CAPTURING LAND POLICY EFFECTS WITH SPATIAL ANALYSIS

A COMPARISON OF DENSIFICATION PATTERNS IN UTRECHT AND BERN

Inaugural dissertation
of the Faculty of Science,
University of Bern

presented by

Vera Götze

from Germany

Supervisors of the doctoral thesis:

Prof. Dr. Jean-David Gerber

Institute of Geography & Centre for Regional Economic Development

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Dr.-Ing. Mathias Jehling

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Prof. Dr. Jean-Louis Reymond

Summary

This thesis is about understanding the effects of land policy on urban development through spatial analysis. While numerous tools exist to describe urban development, they are hardly applied to policy-related questions from the municipal to the national scale. Spatial analysis has the potential to identify and compare development patterns, thereby gauging policy impacts on the built environment. By bridging the gap between spatial and policy analysis, this thesis aims to contribute to a more nuanced understanding of how land policies shape urban development.

I particularly concentrate on the application of spatial analysis in the context of urban densification. Densification presents an interesting context due to its inherent complexity. Within limited space, numerous, often conflicting interests and rights compete for priority. This intensifies as pressure mounts to address critical issues like housing, energy, transportation, and climate change. Municipalities have to navigate this field through land policy. How does the comparison of densification patterns contribute to tracing these land policy effects? What densification patterns emerge across countries and municipalities, and how does land policy possibly explain the observed differences? I approach these questions by zooming in on three different aspects of land policy, namely (1) the effect of institutional regimes on densification patterns across countries, (2) the effect of applied policy instruments on the outcome of individual development projects, and (3) the effect of municipal strategies on the application of policy instruments.

I conducted my analysis in the city regions of Bern, Switzerland, and Utrecht, the Netherlands, which are countries with contrasting institutional regimes. I found that two approaches were especially well-suited to tease out policy effects when comparing densification patterns because they reflect the ability and willingness of municipalities to enable densification and to control the outcome of individual developments. First, measuring not only densification outcomes but focusing on the process. The degree to which municipalities have the power to enable densification at strategic places can show in the kind of neighborhoods densification occurred in and the change it introduced in these neighborhoods. It can also show in the complexity of the planning process as expressed in the size of projects, zoning change, the number of involved landowners and the complexity of parcel changes. Second, by measuring densification outcomes in terms of how they deviate from expectations. This can be achieved by comparing the characteristics of densification projects to the neighborhood average or values predicted by a model simulating market forces. The strength of this latter approach is that, by pointing out projects that deviate from expectations, spatial analysis can be combined with qualitative case study approaches to trace planning processes and establish causal relationships between policy and spatial outcome.

In addition to spatially tracing policy effects on urban densification, this thesis provides evidence of the variation in possible densification outcomes, ranging from the affordability of new-built housing to the prevalence of disruptive, large-scale redevelopments of social housing estates. By monitoring densification outcomes themselves, the methods and findings presented in this thesis contribute to triggering an important discussion on the winners and losers of densification, acknowledging that negative social effects are not inherent to densification itself but depend on the form it takes on, and land policy affects the prevalence and distribution of these forms.

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1 Introduction

This thesis examines the contribution of spatial analysis to tracing the effects of planning on urban development. Land use planning is the strategic allocation of land for efficient resource use. As such, it affects the spatial issues of urban land take, housing, agriculture, and energy, making it a critical factor in achieving sustainable development goals. Consequently, a wealth of scientific literature revolves around how planning best can enable compact urban development, the provision of affordable housing, and the renewable energy transition. With my thesis, I aim to contribute to this research.

In particular, I will focus on the issue of reducing land take from urban expansion through densification. Densification is an important policy goal, but, at the same time, it is difficult to realize since many interests overlap and sustainability trade-offs are inevitable. This makes it an interesting context in which to examine the influence of planning. In this introductory chapter, I will argue that densification is a contested policy goal and that it is crucial to distinguish between different forms of densification. I will also assert that planning is central to shaping these densification forms. I will conclude by stating my overarching goals and research questions for this thesis.

1.1 Densification and sustainable development

Settlement areas continue to grow globally at the cost of agricultural and natural land (UN-Habitat, 2022). While population growth is the most important driver of urban land expansion globally, land take continues in Europe and North America due to economic growth and stagnating population growth. (Mahtta *et al.*, 2022). Land take is considered a major contributor to biodiversity loss, CO_2 emissions, and pollution (Seto, Güneralp and Hutyra, 2012; EEA, 2016). Consequently, the goal of reducing net land take is anchored in international sustainability strategies (European Commission, 2011) In response, many national governments have introduced limits to urban growth through densification. Densification can be defined as an increase in the number of households on existing urban land (Broitman and Koomen, 2015). But densification is not only a policy goal for land thrift. In the past decades, the popularity of cities has been increasing, leading to a growing demand for housing in city centers (Kabisch, Haase and Haase, 2010; Rérat, 2019). This makes densification a potentially profitable business model (Claassens, Koomen and Rouwendal, 2020; Debrunner, Hengstermann and Gerber, 2020).

With many governments pursuing densification policies as part of their sustainability strategies, scholars strive to provide the scientific ground for these policies. However, while density has become almost a synonym for sustainability (Quastel, Moos and Lynch, 2012), its consequences for the economy,

environment, and social equity remain ambivalent (Churchman, 1999; Boyko and Cooper, 2011; Ahlfeldt and Pietrostefani, 2017; Berghauser Pont *et al.*, 2021).

The primary goal of densification (and simultaneously its primary benefit) is to reduce urban land expansion. But its proponents promise more than that. The concept of densification has its roots in the "compact city" ideal (Dantzig and Saaty, 1973). The compact city is supposed to reduce air pollution, car use, and energy consumption while fostering social interaction and innovation (see Burton, 2000 for a review). Yet studies on the sustainability of densification paint a more mixed picture.

Locally, densification is often associated with negative environmental impacts, primarily linked to the loss of urban green spaces (Giezen, Balikci and Arundel, 2018). This can lead to reduced biodiversity, higher temperatures, and lower air quality (Haaland and van den Bosch, 2015). Densification appears to have a positive impact on transportation, encouraging public transit use while discouraging car dependence (Berghauser Pont *et al.*, 2021). Up to a certain point, high population density is crucial for sustaining public infrastructure by providing a sufficient user base, but too high densities lead to overuse and crowding (Boyko and Cooper, 2011). Compact development also improves efficiency in energy and space usage, adding to the economic benefits often cited alongside increased innovation and better access to jobs (Churchman, 1999).

The social effects of densification are probably the most debated (Berghauser Pont *et al.*, 2021). Higher-density cities are often associated with increased crime, crowding, and a lack of affordable housing, but also with less segregation (Burton, 2000). Simultaneously, some researchers argue that densification can lead to *more* segregation (Kim, 2016; Cavicchia and Cucca, 2020) and exclusion (Cavicchia, 2022; Debrunner, Jonkman and Gerber, 2022). More generally, researchers criticizing the adverse social effects of densification claim that there is a tendency to prioritize environmental and economic benefits in sustainability discussions, potentially sidelining social concerns (Immergluck and Balan, 2018; Kremer, Haase and Haase, 2019). As Quastel et al. (2012) put it, a *"particular interpretation of urban sustainability came to prevail – one that stressed the built urban form but which effectively sidelined issues of inequality in cities"* (p. 1056).

Many findings on the (social) effects of densification remain inconclusive. This is also one of the main critiques, leading researchers to call densification efforts "*controversial*" (Bramley *et al.*, 2009, p. 2125). The authors of the above-mentioned studies acknowledge that densification effects differ depending on how densification is measured (e.g., building density vs. population density) and at what scale (Berghauser Pont *et al.*, 2021). The study results are often based on comparing cities or neighborhoods with varying densities. The conclusions drawn may thus not be transferable to other regions because the context in which density is measured plays a role: Culture influences transportation choices independently of densities (Buehler, 2011), and climate can modify the impact on energy usage, such as heating needs (Rinkinen, Shove and Smits, 2021).

Most importantly, different forms of densification, such as the achieved density, morphology, and extent of the development, can significantly alter its effects. For example, while moderate densification has been observed to lower segregation in the United States, extreme densification appears to have the

opposite impact (Pendall and Carruthers, 2003). Additionally, many positive effects, such as promoting sustainable transportation choices, diminish beyond a certain density level (Eom and Cho, 2015). The building morphology can influence the impact of densification on energy consumption (Rinkinen, Shove and Smits, 2021), and the size of densification projects affects how disruptive they are to existing neighborhoods. Finally, the type of densification process has a significant role to play: Interestingly, while a general loss of green space is expected with densification, a study by Wellmann et al. (2020) suggests it has contributed to more urban green in Berlin. And while redevelopment projects that demolish existing dwellings displace residents, infill development avoids this disruption. Additionally, government policies that protect existing residents or mandate affordable housing quotas in new developments can further influence the social effects of densification (Rosol, 2015). In this spirit, Burton (2000) ascribes some of densification's adverse social effects to the British planning system *"that does not necessarily represent best practice in the execution of higher-density environments"* (p. 1988).

Thus, in addition to attempts to arrive at generalizable sustainability effects of densification, it is crucial to consider the various forms it can take on. Acknowledging that densification takes on different forms turns it into a political question. Since higher densities can be achieved through multiple interventions, the prevailing forms are partially determined by negotiations between citizens, local government, and landowners (Charmes and Keil, 2015). This raises questions about who decides on the forms densification takes and what possibilities exist for steering it. Land policy thus becomes central to the inquiry.

1.2 Land policy and the different forms of densification

Governments develop land policies to steer spatial development. They can thus influence what forms of densification prevail (Dembski *et al.*, 2020). Of course, land policies are just one of many factors shaping urban densification patterns: densification is unlikely to occur in areas with no demand for additional housing, and no brownfield redevelopment can happen without brownfields. However, it is especially relevant to consider land policy since it is a political product – therefore, it has to be evaluated and, if necessary, adapted. Thus, land policies are a critical factor because they can be changed through democratic processes. Governments can affect densification by (1) determining the degree to which they enable/allow it in various areas and (2) influencing the forms that individual densification projects take on (Bibby, Henneberry and Halleux, 2020).

Traditionally, the role of local governments was not to enable densification but to prevent excessive density, both for aesthetic and hygienic reasons (Angel and Lamson-Hall, 2014). They have done so through zoning. Therefore, changing the zoning plan can make room for higher densities (Greenaway-McGrevy and Phillips, 2023). However, this is often insufficient, as landowners are not forced to follow zoning changes or exploit maximum allowed densities (Hartmann and Spit, 2015). Many existing densification potentials in cities are not being exploited, be it because the landowners cannot or do not want to develop (Korthals Altes, 2019). Sometimes, landowners wait for land prices to rise before they develop. In this case, the question is whether municipalities have instruments that force landowners to build (e.g., through building obligations). But often, development is not feasible because of neighbors

who are against the development or regulations (e.g. noise) that inhibit development (Herdt and Jonkman, 2021).

Assuming municipalities possess instruments to enable densification, where do they apply them? Upzoning is often targeted at specific areas, usually lower-income neighborhoods where resistance is expected to be lower (Charmes and Keil, 2015). Conversely, instruments restricting densification are frequently applied to affluent neighborhoods (e.g., bans on garden-grabbing) (Dunning, Hickman and While, 2020). Next to the consideration of citizen protest, the location chosen for densification reflects the municipality's goals. For instance, densification might be combined with strategies to revitalize city centers (Giddings and Rogerson, 2021) or promote social mixing in disadvantaged neighborhoods (Kim, 2016).

