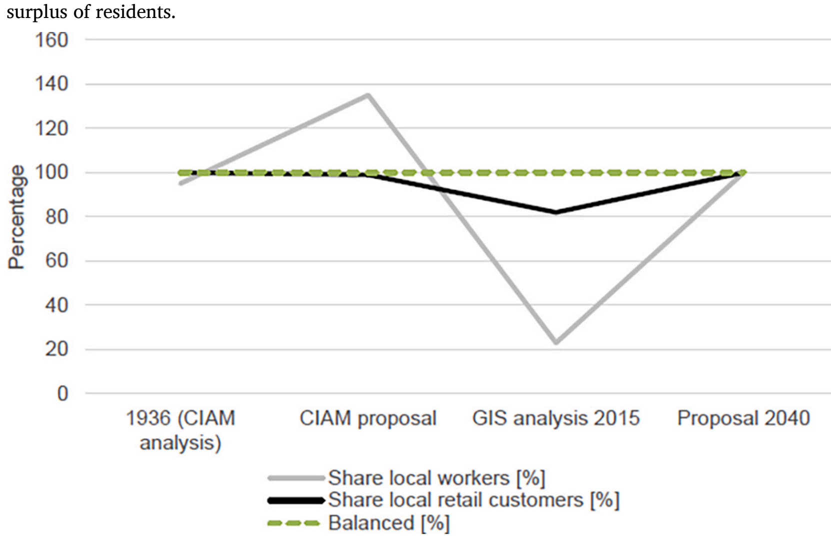
4.1.2. Functional proximity and local integration

We analyzed the relationship between residents, full-time equivalent (FTE) jobs, and FTE retail jobs within the perimeter to assess land use proximity. Table 2 shows that the 1936 CIAM urban analysis and the municipal structure plan "Zürich 2040" aim to achieve a balanced ratio of local workers to retail customers, each approaching 100 %. However, the 1936 CIAM study indicates a surplus of residents as compared to local workers and consumers, while the 2015 dataset shows a surplus of jobs to residents, with only 23 % of jobs being filled by local labor (Table 1). Additionally, with 80 % of retail customers being locals in 2015, this dataset also shows a slight surplus of residents relative to local retail jobs. This significant imbalance between the number of residents and jobs generates a high dependence on commuters and non-local retail customers for both employment and consumer activities.

The 1936 CIAM analysis reflects the modernist planning principles that favored functional segregation — separating residential, commercial, and industrial uses — and prioritized green spaces and vehicular access. In contrast, contemporary urban planning paradigms such as Transit-Oriented Development (TOD) and mixed-use planning emphasize integrated land uses, walkability, and reducing car dependency. These newer approaches seek to balance residential and employment densities within compact, accessible neighborhoods to promote sustainability and social interaction. The persistence of CIAM-era spatial separation in Zurich's urban form partly explains the current imbalances and challenges in achieving these contemporary goals.

Our comparative analysis of the 1936 historical data and the 2015 GIS data shows a decline in "public" uses on ground floors over this period (Fig. 6.1/6.2). This indicates a gradual reduction in the proportion of retail space in favor of other functional areas within the perimeter. In addition, there is a noticeable concentration of space along the

Table 2
Proximity of land use: the share of local workers and retail customers in 1936, 2015, and 2040. Note: 100 % indicates a balanced ratio of 2 residents per 1 job FTE and 30 residents per 1 retail job FTE. Values below 100 % indicate a job and retail job surplus, while values above 100 % indicate a surplus of residents.



Sources; CIAM (1936) analysis, GEOSTAT STATENT (2015a) & STATPOP (2015b).

Fig. 6.1. Analysis of ground-floor uses, Quartierssanierung Aussersihl, "bestandsaufnahme: benutzungsart d. erdgeschossfl. 1:2500", 1936, not standardized, original scale 1:2500.
Source: GTA archives.

Fig. 6.2. Analysis of "public" ground-floor uses, where colored, 2015, standardized, no scale.
Source: GEOSTAT STATENT (2015a).

main roads, which may reflect an increased demand for services from outside the neighborhood.

4.2. Spatial density and typological change

To determine if the increase of residents projected in the 1936 and 2040 scenarios could be accommodated using standard urban typologies, we compared spatial density with density of uses. The gross floor space index (FSI) and the gross ground space index (GSI) were employed to analyze spatial density. The building footprint (GSI) measures the total built areas as a proportion of the perimeter area, including streets and public spaces. Additionally, we examined the impact of land consumption on the FSI. The ratio of floor space consumption to spatial density varies between urban typologies and distinctly characterizes the qualities of public and private spaces within an urban environment (Berghauser Pont & Haupt, 2004).