Lastly, municipalities can try to steer the outcome of individual projects, again aligned with their overall strategy. Municipalities aiming to strengthen their economic position might prioritize large-scale developments, while smaller ones seeking to preserve their character might choose more subtle forms like "soft densification" (Touati-Morel, 2015). Zoning regulations are a primary tool for steering these outcomes, but other instruments exist. Municipalities who own land can choose to sell or lease it to non-profit housing providers. Thereby, they can set up private law contracts, allowing them to determine even detailed regulations, such as putting a limitation on rents (Gerber, Nahrath and Hartmann, 2017).

In other words, *"[d]ensification is the result of planning policy and the application of instruments to regulate land use, which can be a deliberate strategy, an unintended consequence of planning policy, or the lack of enforcement"* (Dembski *et al.*, 2020, p. 211). Through the forms it takes on, densification reveals power relations between actors and exposes whose interests are prioritized (Charmes and Keil, 2015).

1.3 Spatial analysis for capturing land policy effects on densification

Most research on land policy effects on densification cited above is based on qualitative case studies. Such case studies allow for an in-depth analysis of municipalities' land policies and for establishing causal relationships between these policies and densification outcomes through process tracing (Blatter and Haverland, 2014). Furthermore, qualitative case studies allow for describing the sustainability of infill projects in ways that are difficult to capture quantitatively. For example, qualitative research can assess the degree to which citizen requests were implemented in the project, the quality of its architecture and design of facades, or the degree to which it solves or worsens parking issues in the neighborhood. However, qualitative case studies have limitations. While they can showcase unique or extreme cases, they do not capture the full spectrum and spatial distribution of densification outcomes.

Spatial analysis encompasses methods ranging from mapping and data visualization to spatial joins, in addition to describing spatial data characteristics like morphometry, distribution, clustering, and heterogeneity (Samsonov, 2024). By incorporating spatial analysis, we can explore the variety of densification pathways and the social effects connected to these. This enriched understanding is essential for a more nuanced discussion on densification effects. In addition, spatial analysis can be

used to map spatial patterns of densification *across* regions and municipalities. This allows for comparisons that illustrate how different policies steer densification outcomes based on which we can build hypotheses about policy effects. We can also observe changes over time, identifying shifts in densification patterns (e.g., the potential exhaustion of brownfield development or the rise of replacement buildings) and examining the underlying drivers of such trends. For practitioners and researchers alike, such comparisons across time and space are essential to understand one's own context better and evaluate past planning efforts (Van Assche, Beunen and Verweij, 2020), but so far, their potential is far from exploited (Long and Robertson, 2017).

Spatial analysis can contribute to our understanding of the effects of land policy (the independent variable) on spatial development (the dependent variable) by showing the variety of densification outcomes and comparing densification patterns across space. Ultimately, this allows for more conscious planning that balances reduced space consumption with maintaining urban quality of life for all residents.

1.4 Research aims and questions

In this introduction, I have shown that knowledge gaps prevail regarding (1) the different forms that densification takes on and their social effects, (2) the influence of land policy on these densification outcomes, and (3) the possible contribution of spatial analysis to addressing such questions on land policy effects on spatial development.

Against this background, I aim to explore the contribution of spatial analysis to building hypotheses about land policy effects on densification. Concretely, I ask: *How does the comparison of densification patterns contribute to tracing land policy effects?*

I approach this question by posing the two sub-questions:

1. *What densification patterns emerge across countries and municipalities?*
2. *How does land policy possibly explain the observed differences?*

Three research articles address these questions, focusing on different scales of comparison in the context of urban densification in Bern, Switzerland, and Utrecht, the Netherlands. Specifically, the three articles focus on (1) the effect of institutional regimes on densification patterns across countries, (2) the effect of applied policy instruments on the outcome of individual development projects, and (3) the effect of municipal strategies on the application of policy instruments.

In the following chapters, I will build up to these methodological choices by conceptually combining land policy and spatial analysis and defining the variables and their theoretical relationship.

2 Theory

This chapter introduces the main variables of my thesis, land policy, and densification outcomes, and establishes the connection to spatial analysis. It begins by defining the independent variable, land policy, and its position within the broader institutional context. Next, it focuses on the dependent variable, the densification outcomes, by specifying the aspects of the densification outcome affected by land policy. Finally, I explore the application of spatial analysis to measure urban densification in a way that captures land policy effects. Based on this, I build a conceptual framework and hypotheses that will lead my analysis.

2.1 Land policy for densification

Land policy is the strategy that a municipality pursues to achieve its goals. Municipalities develop land policies within a framework of institutions and actors. Land policies build on a *"careful appraisal of power relationships between actors"* (Gerber, Hengstermann and Viallon, 2018, p. 11). Before describing land policy, I will set this institutional background and the problems around densification that land policies aim to address.

2.1.1 Barriers to sustainable densification

The issues around densification that municipalities address through land policy center around (1) ensuring *that* densification happens and (2) ensuring that densification happens sustainably. While there is potential for densification in many areas, these sites often remain un- or under-developed. The reasons for this lack of development can sometimes be found in the landowners. Landowners may be deterred from developing for various reasons. Some speculate on future profits, delaying development until conditions are more favorable (Korthals Altes, 2019). Others may lack the resources to develop immediately or have sentimental attachments to the land, prioritizing factors beyond pure profit (Buitelaar, Segeren and Kronberger, 2008). Additionally, fragmented ownership can hinder progress. If one landowner desires development but others do not, developing a single plot can be impractical, leading to an impasse until consensus is reached (Buitelaar and Segeren, 2011). Furthermore, neighboring landowners may wield veto power or have established agreements (e.g., view protection) that can obstruct development (Elvestad and Holsen, 2020).

Beyond landowners, citizen concerns can impede densification. Residents may put pressure on the municipality because they fear upzoning will negatively impact property values or disrupt their community's socioeconomic makeup (Rousseau, 2015). The better organized citizens are, the more successful they often are at preventing densification. Therefore, densification occurs disproportionately in low-income neighborhoods (Charmes and Keil, 2015).

However, municipalities not only struggle with *enabling* densification in strategic areas (e.g., near public transport) but also with steering the development outcomes. After all, the resurgence of cities (Kabisch, Haase and Haase, 2019; Rérat, 2019) has spurred redevelopment activities in many areas. Intense pressure can lead to undesirable outcomes, such as office-to-rental transformations or subdivision of apartments with insufficient living standards and potential crowding (Remøy and Street, 2018; Bibby, Henneberry and Halleux, 2021). Additionally, concerns arise regarding the demolition of existing housing for luxury redevelopment (Debrunner, Hengstermann and Gerber, 2020).

These issues highlight the complex interplay of actors and their rights within an institutional regime. Actors pursue their goals (whether to spur densification or prevent it), and institutions empower or constrain their actions through established rights. Understanding this context is crucial before exploring municipal strategies to navigate these challenges.

2.1.2 Actors and the institutional regime

New institutionalism emphasizes that spatial development is shaped by the interplay between institutions and actors' agency (Lowndes and Roberts, 2013). Institutions are sets of rules, formal (written laws) or informal (norms and traditions), that guide actor behavior (North, 1990). They constrain actions but also evolve as actors interact with them (Lowndes, 1996). This section explores how institutions influence public and private actors involved in land-use planning.

Institutions constrain actors' room for maneuvering but also provide them with instruments to pursue their interests. This central dichotomy is addressed in the institutional resource regime (IRR) framework, which can be used to analyze causal relationships between institutional regimes, the users of a resource, and the state of the resource (Gerber, Lieberherr and Knoepfel, 2020). The resource regime encompasses public policies and property rights, thereby affecting the scope of action of public and private actors. Property rights grant landowners the right to control the use of their land. A country's constitution usually strongly protects them as an inviolable right. On the other hand, public policies constrain these property rights, defining the extent of government intervention. Public policies are legitimized by laws, target a specific problem in the public interest, and define target groups whose behavior needs to change to solve the problem; they also designate the public actor responsible for enacting the desired change and, importantly, define the policy instruments for achieving the stated goals (Knoepfel *et al.*, 2007). The IRR framework can be applied to analyze the use of the resource land. In the context of land use, land use planning is the central public policy. It aims for coordinated land use and is backed by the Planning Act. It also provides various governmental actors with instruments to intervene in property rights.

Institutions thus balance power between public and private actors, and, in addition, they create power asymmetries across resource users (Gerber and Debrunner, 2022). For instance, landowners have more control over land use than other resource users. They do not have to adapt to zoning changes on their land, and through veto rights, they can prevent the development of neighboring plots. As such, institutions determine who participates in the planning process and what their roles in this process are. Planning law defines citizen rights, specifying their level of influence and when they must be heard.

Translated to the context of densification, the institutional regime affects municipalities' scope of action. The institutional regime (property rights and public policies) provides the instruments (e.g., zoning, taxation, pre-emption rights, building obligation) that municipalities can use to pursue their interests, but it also affects the extent to which resource users can resist these interests (e.g., public hearing, veto rights). However, municipalities act strategically and decide whether and how to use the instruments provided by the institutional regime. These decisions significantly impact the influence of private actors. For instance, using zoning plans solely limits developer involvement compared to project-based planning, which grants developers more influence through negotiation with municipalities (Knoepfel *et al.*, 2012). Within the same institutional regime, municipalities can act very differently, making it essential to both institutions and municipal strategies within these frameworks (Eichhorn *et al.*, 2024). The following section will delve deeper into such municipal land policies.

2.1.3 Land policy

Municipalities are central actors in urban planning. This section focuses on their actions and the instruments they use to achieve their strategic goals. Municipalities use the instruments provided by land use planning and other public policies. However, they can also leverage private law instruments to achieve their objectives. Gerber et al. (2018, p. 9) define land policy as *"the strategic combination of instruments carefully thought through by public authorities in order to impose themselves in front of other private (or public) interests and reach public planning objectives"*.

Municipalities' primary planning instrument, zoning, offers limited control of urban development. The zoning plan defines each parcel's allowed land use and maximum building height. As such, it is very effective in preventing densification from happening. However, zoning is less suitable for enforcing densification, as it cannot compel landowners to develop (Gerber, Hartmann and Hengstermann, 2018). Also, the aspects of a development that the zoning plan can influence are rather limited. For example, it is often impossible to specify the share of affordable housing in the zoning plan. This highlights the need for a broader toolkit beyond land-use planning alone. The term "land policy" reflects this broader strategy, encompassing public and private law instruments. In the most extreme case, municipalities can become landowners, gaining far-reaching control over development. They can develop the land directly or enter into private law contracts with developers, offering more influence than zoning allows.

Zoning and public landownership are examples of policy instruments that municipalities can use. Other examples are pre-emption rights, building obligations, or taxation. The effectiveness of these instruments depends on the degree to which they intervene in property rights. They range from instruments with no effect on property rights to instruments that affect property rights to instruments that redefine property rights (Hengstermann and Hartmann, 2018).