The CIAM redevelopment plan proposes a new perimeter development with buildings limited to three or four stories, which reduces the average net FSI of building density from 1.27 to 0.6 (Table 3). The plan thus addressed the shortcomings of the existing building regulations, which the CIAM group identified as lacking due to not having restrictions on the maximum building density of plots. The lack of planning specifications led to densely packed perimeter block developments with workshops and commercial buildings in the courtyards and a minimal proportion of green and open spaces within the perimeter (CIAM Group Zurich, 1937). In contrast, the CIAM plan aimed to halve the ground use or gross GSI to increase the area dedicated to open space. The planned de-densification and development into a residential area, as suggested in the CIAM redevelopment plan, would not only have led to a reduction in the number of jobs but also to a reduction in the amount of floor space per person from 27.3 m^2 to 20 m^2 (Table 1).

By 2015, however, the decrease in residents was offset by an increase in the consumption of floorspace per person to 41.1 sqm (Table 3). The growth in floor space used per person within the perimeter, combined with an increase in the number of employees, led to a significant increase in the built area. The building footprint, shown in red in Fig. 7.2, displays a 26.7 % increase in the building stock from 1936 (Fig. 7.1) to 2015, predominantly for offices and workspaces. The municipal structure plan "Zürich 2040" (Table 3) highlights the differences in gross FSI based on space consumption per person based on both the 1936 and 2015 levels.

4.3. Availability and quality of open and green space

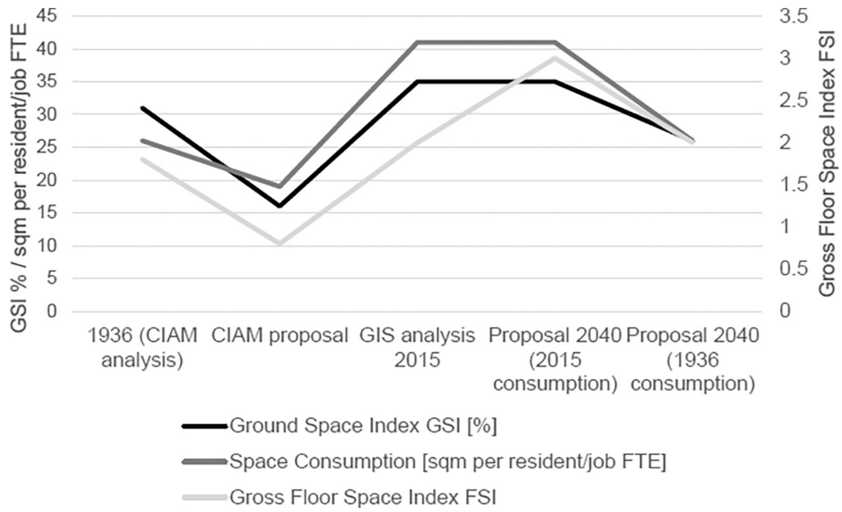
The primary objective of the CIAM group was to incorporate open and green spaces into their redevelopment plan to promote living and recreation as essential elements of modernist planning. Although their urban analysis did not include detailed figures for open space in Aussersihl, the group's emphasis on increasing ground-floor space was a key aspect of their redevelopment proposal. This resulted in a significant reduction in spatial density.

A comparison between CIAM's 1936 redevelopment plan (Fig. 8.1) and the 2015 situation (Fig. 8.2) highlights the group's intention to increase the proportion of unsealed surfaces on existing building plots by reducing building footprints. The proposed shift from perimeter block development to line buildings formed the foundation of the group's new building code proposals. The group advocated for a low spatial density regulated by the newly introduced FSI and increased boundary distances (Fig. 5). The adoption of different urban typologies also resulted in alterations to the quantity and quality of open space. However, this approach required merging building plots and significantly reorganizing transportation infrastructure.

The open space ratio analysis for 2015 shows a ratio of two shares of open space to one share of built-up area (Fig. 8.2). This is partly due to the high proportion of road surfaces in perimeter block developments. However, by 2015, many of the inner courtyards had been sealed and repurposed as car parks or commercial yards. The proportion of unsealed open spaces within the perimeter was relatively low, at only 11 %, and green spaces accounted for only 5 % of all open areas (Fig. 8.2). A comparison between the situation in 1936 (Fig. 8.1) and 2015 (Fig. 8.2) shows a dramatic increase in sealed surfaces, largely explained by ongoing construction on existing building plots over time (see Fig. 7.2).

The population growth predicted in the municipal structure plan "Zürich 2040" will further increase the intensity of the use of public

Table 3
Analysis of the FSI and GSI indices over time. Note: Assumptions are based on the number of inhabitants and the FSI from the CIAM study, with space consumption per person assumed to be the same in 2015 as in 1936.



Sources; CIAM (1936) analysis, GEOSTAT STATENT (2015a) & STATPOP (2015b).

Fig. 7.1. As-built plan, Zurich Aussersihl, 1936, standardized, no scale.
Source: Swiss Topo.

Fig. 7.2. Building stock re-constructed between 1936 and 2015 2015, standardized, no scale.
Source: Zurich City Council (2015).

green spaces (Eggimann, 2022). Consequently, the already limited provision of green spaces for residents in 2015 will further deteriorate. Zurich's planning standards specify eight square meters of open space per person for residents and five square meters per person for each full-time equivalent employee as the guidelines for ensuring sufficient open space (Zurich City Council, 2019). Meeting these standards in Aussersihl will be difficult, if not impossible, without radical dedensification.

A new approach to increasing the proportion of green spaces involves the planning of so-called superblocks. Following the example of superblock interventions in Barcelona's Eixample neighborhood, streets are closed to motorized traffic, expanding the available public space. However, reallocating public space from sealed areas to green spaces is expected to be difficult to achieve.

5. Discussion

5.1. Comparison with international best practice model

The comparison of land use intensity, proximity, and spatial density criteria across different periods shows that neither the modernist residential city model nor the mixed-use perimeter block development offers sufficient growth potential to meet the 2040 densification requirements. Urban typology studies suggest that achieving this would require a shift toward high-density urban forms, such as combining perimeter block developments with additional high-rise towers, resulting in a Floor Space Index (FSI) above 3.0 (Berghauser Pont & Haupt, 2004).

To maintain green spaces within the context of the modernist city model, it is necessary to accommodate future growth by increasing the amount of floor space. Even though a significant increase in GSI would be undesirable (Berghauser Pont & Haupt, 2004), both the modernist city and perimeter block city growth models require additional public measures to ensure environmental quality and social diversity, especially if more cost-intensive densification typologies, such as high-rise buildings, are used (Lang, 2015).

One model for achieving high-density neighborhoods is exemplified by the city of Amsterdam's plans for Sluisbuurt, a new district with 5500

Fig. 8.1. Redevelopment plan proposed by CIAM, "Gesamtplan," Quartierssanierung Aussersihl, undated, not standardized, no scale.
Source: GTA archive.

Fig. 8.2. Allocation of green and public space, 2015, standardized, no scale.
Source: Kanton Zürich. Note: Dark green is public green space (5 %); light green is private green space (6 %); dark gray is sealed public surfaces (35 %); light gray is sealed private surfaces (22 %); and black is building footprints (35 %). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

housing units aiming for an average gross FSI of 5.0 (Municipality of Amsterdam, 2017). To ensure affordable housing and social diversity, Amsterdam mandates that all new urban development projects include 30 % social housing.

Currently, Zurich's zoning framework does not support the spatial density required to house the projected 2040 population within its city limits. As a result, much of the new housing will likely be built outside the city boundaries, leading to longer commutes and increased emissions. This imbalance highlights the limitations of modernist planning approaches still embedded in current density regulations, hindering effective responses to contemporary sustainability, livability, and equity challenges.

5.2. Policy implications

5.2.1. Shifts in land use, functional composition, and density of use

Our longitudinal analysis shows that a long-term shift in land use has occurred in the perimeter block development of Aussersihl. Over time, the balance of residential to commercial space has shifted in favor of commercial uses, as evidenced by the number of residents to full-time employees (Table 2). Residential space has gradually been replaced by commercial space. To counteract this trend, the 1974 building and zoning law revision introduced a minimum residential ratio per building plot (Zurich City Council, 2013). Until then, the mix of land use had been unregulated. However, this regulation did not halt the sharp increase in commercial space in centrally located neighborhoods like Aussersihl. Our analysis suggests that changes in the mix of uses have contributed to a previously underestimated decline in housing supply. Since one of the main objectives of the municipal structure plan "Zürich 2040" is to address Zurich's housing shortage through urban densification and inward settlement development, greater oversight and regulation of the mix of land uses in urban densification areas are necessary.

A change in the mix of land use also impacts the proximity of amenities within a 10-to-15-minute radius. To achieve the proposed walkability for its residents in 2040, the city must rebalance commercial and residential activities in its neighborhoods to enable self-sufficiency. To reach a balanced ratio of two residents to one employee, as suggested in Table 2, while maintaining the current number of jobs, the population in Aussersihl would need to increase to 46,000 residents, resulting in a gross FSI of 2.9. This corresponds to closed perimeter block developments of approximately eight stories in height (see also: Berghauser Pont & Haupt, 2004). The current average building height in Aussersihl is 4 to 5 stories. This means that achieving the desired qualities would require comprehensive redevelopment of the area.

Our comparative study of land use has also shown a steady increase in floor space per capita in the area over time. Assuming residential space consumption per person was approximately 30 square meters per person in 1936, an FSI of 1.9 would have been sufficient to accommodate all additional residents at that time. However, this figure is unlikely to be widely accepted by the public today, given that the average space consumption per person in Switzerland was 46.5 square meters in 2020 (FSO, 2020). As the city of Zurich will remain the region's largest employer, it is crucial to explore additional measures that could be considered as part of an adapted planning and building code to ensure the necessary proximity and functional mix in urban densification areas.

5.2.2. Environmental trade-offs, and sustainability goals

Urban redevelopment on the scale of Aussersihl would significantly alter the spatial character of the neighborhood and increase embodied CO_2 emissions from demolition and reconstruction. Additionally, it could potentially reduce affordable housing stock through the development of new buildings. To mitigate these risks, densification strategies must integrate sustainability goals at multiple scales — parcel, district, and city-wide — and prioritize balanced growth.