Similar to other actors, municipalities strategically choose instruments (Gerber, Lieberherr and Knoepfel, 2020). Generally, instruments with a greater impact on property rights are more challenging to implement. Fear of discouraging investors may lead them to avoid instruments like those promoting affordable housing (Debrunner and Hartmann, 2020) or imposing building obligations (Hengstermann, 2018). As stated above, a particularly powerful strategy is for municipalities to acquire land themselves,

enabling the use of private law instruments. However, this approach requires significant upfront capital and can be politically controversial. Additionally, financial risks are a concern, as exemplified by Dutch municipalities scaling back public land ownership after suffering great losses during the financial crisis (van Oosten, Witte and Hartmann, 2018).

Municipalities differ not only in terms of which instruments they apply but also in what they apply them for. These goals typically build on the *"economic, social and geographical position of municipalities within larger urban areas"* (Touati-Morel, 2015, p. 603). As such, densification may be used to revitalize deprived neighborhoods by increasing real estate values, potentially leading to gentrification (Quastel, Moos and Lynch, 2012), or to strengthen a city's regional position (Touati-Morel, 2015). Municipalities can influence the type of densification, promoting some forms while discouraging others. Sometimes goals overlap, or municipalities may choose to ignore their own regulations, as seen in Utrecht's ban on subdivisions that is not consistently enforced due to the city's need for additional housing (Bouwmeester *et al.*, 2023). These examples illustrate how densification is ultimately shaped by land policy, either through active steering or inaction (Dembski *et al.*, 2020).

In this chapter, I defined land policy as municipalities' strategic use of instruments to achieve their goals. I showed that these policies depend on (1) the institutional regime (determining which actors are part of the planning process and which instruments public and private actors can apply to pursue their interests) and (2) the municipal development goals (influencing which instruments they apply and how they apply them.

Seen from the other side, densification outcomes can be understood as a result of the instruments that were applied in the planning process of individual projects and the strategy with which municipalities applied the instruments, which, again, is based on an appraisal of power relations between actors in a given institutional regime. In the following chapter, I examine how land policy affects the built environment and which methods allow us to trace back policy effects by measuring densification.

2.2 Densification outcomes affected by land policy

This chapter defines this dependent variable – the densification outcome – answering questions about how to define densification from a land policy perspective, and what aspects of densification are affected by land policy.

2.2.1 Defining densification

Taking the goal of reducing land take as a starting point, densification can be defined as all such urban development that is not considered greenfield development (also termed expansion or sprawl). Definitions of densification determine where exactly the line between densification and greenfield development goes. The exact definition can vary greatly depending on the policy goal. The European goal of "no net land take" aims at reducing urban expansion to zero. However, there's a lack of consensus on what constitutes urban expansion. National governments often adopt a rather pragmatic approach, classifying construction within designated growth boundaries as inward development, reserving the term "expansion" for projects exceeding these limits.

For example, the Netherlands employs buffer zones around cities – red lines that municipalities should not cross, but which a regional government can expand if necessary. In Switzerland the policy of inward development covers all construction on existing building zones and aims at avoiding further expansion of these zones. Under this approach, even development outside a city, converting agricultural land to residential, can be considered inward development as long as it occurs within designated building zones. These discrepancies make comparisons of densification efforts across countries challenging (Debrunner and Hengstermann, 2023).

For effective comparison, a more general distinction between inward development and expansion is necessary. As my focus is on densification as a complex planning process navigating various interests and rights, I limit the scope to urban areas. In this way, I deviate from "no net land take" definitions. For instance, redeveloping greenhouses into housing could be considered densification from a land take perspective. But the planning process, which is at the center of my analysis, is equal to greenfield development. Therefore, I do not count greenhouse redevelopment as densification. Similarly, development on sports fields, allotment gardens, or parks could be viewed as land take because it expands the sealed area. However, because these are existing urban land uses, I consider them forms of densification.

Having defined *where* development qualifies as densification, we must also consider *what* development is considered densification. Given my focus on the social effects of densification, my primary concern is housing units (apartments or buildings) constructed on urban land. I will not consider densification of industrial or commercial buildings. Also, I will not consider the densification of people independently from building change (e.g., due to a general shrinking in personal living space). While this phenomenon is interesting and potentially connected to land policy, it is not directly related to construction and, therefore, falls outside the scope of this study.

In addition, I deviate from a strict environmentalist definition, where densification must involve an increase in population density in addition to the increase in building density. In some cases, infill development can lead to decreased population density (e.g., replacement construction where the former residents consumed less living space than the new ones). One could even require that for development to be called densification, user densities must be higher than the neighborhood average. This is where the term “infill” deviates from “densification” and would be a better fit for describing development on urban land, not regarding the density increase as a defining condition. However, since the policy goal is densification, I will continue using the term while acknowledging these cases as less effective or even failed examples of densification. Including these scenarios in the definition is still important because they represent a unique form of infill development, and their prevalence warrants further investigation into the underlying causes. This will be explored in more detail in the following section.

Therefore, for this study, densification refers to all housing units constructed on existing urban land uses. Having established the dependent variable, we can now explore the aspects of densification likely influenced by land policy.

2.2.2 Densification outcomes affected by land policy

Institutional research often focuses on how institutions influence actor behavior and resource management, including planning processes. However, a gap exists regarding how these planning processes manifest in space, i.e., land policy effects on spatial development.

The concept of "land policy effects" requires a definition within my research. Public policy analysts typically evaluate public policy effects by comparing the *intended* change in actor behavior to the *actual* change in actor behavior (Knoepfel *et al.*, 2007). On the contrary, my quantitative approach examines the broader impact of land policies on spatial development patterns, not comparing them to the specific goals pursued by individual municipalities. These goals are difficult to discern through a purely spatial lens. However, by analyzing spatial development patterns, I can identify potential "traces" of land policy influence. My research question, therefore, centers on how spatial development reflects the influence of land policy. As Dembski et al. (2020, p. 211) state, *"[d]ensification is the result of planning policy and the application of instruments to regulate land use, which can be a deliberate strategy, an unintended consequence of planning policy or the lack of enforcement"*. I compare densification with an interest in social effects, but not to compare degrees of sustainability. Land policy, as Puustinen et al. (2022, p. 1) point out, determines *"where and how densification takes place, who will benefit financially, and how the benefits are distributed between public and private actors"*. I will here focus on the extent of densification compared to greenfield development, the location and processes of densification, and project outcomes regarding density, morphology, and resident structure.

Densification share. The extent of densification compared to greenfield development is a common metric for evaluating policy effectiveness (Siedentop and Fina, 2012; Colsaet, Laurans and Levrel, 2018; Koomen, Dekkers and Broitman, 2018). This analysis can be extended beyond the share of infill development to consider the achieved density increase, encompassing both population and building density.

Location. The location of infill development can indicate a municipality's success in enabling densification. If a municipality is well equipped to intervene in property rights, one could expect more densification under complex planning conditions (e.g., fragmented landownership) and at strategic places (near public transport). Conversely, the location of infill development can also reveal where enforcement is lacking or where municipalities actively restrict development due to citizen opposition. This can lead to disproportionate densification in low-income, already dense neighborhoods, such as the skewed upzoning policy of Auckland (Cheung, Monkkonen and Yiu, 2023).

Transformation processes. The prevalence of specific transformation processes can reveal power dynamics among real estate actors. This is because different actors participate in various processes, and some processes are inherently more complex. For example, soft densification is comparatively simple and achievable by smaller landowners, whereas redevelopment requires larger investors (Rérat *et al.*, 2010). Across planning systems, citizens can be given more or less power to prevent unpopular forms of densification, possibly showing in the prevalence of urban green space redevelopment. Likewise, the prevalence of large-scale redevelopment can hint at strong government intervention, while

soft densification processes can happen unplanned (Bibby, Henneberry and Halleux, 2020). Municipalities can directly prohibit unpopular processes, such as garden grabbing (Dunning et al., 2020), and align the prevalence of processes with their development goals. The latter was illustrated by Touati-Morel (2015), suggesting that suburban municipalities strategically choose between more and less intervening forms of densification depending on their development goals.

Morphology. Morphology is a well-researched aspect of densification outcomes influenced by institutions and land policy—for example, Tennekes et al. (2015) examine the effect of institutional regimes on the morphology of newly built single-family neighborhoods. They emphasize analyzing morphology across scales: city-level (dispersion, compactness, ribbon development), project-level (road hierarchies, development geometry, amenity clustering), and street-level (house design and housing type heterogeneity). In a similar vein, Jehling and Hecht (2021) discuss the impact of regional planning and land management on various morphological metrics, such as the heterogeneity of single-family houses. Both studies understand morphology as a (possibly unintended) result of the institutions in place and not necessarily a conscious land policy decision. But morphology can also have political meaning (Charmes and Keil, 2015, p. 591). This perspective considers metrics like housing forms (high-rise vs. low-rise, detached vs. multifamily), the presence of public or private green spaces, and overall density—planned or allowed by the municipality or influenced by developer decisions.

Housing offers and residents. Land policies differ in their degree of influence on the socio-economic groups targeted for new housing. Researchers often criticize that without active intervention, private investors will primarily develop housing unaffordable to most citizens (Cavicchia, 2023). Therefore, many municipalities implement housing strategies to address under-supplied housing types, considering metrics like age, family needs, and affordability. While their power to directly control resident demographics is limited, municipalities can indirectly influence this by controlling housing offers (apartment size, garden access, etc.) and by pursuing strategies of neighborhood upgrading (Rousseau, 2015). Therefore, analyzing not only the socio-economic composition *within* a development project but also *how it compares* to the surrounding neighborhood is crucial. In addition, and as a consequence of prioritizing development for the wealthy, critiques point to a rise in personal living space. As this further undermines the policy goals of densification, some researchers advocate for municipal regulation of maximum living space (Debrunner and Hengstermann, 2023). Comparing personal living space in new developments across regions relative to surrounding neighborhoods can again provide insights into policy effects.

This review highlights the various metrics – extent, location, transformation process, morphology, housing offer, and residents – along which densification outcomes can diverge, influenced by planning decisions. These metrics constitute the dependent variable in my study. Existing research on these metrics has primarily been qualitative, focusing on how municipalities regulate individual aspects. Few studies have examined several metrics together for a holistic comparison of densification patterns across regions, and data is often unavailable at the necessary level of detail.

2.3 Spatial analysis of densification patterns

Having defined the dependent variable, a critical question remains: how can spatial analysis methods be leveraged to approach questions on the effects of land policy on spatial development?

Spatial analysis, together with data capture, spatial modeling and visualization, are components of GIScience. (Buttenfield, 2022). A unifying characteristic is their use of spatial data, where each observation has a geographic location (typically represented by x and y coordinates). Spatial analysis, a core component of GIScience, encompasses methods ranging from mapping and data visualization to spatial joins, in addition to describing spatial data characteristics like morphometry, distribution, clustering, and heterogeneity (Samsonov, 2024). These methods are often combined and used in both data preparation and analysis phases.