Key policy instruments include revisiting building and zoning regulations, ensuring regulatory oversight of land use balance, and defining clear benchmarks for accessibility, such as the '10-minute-neighborhoods' criteria. This includes achieving functional diversity and measuring density not only via FSI and GSI but also with complementary indicators, such as green infrastructure ratios and public open space ratio per resident.

On a strategic level, Zurich must develop an integrated environmental vision to align urban densification with its sustainable development goals. The current parcel-based, patchwork development practice hinders systemic planning. A shift is needed toward district-scale planning that acknowledges and balances the often conflicting goals of the "green," the "growing," and the "just" city (Campell, 2007).

5.3. Limitations and future research

The methodological approach developed in this article serves as an example for analyzing the development of different densities and their application in urban planning over time. It can be transferred to other cities and case study areas if the proposed four-stage method is applied. However, the applicability of the method depends on the availability of historical data and must be adapted to the respective local planning culture and development history.

The study's limitations therefore include reliance on available historical data and assumptions about space consumption, which may not fully capture evolving demographic trends or urban dynamics. It also focuses primarily on perimeter block developments, overlooking other urban typologies. To comprehensively assess the impact of urban densification on ecological conflicts of interest and the assurance of socially equitable development through the provision of affordable housing, further detailed studies are necessary. A multitude of dependencies must be considered in this context; however, due to the methodological approach selected for this study, it is not possible to address all factors. Future research could therefore refine sustainability indicators and investigate the long-term social and environmental impacts of densification. Additionally, comparative cross-city studies and the integration of new technologies could provide further insights into sustainable urban growth.

6. Conclusion

This study contributes to international planning debates by illustrating how the historical development of urban form and land use regulation — in particular the introduction of built density in combination with functional zoning — has limited the positive effects of the compact city model. Our analysis shows that the dependencies between built density, population density, and density of use vary greatly between different historical periods. However, while spatial development models, designs, and values have shifted significantly, planning instruments have not adapted accordingly. Using Zurich as a case study for a global city, we show the need for tailored planning tools to understand and manage the interdependencies in order to achieve sustainability goals such as proximity, functional mix, and livability.

Our findings highlight three main contributions:

- Methodologically, the four-stage analysis provides a transferable way to examine the relationship between land use change, the influence of built density as a planning instrument, and sustainability goals over time.
- Policy-wise, the results reveal shortcomings in traditional zoning frameworks worldwide in supporting sustainable urban growth and emphasize the need for regulatory innovations, such as mandatory housing quotas and control on the mix of functions.
- Theoretically, by linking the urban form literature with planning theories such as the compact city paradigm and Campbell's triangle, the study exposes tensions between densification, green infrastructure, and social equity and underscores the importance of urban form to achieve these goals.

The case of Zurich is not unique. Many cities face similar challenges when intensifying land use through inward settlement development while seeking to maintain livability and affordability. Learning from Amsterdam, Copenhagen, Vancouver, and others, Zurich — and global cities more broadly — must incorporate stronger mechanisms for housing equity, open space access, and proximity-based planning into their regulatory frameworks. Our methodological approach and empirical analysis enable a better understanding of the interdependencies between built density, population density, and density of use over time, helping to assess the impacts of densification measures on livability and weigh trade-offs between sustainable development goals such as preserving green spaces and ensuring affordable housing. A differentiated monitoring system — encompassing population density, employment density, and residential floor space per capita as supplementary indicators — can provide a practical basis for evaluating the potential and limits of compact city policies.

Upcoming planning reforms — as in Zurich's example, the 2028 building and zoning code revision — offer a timely opportunity to embed such tools into regulatory frameworks, ensuring that compact city strategies deliver both sustainability and equity.

CRediT authorship contribution statement

Tanja Herdt: Writing – review & editing, Writing – original draft, Validation, Project administration, Methodology, Investigation, Data curation, Conceptualization. **Sibylle Wälty:** Writing – review & editing, Visualization, Validation, Formal analysis.

Declaration of competing interest

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

Data availability

Data will be made available on request.

References

Aalbers, M. B. (2017). Symposium on the variegated financialization of housing. *International Journal of Urban and Regional Research, 41*(4), 542–554. https://doi.org/10.1111/1468-2427.12522

Adelfio, M., Navarro Aguiar, U., Fertner, C., & Brandão, E.d. C. (2021). Translating 'New Compactism', circulation of knowledge and local mutations: Copenhagen's Sydhavn as a case study. *International Planning Studies, 27*(2), 173–195. https://doi.org/10.1080/13563475.2021.1979943

Ahlfeldt, G. M., & Pietrostefani, E. (2019). The economic effects of density: A synthesis. *Journal of Urban Economics, 111*, 93–107. https://doi.org/10.1016/j.jue.2019.04.006

Allam, Z., Bibri, S. E., Chabaud, D., & Moreno, C. (2022). The '15-Minute City' concept can shape a net-zero urban future. *Humanities and Social Sciences Communications, 9* (1). https://doi.org/10.1057/s41599-022-01145-0

Angelo, H., & Wachsmuth, D. (2020). Why does everyone think cities can save the planet? *Urban Studies, 57*(11), 2201–2221. https://doi.org/10.1177/004209802091908

Berghauser Pont, M. Y., & Haupt, P. (2004). *Spacemate. The spatial logic of urban density*. DUP Science.

Bibri, S. E., Krogstie, J., & Kärrholm, M. (2020). Compact city planning and development: Emerging practices and strategies for achieving the goals of sustainability. *Developments in the Built Environment, 4*, Article 100021. https://doi.org/10.1016/j.dibe.2020.100021

Bovet, J., Marquard, E., & Schröter-Schlaack, C. (2019, 4–5 April). International expert workshop on land take: Workshop report. Berlin, Germany. https://www.ufz.de/export/data/464/258132_235934_SURFACE%20Workshop%20report_final_2019-11-07.pdf.

Boyko, C. T., & Cooper, R. (2011). Clarifying and re-conceptualising density. *Progress in Planning, 76*(1), 1–61. https://doi.org/10.1016/j.progress.2011.07.001

Broitman, D., & Koomen, E. (2015). Residential density change: Densification and urban expansion. *Computers, Environment and Urban Systems, 54*, 32–46. https://doi.org/10.1016/j.compenvurbsys.2015.05.006

Brunsing, J., & Frehn, M. (Eds.). (1999). *Stadt der kurzen Wege: Zukunftsfähiges Leitbild oder planerische Utopie?*. Institute of Spatial Planning, University of Dortmund. https://isbnsearch.org/isbn/9783882111163.

Büchel, S., & Lutz, E. (2021). The local effects of relaxing land use regulation on housing supply and rents. In *MIT Center for Real Estate Research, paper no. 21/18*. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3960822.

Bulkeley, H., & Betsill, M. (2005). Rethinking sustainable cities: Multilevel governance and the 'urban' politics of climate change. *Environmental Politics, 14*(1), 42–63. https://doi.org/10.1080/0964401042000310178

Burton, E. (2000). The compact city: Just or just compact? A preliminary analysis. *Urban Studies, 37*(11), 1969–2001.

Burton, E. (2010). Housing for an urban renaissance: Implications for social equity. *Housing Studies, 18*(4), 537–562. https://doi.org/10.1080/02673030304249

Campell, S. (2007). Green cities, growing cities, just cities? Urban planning and the contradictions of sustainable development. *Journal of the American Planning Association, 62) 3*, 296–312. https://doi.org/10.1080/01944369608975696

Canton of Zurich, Office for Spatial Development; Federal Office for Spatial Development. (2015). *Canton of Zurich structure plan: Comprehensive review – Approval by the Federal Council*. https://www.are.admin.ch/dam/are/en/dokumente/raumplanung/dokumente/richtplangenehmigung/richtplan_kantonzuerichgenehmigungdurchdenbundesratvom29042015.pdf.

Caudeville, J. (2021). Operationalizing the health-environment nexus: Measuring environmental health inequalities to inform policy. In É. Laurent (Ed.), *The well-being transition*. Palgrave Macmillan. https://doi.org/10.1007/978-3-030-67860-9_6.

Christophers, B. (2022). Mind the rent gap: Blackstone, housing investment and the reordering of urban rent surfaces. *Urban Studies, 59*(4), 698–716. https://doi.org/10.1177/00420980211026466

Churchman, A. (1999). Disentangling the concept of density. *Journal of Planning Literature, 13*. https://doi.org/10.1177/08854129922092478

CIAM Gruppe Zürich. (1936). *kurzer bericht über die schweiz, gruppenarbeit: sanierung des langstrassen-quartiers in zürich, Bericht, August 1936, gta Archives / ETH Zurich, CIAM, Signatur: 42-JT-1-6/9, Zürich*.

CIAM Gruppe Zürich. (1937). *Bericht über die Arbeit der Zürcher Gruppe: 'Quartierssanierung langstrasse', Bericht, CIAM 5. Congress, Paris, Juni 1937, gta-Archiv, gta Archives / ETH Zürich,s CIAM, Signatur: 42-05-2-33, Zürich*.

Cohen, M., & Gutman, M. (2007). Density: An overview essay. *Built Environment, 33*(2), 141–144. https://doi.org/10.2148/benv.33.2.141

Debrunner, G., & Hartmann, T. (2020). Strategic use of land policy instruments for affordable housing – Coping with social challenges under scarce land conditions in Swiss cities. *Land Use Policy, 99*. https://doi.org/10.1016/j.landusepol.2020.104993

Debrunner, G., Hengstermann, A., & Gerber, J. D. (2020). The business of densification: Distribution of power, wealth and inequality in Swiss policy making. *Town Planning Review, 91*(3), 259–281. https://doi.org/10.3828/tpr.2020.15

Debrunner, G., Jonkman, A., & Gerber, J. D. (2020). Planning for social sustainability: mechanisms of social exclusion in densification through large-scale redevelopment projects in Swiss cities. *Housing Studies*. https://doi.org/10.1080/02673037.2022.2033174 (02/2022).