Social science research widely utilizes spatial analysis (Rey and Franklin, 2022; Kent and Specht, 2024). It empowers researchers to access and integrate diverse data sources with varying spatial and temporal resolutions (Buttenfield, 2022). In social sciences, spatial analysis is frequently employed to map and understand phenomena like inequality, gentrification, and neighborhood change (Rey and Franklin, 2022). A central objective often involves exploring relationships between observed spatial patterns and underlying spatial processes: *"identifying what drives the detected trends and global patterns, why local anomalies of high or low values are present, or what interactions give rise to different spatial configurations of features"* (Robertson and Long, 2022, p. 85). In this context, spatial analysis excels at revealing trends, patterns, and disparities, making it a valuable tool for exploratory analysis and hypothesis generation. While it provides associative evidence, it is typically not used to establish causal relationships due to the often-complex temporal separation of cause and effect, the influence of numerous intervening factors, and the inherent "noise" within data (Robertson and Long, 2022). For example, showing that house prices are higher in a city with a green belt (functioning as an urban growth boundary, such as in London) compared to an otherwise similar city without a green belt does not prove that the green belt causes the high house prices and that prices would be lower without the boundary, it just shows covariation. Still, comparisons are a central tool for studies that aim at inferring causal relationships between observed patterns and underlying processes. This is because of the central role in comparisons in detecting changes, assessing models and collecting reference data (Robertson and Long, 2022). I will now review applications of spatial analysis to the question of land policy effects on spatial development, focusing on comparisons.

With spatial analysis, one can measure the individual metrics addressed above and compare across countries, for example, the share of densification or densification effects like housing affordability or green spaces. However, spatial analysis can also be applied to cluster more than one metric, thereby comparing densification patterns. For this, planning researchers frequently make use of typologies, for instance, to assess residential segregation or walkability across neighborhood types (Berghauser Pont, Stavroulaki and Marcus, 2019; Boterman, Musterd and Manting, 2021). To create a typology, several metrics are combined. The chosen (composite) metrics can then be mapped, and their spatial distribution described. Such mapped patterns can be assessed purely visually or by using metrics of spatial distribution, such as Moran’s I, that can be used to quantify spatial dispersion or spatial

clustering. The mapped patterns allow for comparison that can be used to assess differences between regions or between points in time. Thereby, pattern comparison is well suited to illustrate a variation in outcomes. However, comparison can also be applied to understand the processes that shape observed patterns. Comparisons can be conducted across time, space or by contrasting modeled and real patterns (Long and Robertson, 2017).

An example of a comparison across time is the study by Claassens et al. (2020) on the effects of land policy changes on densification patterns. In particular, they examine the prevalence and spatial distribution of transformation processes (e.g., greenfield development, brownfield redevelopment, residential infill) before and after the deregulation of the Dutch planning system. They thus attempt to isolate the effect of planning by assuming that all other important variables remained stable over time.

On the other hand, comparisons can be conducted across space – ranging from across countries to across single projects within the same city. While comparisons across countries can capture the effects of contrasting planning systems, comparisons within regions can reveal differences in municipal strategies within the same planning system (Bibby, Henneberry and Halleux, 2020; Jehling, Schorcht and Hartmann, 2020). Comparisons across space can be further divided into studies using *similar* cases (where everything apart from the land policy is similar) and studies using *contrasting* cases (where both land policy and other variables differ).

Researchers compare spatial patterns across *similar* regions in an attempt to isolate planning effects. Economists often utilize this method, for example, when comparing house price development between areas *with* implemented upzoning (i.e., areas that received a “treatment”) and areas *without* implemented upzoning (i.e., a control group), keeping all other variables equal (Greenaway-McGrevy, Pacheco and Sorensen, 2021). Likewise, in planning literature, it is common to compare urban forms across border regions that differ in terms of land policy but are otherwise similar. The comparison can be qualitative (by visually assessing differences in urban form, as done by Tennekes, Harbers and Buitelaar, 2015), or quantitative (by assessing what variables computer models use to distinguish between urban form across a border region, as done by Jehling and Hecht, 2021).

In a similar vein, Chakraborty et al. (2022) compare three economically similar but differently governed regions in Belgium. Instead of comparing densification outcomes, though, they compare the explanatory power of densification drivers, thus comparing densification *processes* rather than outcomes. Specifically, they develop a regression model that predicts densification based on 18 socio-economic, political, and topographical drivers. Comparing the variables’ explanatory power, they find that the effect of neighborhood income or the distance to the nearest park differs across the three cases.

Also, Verstegen and Goch (2022) use the approach of comparing drivers of urban development, though not focused on densification. Contrary to the previous study, they do not employ a regression model but a spatial simulation model, testing how well it predicts growth in mono- versus polycentric regions and based on which variable weighting. More importantly, while the first study fits *different* models for different regions, the latter compares the fit of the *same* model across regions**.** Verstegen and Goch are interested in comparing modeled outcomes to real development patterns and use this as a basis to

discuss possible ways in which the planning systems of the three countries shape these patterns. For this, they choose *contrasting* regions (Warsaw, Milan, and Dublin), intending to show maximum variation. Comparing modeled to real patterns is a way of measuring how expected relationships play out in reality. Especially instances where the model does not explain real development are interesting cases for further study (Long and Robertson, 2017). The residuals of a model (the mispredicted cases) can be mapped, and their spatial distribution can be analyzed.

In summary, spatial analysis provides associative evidence between spatial processes and spatial patterns. It is used to show and explain variations in spatial patterns. Central to this is the comparison of spatial patterns across time and space or between modeled and observed patterns.

2.4 Combining land policy and spatial analysis

I introduced land policy and its possible effects on densification outcomes in the previous chapters. While land policy is classically a subject of policy analysis, rooted in new institutionalism, I aim to explore the contributions of spatial analysis to capturing land policy effects on densification. While policy analysis aims to understand how political decisions are made, spatial analysis aims to describe spatial patterns. In combining the two approaches, policy analysis provides a framework for understanding how actors and the institutional context influence spatial outcomes at various scales. Municipalities operate within these contexts, formulating policies and employing instruments to achieve desired outcomes. Spatial analysis then provides the tools to understand the resulting spatial patterns.

Combining these approaches offers significant value. With knowledge of the interaction between institutions and actors, spatial analysis can be more targeted at measuring spatial development in a way that allows for building hypotheses about land policy effects. Here, institutional theories and literature provide the mechanisms to explain causal relationships – thereby adding plausibility to the observed associative strength as criteria for causality (Hill, 1965). In addition, institutional theory helps spatial analysts deal with multicausality by providing knowledge on other processes that could explain the observed pattern. Multicausality is a dominating problem in planning research where many actor rationales and regulations overlap.

For policy analysis, spatial analysis provides crucial evidence of spatial outcomes. This is especially valuable for comparing institutional regimes or studying how regimes change over time. By taking these considerations into account, we can effectively discuss the influence of land policy on spatial development. Spatial analysis can thus be used to test such institutional theories on a large scale, especially by providing evidence of cases that do not correspond to the existing theory, or by testing and comparing the evidence for competing theories (Robertson and Long, 2022).

The strength of my approach lies in its large-scale perspective that allows for showing the variation in densification outcomes across countries, municipalities, and projects, followed by a discussion of possible land policy effects on these densification patterns. However, this breadth necessarily comes with limitations. In-depth institutional analysis becomes impractical as covering all institutions and municipal land policies in a region is difficult. Neither is a large-scale spatial analysis suitable for

comparing the land policy objectives of individual municipalities to actual development. Such an evaluation of policy effectiveness is also made difficult by the fact that the data for relevant metrics is not accessible or not in the necessary level of detail. Even if possible, isolating the effects of land policy within a complex system remains challenging.

Land policy and spatial analysis have been combined before, as I have shown in section 2.3. However, previous research was often kept narrow in an attempt to isolate cause-effect relationships. In economic research, this has led to reducing the planning variable to a simple indicator of restrictiveness (Ehrlich and Overman, 2020). In planning literature, researchers tend to focus on the morphology of single-family areas, arguing that planning effects are visible most clearly in these areas. Contrarily, my starting point is the diverse outcomes of densification and their social implications. I am particularly interested in the housing offer, affordability, and the socio-economic target groups of densification. I measure these densification outcomes because they are central to discussing who benefits and who loses from densification.

2.5 Conceptual framework and hypotheses

To answer my research question, *"How does the comparison of densification patterns contribute to tracing land policy effects?"* I conceptualize spatial analysis methods within theoretical assumptions of densification as an outcome of interactions between institutions and actors. This approach is also reflected in my two sub-questions:

1. *What densification patterns emerge across countries and municipalities?*
2. *How does land policy possibly explain the observed differences?*

Throughout Chapter 2, I operationalized *land policy effects* and referred to three levels: (1) the institutional regime that determines which policy instruments municipalities can use, (2) the application of policy instruments that affect municipal influence on individual developments, and (3) the municipal strategy (as an intermediary variable) that affects if and how municipalities apply instruments. These are the focus points of the three research articles. Figure 1 summarizes these variables and expected relationships.

Each article thus builds on (1) a theoretical assumption (hypothesis) on the relationship between land policy and densification outcomes and (2) a methodological assumption on a spatial analysis approach that allows for capturing these relationships in space. The assumptions are to be understood as a guide for my analysis since they concretize underlying assumptions of the relationship between dependent and independent variables. I will structure my discussion of results along with them, but it is not the goal to ultimately verify or falsify them. Table 1 presents my hypotheses.

Table 1 Hypotheses

Hypothesis for land policy effect on densification patterns	The institutional regime determines what instruments municipalities can choose from to steer densification outcomes. This affects their ability to assert their interests against the interests of other actors, which is ultimately reflected in the evolving densification patterns.	By applying policy instruments to specific development projects, municipalities can increase their control over these projects' characteristics. Since municipalities are public actors, they are expected to pursue goals that are in the public interest. Therefore, municipalities will try to use their power to create more sustainable densification projects than what would happen without their intervention.	Municipalities apply instruments according to their strategic goals. Their strategies vary in the degree to which (1) they are generally willing to intervene in property rights and (2) they support densification (in low-density neighborhoods). Strategies differ according to a municipality's location within a region: While central municipalities need to accommodate growth, suburban municipalities can actively prevent densification. Rural municipalities may not dare to intervene in property rights for fear of scaring off investors.
Scale on which policy effect shows and indicators to capture the effect on the densification outcome	Across countries. Institutional effects will show in the prevalence of densification processes and spatial distribution of densification types regarding created density, housing offer, and resident structure. In contexts where municipalities have more control over development, the produced housing offer and targeted socio-economic groups will align more with policy goals. In institutional regimes where citizens control which development gets approved, less "unpopular" forms of densification will exist, such as redevelopments of urban green spaces or densification in high-income, low-density neighborhoods.	Across projects. A project that deviates from market expectations toward the public interest is probably a project that a municipality interfered in.	Across municipalities. Differences across municipal strategies show in the degree to which they apply a specific policy instrument, the developments and the locations they apply it to, and the density they reach by applying it.

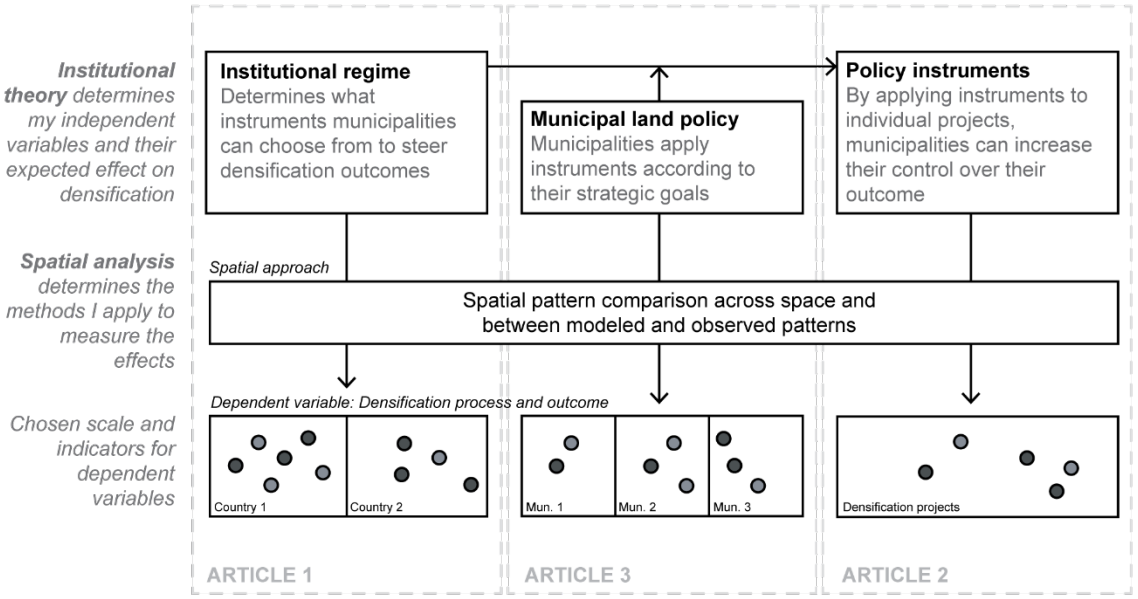


Figure 1 Conceptual framework

3 Research design

Having specified my research questions above, this chapter introduces my research design. To begin with, I will briefly discuss my positionality, which influences the chosen research approach. I will then discuss this approach, followed by an overview of the methods that run through all articles and, ultimately, a presentation of my cases: the regions of Bern, Switzerland, and Utrecht, the Netherlands.

3.1 Positionality

To provide context for my research question, I revisit my positionality, as it sheds light on my interest in integrating policy analysis and spatial analysis. This doctoral thesis emerged from an SNF research project named “Goverdense”. Alongside Jessica Verheij and Josje Bouwmeester, we were three PhD candidates tasked with comparing densification patterns in the Netherlands and Switzerland. While the other two focused on case studies, my role involved supporting the project using a geodata-based approach. As a planner by training, this was uncharted territory for me, having only previously conducted qualitative case studies and interviews. Consequently, my initial research questions were qualitatively oriented – I sought to understand how planning systems in the two countries influenced densification patterns. However, I suddenly found myself constrained by a quantitative approach. This felt restrictive, as my qualitative questions could not be directly addressed with geodata. Naturally, I explored ways to address these questions within the given framework. Over time, this prescribed approach also influenced my perspective. I believe that qualitative case studies can inadvertently lead to a focus on the negative aspects of densification, as they often examine individual projects where densification went “wrong” – where planners lost control, existing residents were displaced, public green spaces enclosed, and promised shares of affordable housing were not kept. While these projects undoubtedly warrant investigation, the quantitative approach compelled me to view the broader picture, gradually convincing me that these negative portrayals do not represent the entire reality – densification is not inherently connected to loss of green spaces and the creation of small, luxurious apartments. It is also therefore, that showcasing the diverse ways densification can manifest is of such central importance to me.

3.2 Choice of approach

At the core of my research was the question of how land policy manifests in space. This question can be approached from two sides – analyzing policies first and then looking for their effects on spatial development (effect of cause) or analyzing spatial development first and then discussing the observed patterns in the light of land policy (cause of effect) (Rohlfing, 2012). I chose the latter approach since I aimed to develop a large-scale approach for comparing densification patterns across jurisdictions. This

had the practical reason that the independent variable land policy was difficult to measure on a large scale. Without gross oversimplification, I could not sort municipalities based on their strategies, individual development projects based on the policy instruments applied in the planning process, or countries based on their institutional regimes. The goal was to draw conclusions about these institutional differences, even though data is unavailable. Spatial analysis can provide such associative evidence and is well suited for this kind of exploratory, hypothesis-building research (Robertson and Long, 2022). The quantitative nature of this approach further encouraged a focus on covariation rather than causal mechanisms.

The research design employed a comparative approach on three scales. First, I compared across countries. Consistent with exploratory research principles, contrasting cases were selected (Rohlfing, 2012). Since I did not know densification patterns beforehand, I chose countries that exhibit significant variation in the independent variable (institutional regime), which I expected to yield contrasting spatial outcomes. While isolating the causal effect remained impossible due to potential confounding factors, it was possible to make informed assumptions regarding policy influences on densification patterns and, crucially, to showcase these diverse patterns themselves.

Subsequent comparisons delved deeper, focusing on municipalities and individual projects within a single country. Here, too, the approach prioritized demonstrating variation in outcomes before attempting to explain these variations. I reduced the complexity of both dependent and independent variables to facilitate stronger hypothesis development in these later stages. For example, the comparisons remained confined to a single country, thus holding the institutional regime constant to better isolate the effects of municipal strategies and individual policy instruments.

The research design incorporated spatial comparisons across space but also between modeled and observed spatial patterns (Long and Robertson, 2017). The latter approach leverages spatial analysis as a tool to identify case studies for further qualitative investigation (Seawright, 2016). By combining the strengths of quantitative research (identification of broad trends) and qualitative research (in-depth process tracing) (Goertz and Mahoney, 2012), I intended to enhance the ability of the analysis to shed light on cause-and-effect relationships.

In essence, the research design adopted a two-step approach across three spatial scales, first describing variation in spatial patterns of densification and then seeking explanations for these observations. It started with a broad, cross-country exploration before transitioning to a more focused, within-country analysis. This multi-tiered approach ensured a thorough exploration of the research question.

3.3 Overarching methodological considerations

The methods employed in the three articles are dealt with in detail in the respective chapters 5, 6, and 7. Here, I will, therefore, only present overarching methodological considerations. All three articles were based on a similar approach for automatically detecting urban densification and subsequently delineating densification projects and their corresponding neighborhoods.

3.3.1 Detecting densification

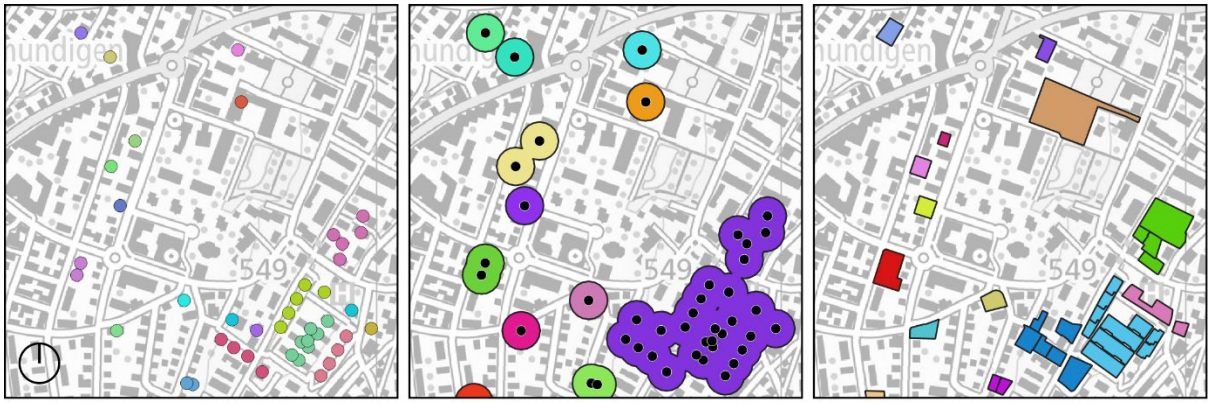
As a first step towards detecting densification, I used topographical land use data to distinguish urban from non-urban land at t_0. Following my definition in 2.2.1, non-urban land includes agricultural and natural land use. The next step was to detect new construction on urban land between t_0 and t_1. I refrained from comparing building footprints between t_0 and t_1 because, in the past 20 years, mapping techniques have become more detailed, leading to many „unreal" changes where the building footprint coverage changed without changes to the actual building (Schorcht, Hecht and Meinel, 2018). In addition, changes in the building footprint can conceal redevelopment or new floors added to an existing building. Instead, and thanks to very detailed data availability in Switzerland and the Netherlands, I used cadastral point data, which registers every building's use, surface area, construction, and, if applicable, demolition year. A further advantage of cadastral point data is that apartments are registered with their corresponding construction year. This enabled the detection of subdivisions or transformations of offices to apartments.

In several of the articles, I further distinguished between various densification processes, which I also called transformation processes (Figure 2). Transformation processes describe the change in land use. I distinguished between the redevelopment of brownfields, greyfields, urban green spaces, and infill in existing residential areas. This latter type is again divided into three groups: infill between houses, infill that was preceded by the demolition of residential units (demolish-and-rebuild, or replacement construction), and soft densification that includes subdivision of apartments, adding floors to an existing building or changing the use of the building, for example from office to housing.

Figure 2 Transformation processes

3.3.2 Delineating densification projects

Throughout the articles, I gradually improved my approach to delineating densification projects. I started with simply aggregating address points that lie within maximally 60 meters from each other and later moved on to employing a DBSCAN (density-based spatial clustering of applications with noise) algorithm that, in addition to a maximum point-to-point distance, considers a minimum number of points per cluster, i.e., project (Ester *et al.*, 1996). The difficulty with both methods was to find a balance between an algorithm that is too strict (cutting projects in individual parts) and an algorithm that is too coarse (joining addresses that do not belong together). In the end, the most accurate method was joining addresses on neighboring parcels into projects (Figure 3). To account for the fact that projects can be divided by streets, parcels up to 25 meters apart were considered neighbors.



(a) DBSCAN Clustering with a minimal project size of 1 and maximum distance of 30m

(b) 30m buffer

(c) Neighboring parcels (up to 25m distance) and same zoning instrument

Figure 3 Three approaches for neighborhood delineation. Data sources: Swisstopo; GWR BFS 2024; GREIKA Kanton Bern 2024

3.3.3 Delineating neighborhoods

In all of my articles, I was interested in comparing project characteristics to their surroundings. These neighborhoods could range from directly adjoining parcels to statistical neighborhoods to circles with an area of 1 km^2 around the densification project. Their size depended on the metrics of interest. For instance, when comparing the median household income in a project to the median household income in the neighborhood, I chose statistical neighborhoods that are developed by statistical offices based on socio-economic characteristics and urban form. When comparing the building density on a newly developed plot to the building density in the neighborhood, I was only interested in adjoining parcels.

These methods for delineating densification projects and their neighborhoods formed the basis of my analyses. Depending on the focus of the individual articles, I joined these projects and neighborhoods with socio-economic and morphological data.

3.4 Case selection

I studied densification patterns in two city regions in the countries of Switzerland and the Netherlands – two highly urbanized countries that are used to dealing with scarcity of land and have correspondingly developed policies to cope with further urban growth. Both countries are experiencing affordability problems, with low-income households paying a large share of their income on housing (in 2022, 47% in the Netherlands and 46% in Switzerland[1]) and high population growth rates (between 1990 and 2020, 29% in Switzerland and 17% in the Netherlands[2]) – making densification not just a policy goal but also a demanded real estate strategy.