Dembski, S., Dunning, S., Hartmann, T., & Hengstermann, A. (2020). Introduction: Enhancing the understanding of strategies of land policy for urban densification. *Town Planning Review, 91*(3), 209–216. https://doi.org/10.3828/tpr.2020.12

Dovey, K., & Pafka, E. (2017). What is the functional mix? An assemblage approach. *Planning Theory & Practice, 18*(2), 249–267. https://doi.org/10.1080/14649357.2017.1281996

Duany, A., Plater-Zyberk, E., & Speck, J. (2000). *Suburban nation: The rise of sprawl and the decline of the American dream*. North Point Press.

Eggimann, S. (2022). Expanding urban green space with superblocks. *Land Use Policy, 117*(06/22), Article 106111. https://doi.org/10.1016/j.landusepol.2022.106111

European Commission. (2011). Roadmap to a resource efficient Europe. *COM, 2011*, 571. http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52011DC0571.

Ewing, R. (1997). Is Los Angeles-style sprawl desirable? *Journal of the American Planning Association, 63*(1), 107–126. https://doi.org/10.1080/01944369708975728

Ewing, R., & Cervero, R. (2010). Travel and the built environment. *Journal of the American Planning Association, 76*(3), 265–294.

Fainstein, S. S. (2000). New directions in planning theory. *Urban Affairs Review, 35*(4), 451–478.

Federal Spatial Planning Act (SPA) AS 1979 1573. (2019.01.01). https://www.fedlex.admin.ch/eli/cc/1979/1573_1573_1573/de. (Accessed 22 March 2022).

Federal Statistical Office (FSO). (2015). Szenarien zur Bevölkerungsentwicklung der Schweiz 2015-2045. https://www.bfs.admin.ch/bfs/en/home/statistics/catalogues-databases/publications.assetdetail.350324.html. (Accessed 22 March 2022).

Federal Statistical Office (FSO). (2020). "Occupancy status of occupied dwellings," structural survey buildings and dwellings statistics. https://www.bfs.admin.ch/bfs/en/home/statistics/construction-housing/dwellings/housing-conditions/tenants-owners.html. (Accessed 22 March 2022).

Federal Statistical Office (FSO) Geoinformation Section (GEOSTAT). (2015). Corporate Structure Statistics (STATENT). https://www.bfs.admin.ch/bfs/en/home/services/geostat/swiss-federal-statistics-geodata/business-employment.html. (Accessed 13 June 2024).

Federal Statistical Office (FSO) Geoinformation Section (GEOSTAT). (2015). Corporate Structure Statistics (STATPOP). https://www.bfs.admin.ch/bfs/de/home/dienstleistungen/geostat/geodaten-bundesstatistik/gebaeude-wohnungen-haushalte-personen.html. (Accessed 13 June 2024).

Frey, B. S. (2003). Why are efficient transport policy instruments so seldom used? In J. Schade, & B. Schlag (Eds.), *Acceptability of transport pricing strategies* (pp. 63–75). Leeds: Emerald Group Publishing Limited. https://doi.org/10.1108/9781786359506-004.

Gyourko, J., Mayer, C., & Sinai, T. (2013). Superstar cities. *American Economic Journal: Economic Policy, 5*(4), 167–199. https://doi.org/10.3386/w12355

Habermehl, V., & McFarlane, C. (2023). Density as a politics of value: Regulation, speculation, and popular urbanism. *Progress in Human Geography, 47*(5), 664–679. https://doi.org/10.1177/03091325231189824

Hall, P. (2014). *Cities of tomorrow: An intellectual history of urban planning and design since 1880* (4th ed.). Wiley-Blackwell.

Harbusch, G., et al. (Eds.). (2014). *Atlas of the functional city: CIAM 4 and comparative urban analysis*. GTA Verlag.

Herdt, T., & Jonkman, A. (2022). *Spatial justice and the NIMBY effect: An analysis of the urban densification debate in Switzerland and the Netherlands*. The Evolving Scholar. https://doi.org/10.24404/615ec0f601ef1c0009df6e3a

Heynen, N., Kaika, M., & Swyngedouw, E. (Eds.). (2006). *In the nature of cities: Urban political ecology and the politics of urban metabolism*. Routledge.

Hildebrand, S. (Ed.). (2007). *Haefeli Moser Steiger: die Architekten der Schweizer Moderne*. GTA Verlag.

Institute for Transportation and Development Policy. (2020). Pedestrians first: Tools for a walkable city. https://pedestriansfirst.itdp.org/. (Accessed 13 June 2024).