For a long time already, both countries have pursued policies that are supposed to limit urban growth and protect the unbuilt area. The Netherlands famously has its “green heart”, the area in the middle of

[1] Housing cost as share of total disposable income among people with a disposable income below 60% of the national median. In comparison, the European mean is at 37.9%. Source: Eurostat 2022

[2] Compared to a total population growth of 6% in the EU between 1990 and 2020. Source: World Bank, “Population”

the Randstad protected from urban development. It also traditionally pursues compact city policies, which are connected to the weak soil conditions that make coordinated development necessary (Buitelaar and Witte, 2011). Switzerland strongly protects its agricultural land through the Law on Peasants' Land Rights (German: *Bundesgesetz über das bäuerliche Bodenrecht*), which regulates the price of agricultural land and restricts buyers to those who will self-manage the farm. Furthermore, the country is divided into a building zone and a non-building zone as a measure to prevent uncoordinated land take. In addition, the construction of second homes has been strictly regulated (German: *Zweitwohnungsgesetz*) since 2015.

Densification, as a particular policy goal, has first been introduced in both countries within the past 20 years. In the Netherlands, it has been part of the national Spatial Strategy since 2004. In 2004, The National Strategy set a target of 40% development within the existing urban area (VROM, LNV and V&Wand EZ, 2004) but replaced this goal later with the ladder for sustainable development, which prompts municipalities to prioritize densification over greenfield development without setting explicit goals. In Switzerland, the densification goal is more explicit and more binding. Since the amendment of the Spatial Planning Act (SPA) in 2014, a ‚thriftily' use of land is stated as one of the main goals of spatial planning. Every municipality can only have as many building zones as it is predicted to need to accommodate its population growth for the next 15 years. Municipalities with excess building land must return these plots to the non-building zone.

Against the backdrop of this common policy goal of densification, the two countries feature contrasting institutional regimes and actor constellations, making for an interesting comparison:

1. *Planning hierarchy.* In both countries, planning power lies primarily with the municipalities, which form the lowest level of government. In Switzerland, as a federal country, the Cantons have far-reaching autonomy in relation to the national level, meaning that not all Cantons provide their municipalities with the same instruments and that detailed regulations of instruments differ from Canton to Canton. Compared to the Netherlands, municipalities in Switzerland are much smaller and more fragmented. On an almost identical surface area of 41,000 km^2, the Netherlands has 342 municipalities with an average population of 52,000 (CBS, 2023), and Switzerland has 2,131 municipalities with an average of less than 4,000 inhabitants (BFS, 2021). Consequently, planning departments in Switzerland are on average rather small (Klaus, 2020).
2. *Plan flexibility and negotiations.* In both countries, municipalities develop zoning plans to guide urban development. However, in the Netherlands, zoning plans are seen more as a basis upon which municipalities and developers negotiate development regulations. A zoning plan, therefore, does not give much planning security since density regulations, shares of affordable housing, and public spaces are up for discussion. Rather than dictating development, the zoning plan records the detailed agreement between the parties (Buitelaar, Galle and Sorel, 2011). Consequently, collaborations between planners and developers are very common in the Netherlands, also because the municipality often owns parts of the land (Hartmann and Spit,

2015). In Switzerland, negotiated planning remains an exception and is only allowed through a specific instrument, the planned unit development (German: *Sondernutzungsplanung*).

3. *Intervention in property rights.* The two countries differ starkly regarding how governments intervene in private property rights. Switzerland is known for its exceptionally strongly protected private property rights, with expropriation happening very rarely (Alterman, 2010). On the other hand, in the Netherlands, expropriation happens comparatively often, and the public interest legitimizing it is defined more broadly, covering spatial development, infrastructure, and housing (Holtslag-Broekhof, Hartmann and Spit, 2018). In addition, Dutch municipalities can use pre-emption rights to purchase land and do so for spatial development. Large shares of urban development happen through active land policy, where the municipality buys the land, rezones it, prepares it for construction, and then sells it to a developer (Bregman *et al.*, 2018). Consequently, urban development in the Netherlands is generally more consolidated and large-scale.
4. *Citizen participation.* Development plans in both countries have to be published for public hearing. However, in Switzerland, citizens have more far-reaching rights in co-creating spatial development than in the Netherlands. This is due to the Swiss semi-direct democratic system, which allows citizens to vote on changes in the zoning plan (re-zoning or up-zoning).
5. *Tenure and landownership.* In global comparison, both countries have exceptionally high rental shares (40% in the Netherlands and 60% in Switzerland). However, in Switzerland, residential property is more fragmented than in the Netherlands. In Switzerland, in 2023, almost 90% of all rental housing is private rental (44% rented out by private persons and 46% by businesses) compared to 10% owned by municipalities or housing co-operatives (BFS, 2024). In contrast, in the Netherlands, only 23% of all rental housing is private rental, while 67% is rented out by non-profit housing corporations (CBS, 2023).

In conclusion, municipalities in the Netherlands could generally be described as more intervening in property rights. In Switzerland, on the other hand, municipalities are smaller, and citizens have more power to block densification.

3.4.1 Utrecht and Bern

My analyses did not cover the whole of Switzerland and the Netherlands but focused on the two regions, Bern and Utrecht (see Figures 4 and 5). Since it was my aim to combine qualitative and quantitative approaches, I limited the analysis to a scale where it was still possible to visually assess pattern distribution and examine single developments in more detail. Another advantage of limiting the analyses to single regions was a good balance of within-case variation. Limiting the analyses to single reasons meant that there was comparatively little variation in housing markets and no mix of growing versus shrinking regions. On the other hand, the regions still provided variation between large cities, suburbs, and more rural municipalities, which was important for discussing municipal strategies. A final reason for choosing only one region per country was the federal structure of Switzerland, which meant that institutional regimes differ across Cantons. I chose the Canton of Bern and the Province of Utrecht because they are some of the largest and fastest-growing regions in their respective countries. Both

are concentrated on domestic housing demand, as opposed to Zurich and Amsterdam, which attract high shares of international investment and residents, thus being less representative of their countries.

The population of Utrecht (1.4 Mio in 2024) is a bit larger than the population of Bern (1 Mio in 2024), although the surface of Utrecht (1,500 km^2) is much smaller than the surface of Bern (6,000 km^2). Consequently, the population density is 5.6 times higher in Utrecht than in Bern. Figure 5 shows the location of new construction between 2021 and 2022.

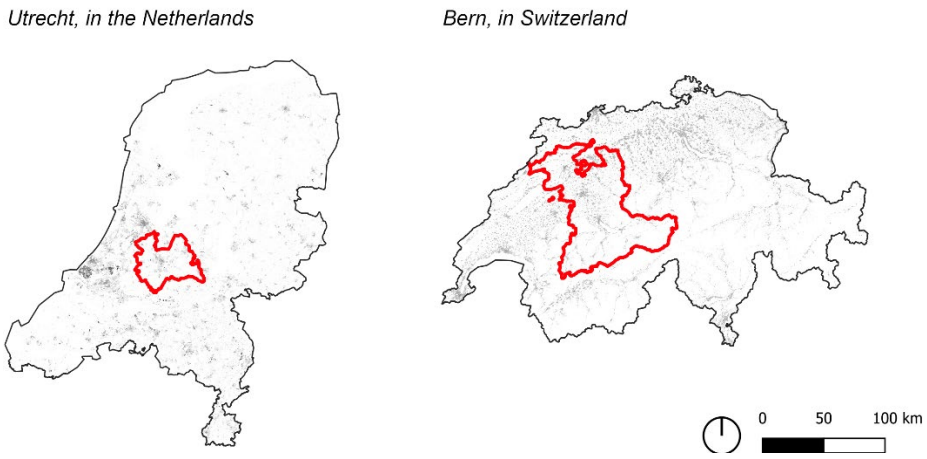


Figure 4 Case countries and regions in red: The Netherlands and Utrecht (left) and Switzerland and Bern (right). Data sources: TOP10NL, Kadaster 2022; Swisstopo 2024

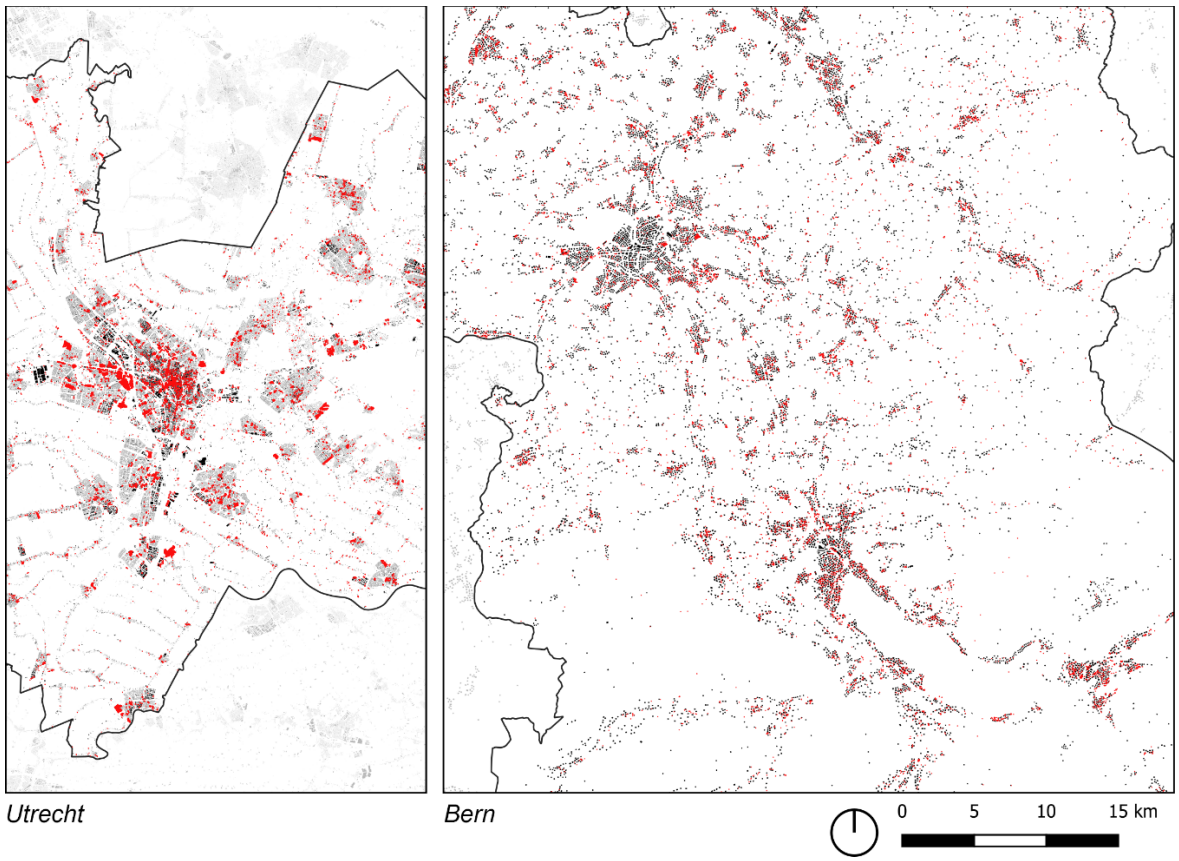


Figure 5 New buildings (in red) since 2012 and until 2022. Data sources: BAG and TOP10NL, Kadaster 2022; GWR; BFS 2022; SwissTLMRegio, Swisstopo 2024

4 Article structure

The research articles each address aspects of my research questions: *"How does the comparison of densification patterns contribute to tracing land policy effects?"*

1. *What densification patterns emerge across countries and municipalities?*
2. *How does land policy possibly explain the observed differences?*

I specified that the relationship between land policy and densification shows on three levels. Each of my articles addresses one of these levels, namely (1) the effect of institutional regimes on densification patterns across countries, (2) the effect of applied policy instruments on the outcome of individual development projects, and (3) the effect of municipal strategies on the application of policy instruments. This means that each of the articles answers aspects of both subquestions 1 and 2. As such, each article explores one cause-effect relationship, and for each of these relationships, I test a spatial analysis method and a set of indicators to capture this relationship. I have already presented these steps above, but I want to concretize the case and method featured in the three articles. Table 2 summarizes these focus points of the three articles and provides information on status and authorship.

Article 1: "Comparing types and patterns: A context-oriented approach to densification in Switzerland and the Netherlands"

In Article 1, I approach the relationship between institutional regimes and densification patterns through a cross-country comparison of densification patterns in Utrecht and Bern. Having chosen two countries with contrasting institutional regimes, I aim to illustrate large differences in the distribution of densification patterns and connect them to known differences in the institutional regimes.

To map densification patterns, I create densification types. For this, I introduce a method of automatically detecting densification projects. I combine morphological, social, and land use data to describe such projects in terms of their size, building and population density, building height, apartment size, resident age distribution, household size, and mean personal living space. The densification projects are described in terms of how they deviate from their surroundings, for instance, whether the apartments are larger or smaller and whether the share of elderly is higher or lower than in the neighborhood. The types are then created via a k-proto cluster analysis. This reduces the number of metrics and allows for comparing distinct densification types' prevalence and spatial distribution. Finally, I discuss observed differences based on my knowledge of the institutional regimes.

Table 2 Article structure

	Cause-effect relationship	***Research question in article***	***Dependent variable: densification outcome***	***Spatial analysis***	***Authors and Status***
Article 1: Comparing types and patterns	Institutional arrangements affecting densification outcomes	What types of densification emerge in different institutional contexts? Which patterns of densification become visible within city regions and across national institutional contexts?	Location (center, periphery), processes (land use change, size), project characteristics (density, population, morphology)	Comparison across space, typology of densification	Götze & Jehling. Published in Environment and Planning B, 2022
Article 2: For whom do we densify?	Policy instrument application affecting project outcomes	What is the distribution of household incomes across densification projects at the city-region level? How do project location, transformation type, land ownership, and planning interventions affect household incomes?	Median household incomes	Comparison of modeled and observed patterns, spatial model with error structure, multi-method	Götze, Bouwmeester, Jehling. Published in Urban Studies, 2023
Article 3: Mapping municipalities' strategic application of flexible planning instruments for densification	Municipal strategies affecting instrument application	How does the application of planned unit development vary within a city-regional context compared to conventional zoning? To what degree do municipal characteristics explain this variation?	Achieved density (increase)/ in low-density neighborhoods, project complexity	Comparison across space	Götze, Gerber, Jehling. To be submitted to Buildings & Cities, August 2024

The article's primary goal is thus to visualize and compare densification patterns and formulate hypotheses about possible relationships between the countries' institutional regimes and the observed densification patterns.

<u>Article 2:</u> "For whom do we densify? Explaining income variation across densification projects in the region of Utrecht, the Netherlands"

Article 2 addresses the relationship between the application of policy instruments and project outcomes. I focus only on *one* city region, namely the Province of Utrecht. I further narrowed down the dependent variable to cover only affordability. Specifically, I examine the variation in median household incomes across densification projects, hypothesizing that projects with a surprisingly low household income indicate that municipalities have actively intervened in the project planning by, for example, applying pre-emption rights. In addition, this article aims to illustrate income variation across densification

projects, thereby addressing the claim that densification mainly targets the rich. I aim to show that densification does not have to be exclusively for the rich and to examine the conditions under which inclusive forms of densification are possible.

I was granted access to household-level income data from Statistics Netherlands (CBS) for this research. To show municipal interference in property rights, I developed a method that helps me point out projects where the median household income deviates from market expectations. I do so by building a regression model that explains median household incomes in densification projects based on neighborhood income (change), centrality, and type of land use change. Then, I map the model residuals to see in which cases the model greatly under- or overestimates the median household income. Employing a multi-method approach, I finally conducted qualitative case studies on the most mispredicted projects, examining who owned the land and what instruments the municipality applied to influence affordability.

<u>Article 3:</u> "Approaching land policy through space. Capturing municipal strategies in the application of flexible planning instruments for densification in Bern, Switzerland"

The focus of Article 3 is on differences in how municipalities apply planning instruments according to their individual development strategies. Just as in Article 2, the analysis is confined to one region – this time, the Canton of Bern. I concentrate on the instrument of *planned unit development* (PUD), a flexible planning instrument allowing for a deviation from or addition to the zoning plan. The instrument is meant to help municipalities enable densification under complex conditions and safeguard the quality of the project through detailed regulations. In the article, I ask how the application of PUD in the context of densification differs across municipalities, especially focusing on whether municipalities use it to enable densification.

To do so, I develop indicators representing strategic instrument application. These include the extent to which municipalities use the instrument, the complexity and type of projects they apply it to (i.e., project size, building use, density, mix, and parcel structure), and the contexts in which they apply it (neighborhood type). These indicators depict whether a municipality is interested in actively shaping the planning process and to which degree it uses the instrument to achieve higher densities under complex planning conditions. In the second step, I examine how the application of PUD varies across various municipality types. For this, I divide municipalities into functional groups, ranging from core municipalities to suburbs, rural, and tourist municipalities.

Articles in the appendix

In addition to the articles that make up my dissertation, I published three further articles. Two of them are peer-reviewed, and in one of them, I am listed as the second author. I did not include them in this framework, but they give you a more complete picture of what I worked on during my studies.

5 Comparing types and patterns: A context-oriented approach to densification in Switzerland and the Netherlands[3]

While governments worldwide develop policies to promote urban densification, critics point to the possible negative effects of densification on social sustainability. The occurrence and distribution of these negative social effects are strongly influenced by land policies. This makes it crucial to monitor the role of land policies and understand what processes shape urban development in the context of densification. To do so, detailed, large-scale international comparisons of densification patterns, including building and social changes, are needed. We address this issue by introducing a method to measure and compare urban development in two countries with contrasting planning systems: the Netherlands, where public actors play a strong and active role, and Switzerland, where strong private property titles and a highly democratic planning system prevail. Our GIS-based method analyses densification processes within their surrounding morphological and socio-demographic context. A k-proto cluster analysis on highly detailed spatial and statistical data based on housing units, covering 2011–2019, results in five densification types. The distribution of these types reveals different patterns in the two city regions of Utrecht (NL) and Bern (CH). Most strikingly, contiguous redevelopments frequently occurred in Utrecht but hardly in Bern, pointing at possible advantages for Dutch municipalities to intervene in property rights. While having developed an empirical basis in this study, future research that refines the analysis of the legal, planning and ownership conditions underlying the identified densification patterns can contribute significantly to policy evaluation.

5.1 Introduction

While governments worldwide rely on densification policies to reduce land consumption from urban growth, possible ecological, economic and social effects of urban densification are being widely discussed (Berghauser Pont *et al.*, 2021). Many of these effects are not inherent to densification – they manifest in some cases but not in others. For instance, some types of densification are associated with the decrease of green spaces, while others seem to increase their amount (Wellmann *et al.*, 2020).

[3] Götze, V., & Jehling, M. (2022). Comparing types and patterns : A context-oriented approach to densification in Switzerland and the Netherlands. Environment and Planning B: Urban Analytics and City Science, 0(0), 1–15. https://doi.org/10.1177/23998083221142198

Since densification types come with different ecological, economic and social effects, it is important to understand under which conditions these types occur.

Different forms of densification can be observed both between and within urban regions (Jehling, Schorcht and Hartmann, 2020; Angel, Lamson-Hall and Blanco, 2021). However, studies on the effects of densification seldom differentiate its location within a region or distinguish varying transformation processes (Bibby, Henneberry and Halleux, 2020; Jehling, Schorcht and Hartmann, 2020). Often, these studies are too coarse to show intra-regional differences, thereby hiding the local factors that shape urban development (Bibby, Henneberry and Halleux, 2020; Broitman and Koomen, 2020). Revealing these influencing factors is crucial to understanding under which conditions governments can use land policies to steer densification in a more desired direction (Nabielek, 2011; Jehling, Schorcht and Hartmann, 2020).

Land policies strongly influence densification and thus the occurrence and distribution of its effects. By determining which planning instruments municipalities have at their disposal (Gerber, Hengstermann and Viallon, 2018), they change power relationships between public and private actors, ultimately reflected in the evolving patterns of urban densification (Charmes and Keil, 2015). More concretely, land policies determine the extent to which urban development takes place on private or public land, whether fragmented landownership impedes brownfield transformations, but also what forms of housing are constructed and for whom. As governments pursue varying land policies, different densification patterns evolve.

Research on the effect of the institutional context (of which land policies are part) on urban densification is generally limited to small-scale, qualitative case studies. Single-case studies uncover, for instance, how increases in rent after redevelopment are anchored in Swiss institutions (Debrunner, Hengstermann and Gerber, 2020) or how, in the Netherlands, high densities in redevelopment projects are related to land acquisition costs (Buitelaar and Segeren, 2011). In addition, comparative case studies have helped explain causal relationships between national policies and urban development patterns (Tennekes, Harbers and Buitelaar, 2015; Giddings and Rogerson, 2021). Few studies apply this knowledge to explain densification patterns on a larger scale (Claassens, Koomen and Rouwendal, 2020; Jehling, Schorcht and Hartmann, 2020). However, they often focus on one region only. As an exception, Jehling and Hecht (Jehling and Hecht, 2021) compare urban morphology in Germany and France – though not regarding urban densification or social changes.

In light of the above, there is a need for analyses that differentiate between various forms of densification – including building and social changes – within metropolitan regions to nuance the debate on social effects. Comparisons of these analyses further shed light on the conditions under which densification evolves, and the role of institutional contexts in steering it. Thus the aims of this paper are to (1) present and test a comparative method to analyze densification as a process within existing social and built urban contexts and (2) develop hypotheses for the role of institutional contexts in shaping densification. These aims can be operationalized with the following questions: On the scale of new housing units and their urban context, “What types of densification emerge in different institutional contexts?”; regarding

the distribution of these types, “Which patterns of densification become visible within city-regions and across national institutional contexts?”. To answer these questions, we analyze densification in two city-regions across two countries with contrasting institutional arrangements – Utrecht in the Netherlands, where public actors play a strong and active role, and Bern in Switzerland, where strong private property titles and a highly democratic planning system are prevailing. The approach is based on a particular interest in how urban contexts are affected by densification. Densification is thus measured in terms of (1) how new housing deviates from existing contexts regarding morphology, (2) how residents of newly constructed housing deviate from existing residents regarding socio-demographic variables, and (3) procedural metrics regarding the average project size in square meters and the process through which the new housing units emerged, i.e. transformation of brownfields or urban green spaces, or (soft) densification in existing residential areas (Claassens, Koomen and Rouwendal, 2020). Using a k-proto cluster analysis (Huang, 1998), we identify and define five densification types and compare their occurrence between, as well as within the two regions. Observed differences in these patterns allow us to build hypotheses on the institutional conditions that shape urban development in the context of densification in the two case regions.