Jabareen, Y. R. (2006). Sustainable urban forms: Their typologies, models, and concepts. *Journal of Planning Education and Research, 26*(1), 38–52. https://doi.org/10.1177/0739456X05285119

Jacobs, J. (1961). *The death and life of great American cities* (New York).

Kain, J., Adelfio, M., Stenberg, J., & Thuvander, L. (2021). Towards a systemic understanding of compact city qualities. *Journal of Urban Design, 27*(4). https://doi.org/10.1080/13574809.2021.1941825

Kjærås, K. (2020). Towards a relational conception of the compact city. *Urban Studies, 58*(6), 1176–1192. https://doi.org/10.1177/0042098020907281

Lampugnani, V. M. (2011). *Die Stadt im 20. Jahrhundert: Visionen, Entwürfe, Gebautes, Band 1: Von den urbanistischen Entwürfen des ausgehenden 19. Jahrhunderts über den Städtebau der Avantgarde bis zur Stadt der Klassischen Moderne*. Verlag Klaus Wagenbach.

Lang, S. (2015). Das Hochhaus - Ein Verdichtunsgtool? Masterthesis MAS Raumplanung, ETHZ, 2013/15. https://www.espacesuisse.ch/sites/default/files/documents/2015_lang_sandro_DasHochhausVerdichtung.pdf. (Accessed 14 April 2021).

Linder, W. (1994). *Swiss democracy: Possible solutions to conflict in multicultural societies*. St. Martin's Press.

Matsumoto, T., Yoshida, Y., Ostry, A., Sanchez-Serra, D., et al. (2012). Compact city policies. A comparative assessment. In *OECD green growth studies*. OECD Publishing.

McClintock, N. (2018). Cultivating (a) sustainability capital: Urban agriculture, ecogentrification, and the uneven valorization of social reproduction. *Annals of the American Association of Geographers, 108*(2), 579–590. https://doi.org/10.1080/24694452.2017.1365582

Moreno, C., Allam, Z., Chabaud, D., Gall, C., & Pratlong, F. (2021). Introducing the 15-minute city: Sustainability, resilience and place identity in future post-pandemic cities. *Smart Cities, 4*(1), 93–111. https://doi.org/10.3390/smartcities4010006

Municipality of Amsterdam. (2017). Stedenbouwkundig Plan Sluisbuurt d. d. 27. October 2017. https://www.amsterdamsebinnenstad.nl/archief/sluisbuurt/concept_stedenbouwkundigplan_sluisbuurt.pdf. (Accessed 2 July 2020).

Neumann, M. (2005). The compact city fallacy. *Journal of Planning Education and Research, 25*(1), 11. https://doi.org/10.1177/0739456X04270466 2005 25:11 (Sage).

Newman, P., & Kenworthy, J. (1989). *Cities and automobile dependence: An international sourcebook*. Gower Publishing.

Newman, P., & Kenworthy, J. (1999). *Sustainability and cities: Overcoming automobile dependence*. Island Press.

Newman, P., & Kenworthy, J. (2015). *The end of automobile dependence: How cities are moving beyond car-based planning*. Island Press.

Organisation for Economic Co-operation and Development. (2012). *Compact city policies: A comparative assessment (OECD green growth studies)*. OECD Publishing. https://doi.org/10.1787/9789264167865-en

Phillips, S. (2020). *The affordable city: Strategies for putting housing within reach (and keeping it there)*. Island Press.

Quastel, N., Moos, M., & Lynch, N. (2012). Sustainability-as-density and the return of the social: The case of Vancouver, British Columbia. *Urban Geography, 33*(7), 1055–1084. https://doi.org/10.2747/0272-3638.33.7.1055

Röösli, M., et al. (2019). Die SIRENE-Studie. Verkehrslärm, kardiovaskuläre Sterblichkeit, Diabetes, Schlafstörung und Belästigung. *Swiss Med Forum, 19*(0506), 77–82. https://doi.org/10.4414/smf.2019.03433

Sampson, R. J. (2017). Urban sustainability in an age of enduring inequalities: Advancing theory and ecometrics for the 21st-century city. *Proceedings of the National Academy of Sciences, 114*(34), 8957–8962. https://doi.org/10.1073/pnas.1614433114

Sassen, S. (2005). The global city: Introducing a concept. *The Brown Journal of World Affairs, 11*(2), 27–43. https://saskiasassen.com/pdfs/publications/the-global-city-brown.pdf.

Searle, G., & Filion, P. (2011). Planning context and urban intensification outcomes: Sydney versus Toronto. *Urban Studies, 48*(7), 1419–1438. https://doi.org/10.1177/0042098010375995

Smart Growth America. (2025). What is smart growth?. https://smartgrowthamerica.org/what-is-smart-growth/. (Accessed 3 April 2025).

Sonne, W. (2014). *Urbanität und Dichte im Städtebau des 20*. Jahrhunderts: DOM-Publisher.

Sonne, W. (2022). Geschichte der Dichte im Städtebau Achterbahnfahrten eines reduktiven Konzepts. *VHW Forum für Wohnen und Stadtentwicklung, 5*(09/22), 227–230.

Squires, G. D. (2002). *Urban sprawl: Causes, consequences and policy responses*. The Urban Institute Press.

Statistics 2017. (2017). Immer mehr Leerkündigungen bei Umbauten. Available at: https://www.stadt-zuerich.ch/prd/de/index/statistik/publikationen-angebote/publikationen/webartikel/2017–09-14_Immer-mehr-Kuendigungen-bei-Umbauten.html. (Accessed 31 July 2025).

Statistics 2020. (2020a). *Stadt Zürich Statistik "Quartiersspiegel Langstrasse 2020", Zurich, 2020*.

Statistics 2020. (2020b). Stadt Zürich Statistik "Bevölkerungs- und Wirtschaftsentwicklung Stadt Zürich". Available at: https://www.stadt-zuerich.ch/prd/de/index/statistik/themen/bevoelkerung.html. (Accessed 31 July 2025).

The Economist Group. (2025, June 17). The EIU Global Liveability Index 2025: Copenhagen replaces Vienna as world's most liveable city. https://www.economistgroup.com/press-centre/economist-intelligence/eiu-global-liveability-index-2025-copenhagen-replaces-vienna-as-worlds-most.

Theurillat, T., & Crevoisier, O. (2013). The sustainability of financialized urban megaproject: The case of Sihlcity in Zurich. *International Journal of Urban and

Regional Research, 37, 2052–2073. https://doi.org/10.1111/j.1468-2427.2012.01140.x

Touati-Morel, A. (2015). Hard and soft densification policies in the Paris City-region. *International Journal of Urban and Regional Research, 39*(3), 603–612. https://doi.org/10.1111/1468-2427.12195

UN General Assembly. (2015, 21 October). Transforming our world: the 2030 Agenda for Sustainable Development, A/RES/70/1. https://www.refworld.org/legal/resolution/unga/2015/en/11181. (Accessed 15 March 2024).

UN-Habitat. (2012). *Urban planning for city leaders*. UN-HABITAT: Nairobi. https://unhabitat.org/urban-planning-for-city-leaders-0. (Accessed 15 March 2024).

Verheij, J., et al. (2025). Land policy in Switzerland: A renewed interest in public landownership to support land-use planning. In T. Hartmann, et al. (Eds.), *Land policies in Europe* (pp. 187–200). https://doi.org/10.1007/978-3-031-83725-8_12

Wälty, S. (2018). Based on the analysis of ten essential elements: Does Greater Zurich provide Healthy, 10-Minute Neighbourhoods?. In , *ETH research collection55th IMCL conference on health. 10-Minute neighborhood. Mai 14-18, Ottawa*. https://doi.org/10.3929/ethz-b-000304251

Wälty, S. (2020). Implementing Parsimonious Land Use: Basic analysis and decisive changes for Switzerland. In *ETH research collection*. ETH Zurich. https://doi.org/10.3929/ethz-b-000418417.

Wälty, S. (2021). Greater Zurich does not use land parsimoniously despite the Spatial Planning Act, which has been in force since 1980. *Journal of Urbanism: International Research on Placemaking and Urban Sustainability., 14*(1), 58–74. https://doi.org/10.1080/17549175.2020.1762707

Wälty, S. (2024). *Haushälterische Bodennutzung vollziehen*. Zürich: Park Books.

Woodcock, I., Dovey, K., Wollan, S., & Beyerle, A. (2010). Modelling the compact city: Capacities and visions for Melbourne. *Australian Planner, 47*(2), 94–104. https://doi.org/10.1080/07293681003767793

Zurich City Council. (2013). Gerechter: Die Entwicklung der Bau- und Zonenordnung der Stadt Zürich. Stadtverwaltung Zürich. https://www.stadt-zuerich.ch/hbd/de/index/staedtebau/Themenhefte/publikation_gerechter2.html (in German).

Zurich City Council. (2015). Building age. https://data.stadt-zuerich.ch/. (Accessed 22 June 2021).

Zurich City Council. (2019). Die Freiraumversorgung der Stadt Zürich und ihre Berechnung: Methodenbeschrieb und Anwendung [The supply of open space in the city of Zurich and its calculation: Method description and application]. Stadtverwaltung Zürich https://www.stadt-zuerich.ch/ted/de/index/gsz/beratung-und-wissen/publikationen-und-broschueren/die-freiraumversorgung-der-stadt-zuerich-und-ihre-berechnung–me.html. (Accessed 21 July 2024) (in German).

Zurich City Council. (2021). Richtplantext Kommunaler Richtplan Siedlung, Landschaft, öffentliche Bauten und Anlagen [Municipal structural plan: Settlement, landscape, public buildings and facilities]. https://www.stadt-zuerich.ch/hbd/de/index/staedtebau/planung/richtplanung/kommunaler-richtplan/richtplantext-und-richtplankarte.html. (Accessed 24 August 2024) (in German).