5.2 Institutions and urban development

Urban development, understood as a result of human actions, happens within a web of existing institutions (Gerber, Hengstermann and Viallon, 2018). Institutions are formal rules and informal practices or narratives impacting actor agency (Lowndes and Roberts, 2013). While informal institutions represent implicit norms, such as planning cultures (Buitelaar and Bregman, 2016). Formal institutions legally constrain actors through procedural rules pertaining to planning, property rights, the distribution of competencies between government agencies, and land policies (Gerber, Hengstermann and Viallon, 2018, p. 13). We define land policy as the strategic application of political and legal measures by a municipality to deal with the problem of land scarcity (Hartmann and Spit, 2015). This definition introduces governments as political actors that pursue goals, making densification “a deliberate strategy, an unintended consequence of planning policy or the lack of enforcement” (Dembski *et al.*, 2020, p. 211). Put differently, the interplay between institutions and interests affects urban development and its corresponding benefits and drawbacks. Together, institutions and interests determine “[w]ho owns the land, who decides which land uses should prevail, who appropriates the benefits of land uses, who suffers the burden […]” (Davy, 2012, p. 68). Consequently, this informs our understanding of densification, its spatial distribution, transformation processes, and resulting housing forms.

This sets the institutional context as a known cause of which we want to investigate the spatial effect (Rohlfing, 2012). To do so, we study cases with a high variation on the cause, as this “permits the identification of potential independent variables that would be made subject to a subsequent hypothesis test” (Rohlfing, 2012, p. 65). This implies choosing countries with contrasting institutional contexts and developing working hypotheses that explain observed differences in densification.

5.3 Methods, case selection and data

5.3.1 Methods

Our methodological approach consists of two steps; first, we assign densification metrics to individual housing units based on harmonized data, and subsequently, we identify densification types. In the context of this study, a housing unit is an individual, self-contained residential unit and can represent an apartment or a single-family house.

5.3.2 Relative metrics for social and built densification

For each new housing unit within the cases, we distinguish whether it was created through expansion or densification (following Hecht *et al.*, 2019). Expansion encompasses all residential addresses constructed after a specific date (t_0) on non-urban land, e.g. agricultural land, forests, water bodies and other natural areas. These developments are excluded. The remaining developments on existing urban land fall into the densification category (following Broitman and Koomen, 2015). For addresses on a plot labeled "construction site" in t_0, we proceed with land use information from previous years (t_{-1}). Within the densification category, we further distinguish transformation processes using land use information from t_0, i.e. "transformation of urban green spaces", "transformation of brown- and grey fields", "densification in residential areas", and "soft densification" (Claassens, Koomen and Rouwendal, 2020) (see Figure S1). "Soft densification" includes the transformation of non-residential addresses (such as offices, shops or attics) into apartments, the subdivision of apartments, and the expansion of existing buildings (Bibby, Henneberry and Halleux, 2020).

The **social metrics** cover age structure, household size, living space, and population density. These are measured at the highest possible resolution and describe the state after densification happens (t_1). The age distribution is measured per hectare and is expressed as shares of children, students, and elderly (Jehling, Hecht and Herold, 2018). Population density is also measured per hectare (following Jehling and Hecht, 2021). Furthermore, to measure possible effects of crowding (Burton, 2000), we include apartment sizes (relating to individual addresses) and living space per person, expressed as the sum of apartment sizes divided by the number of inhabitants per hectare. In addition to social metrics, **morphological metrics** include building densities, such as floor space index, ground space index, and average building heights, measured at street block resolution.

The **patch size of a densification project** is measured by aggregating adjoining housing units into polygons (following Eggimann *et al.*, 2020), using an empirically determined cut-off distance of 60 meters that allows for the best possible separation of housing units in the case regions (Figure 6B). Separate units that are not part of a larger project are assigned a default patch size of 100 m^2.

Finally, to take into account the social and built context, new housing units are described using relative metrics: Each new housing unit is characterized by its deviation from existing housing units within a 1 km^2 circle (following Van Leeuwen and Venema, 2021) (Figure 6A). We express average differences in terms of standard deviations. The social, morphological, and relative metrics, together with the respective patch size and transformation process, are assigned to the individual housing unit.

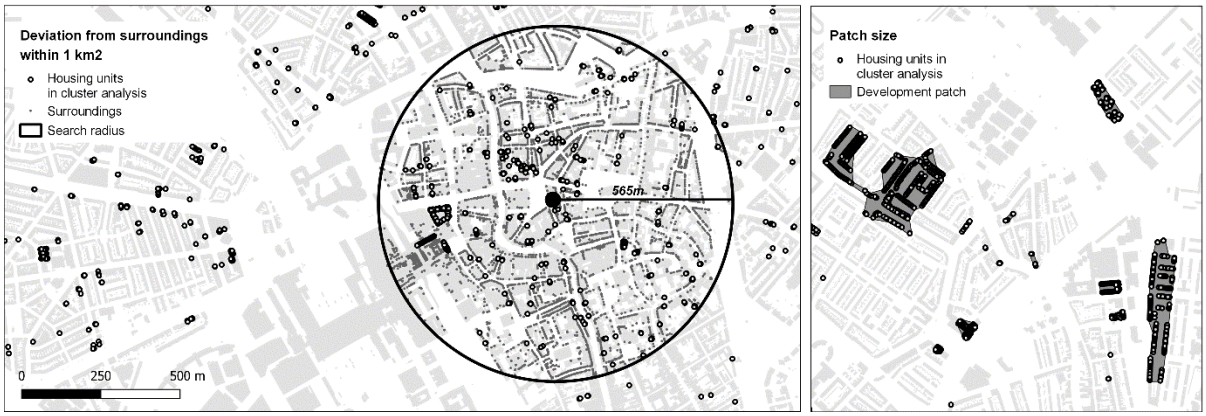


Figure 6A Deviation from urban context: New housing units are analyzed in relation to all pre-existing surrounding housing units (constructed before 2011) within a 1 km² circle; 6B: Patch size of densification projects (Utrecht city center) (author's work; data sources: Kadaster 2022)

5.3.3 Classification and interpretation of densification types

Before performing cluster analysis, dimensionality reduction is necessary to enhance clustering results and ease cluster interpretation (Wilmink and Uytterschaut, 1984). To that end, variables resulting from the pre-processing steps described above are subjected to a multiple correlation analysis. In this step, highly correlated variables are iteratively pruned from the dataset until no two variables are highly correlated. This is done in preparation of the computationally expensive k-proto cluster analysis. To a certain extent, k-proto clustering resembles the better-known k-means method that has proven viable in urban analytics, especially when working with large datasets (Berghauser Pont, Stavroulaki and Marcus, 2019; Bobkova, Berghauser Pont and Marcus, 2021). Both algorithms partition data into *k* clusters, within which observations resemble each other as much as possible. However, unlike k-means, the k-proto algorithm calculates the distance between two variables expressed as the sum of their Euclidean distance and a simple distance measure for categorical variables, weighted by a factor *γ* (Huang, 1998). The resulting clusters are described using mean values for continuous variables and modes for categorical variables. This alternative clustering algorithm allows us to include the categorical variable "transformation process" in the classification. We perform a combined cluster analysis on all new housing units that were created through densification across the two case regions. The resulting types are, therefore, common for both cases and allow for cross-case comparison, including the prevalence of types by region and their spatial distribution within the regions. For cluster validation, we visually assess the resulting classification by way of principal component analysis.

5.3.4 Case selection

The Netherlands and Switzerland have been pursuing compact city policies for decades and institutionalised urban densification as a primary goal in 2012 (Dutch Ladder for Sustainable Urbanisation) and 2014 (revision Swiss Spatial Planning Act). However, the implementation of these policies strongly differs in the degree to which municipalities can steer urban development projects, the role of property rights, and their legitimization.

In the Netherlands, municipalities play an active role in urban development – either through land purchases or partnerships with private developers (Meijer and Jonkman, 2020). Especially public-

private partnerships are becoming more frequent following decentralization and the withdrawal of national funding for public land acquisition (Claassens, Koomen and Rouwendal, 2020).

In Switzerland, public-private partnerships for urban development are uncommon. Also, other forms of active land policy, such as public land ownership combined with long-term land leases, have only recently been gaining momentum (Gerber, 2016). Compared to the Netherlands, citizens (through direct voting on re-zoning proposals) and private land owners (through strongly protected property rights) both have strong veto rights to block densification. Densification lies in the hands of private developers, with public actors facilitating (Debrunner, Hengstermann and Gerber, 2020). This difference in stakeholder power balance is also apparent in the rental housing sector: while individual private investors in Switzerland own 50% of the country's rental housing (BFS, 2020), the Dutch rental housing sector is dominated by corporations (70%) and institutional investors (15%) (SCP, 2020).

To analyze densification, a scope is required that encompasses its variety within functional urban regions (Jehling, Schorcht and Hartmann, 2020). Since Switzerland is a confederation, with each canton applying policies differently, we confine the analysis to one canton. Accordingly, data collection in the Netherlands is limited to one province. Bern in Switzerland and Utrecht in the Netherlands form the two cases – two rapidly growing regions that do not exhibit the exceptional trends of the leading metropoles of Zürich and Amsterdam.

5.3.5 Data collection, harmonization and metrics

Data on housing units is available at unit resolution for both countries starting in 2011 (t_0 in this study) (Table 1). Morphological data is aggregated per street block using national topographical datasets. Data on age distribution and household sizes is available at a 100 m resolution until 2019 (t_1) for both countries. Data harmonization requires particular attention to land use. Swiss Area Statistics on land use are available on a hectare grid only, where the value of each grid cell is determined by the land use covered by its lower left coordinate. We engineered the Dutch data to an identical representation. The resulting crude resolution land use patterns required redefining what constitutes a 'residential area'. Functions usually found in residential areas such as retail, smaller roads and public buildings are hence included in the category "residential area". Finally, a harmonized, comparative set with metrics to characterize morphology, inhabitant structure and transformation processes of urban redevelopments in Utrecht and Bern is summarised in Table 3 (see Table S1 for summary statistics). The metrics indicating deviation (d_), patch size and transformation type are assigned to individual housing units and passed to the cluster analysis.

Table 3 Metrics for characterizing densification on the level of housing units based on the harmonized data set. Except for "transformation type", all metrics refer to 2019. Transformation type is determined with land use data from 2000, 2010 and 2015 (NL) and 1997, 2009 and 2018 (CH)

	Name	Relevance	Description	Aggregation level	Source
SOCIAL	pop_dens	Crowdedness	Inhabitants per hectare	Hectare grid	A

	per_kids	Compatibility with families	Share of children (age 14 and below) per hectare	Hectare grid	
	per_students	Compatibility with students	Share of students (age 15 to 24) per hectare	Hectare grid	
	per_elderly	Compatibility with elderly	Share of elderly (age 65 and above) per hectare	Hectare grid	
	hh_size	Compatibility with families	Average household size per hectare	Hectare grid	
	m2person	Crowdedness	Sum of apartment sizes divided by population per hectare	Hectare grid	A/B
BUILT	layers	Building height	Average number of stories per street block	Street block	B
	fsi	Building density	Ratio between floor area and block area per street block	Street block	
	gsi	Loss of open space	Ratio between building footprint and block area per street block	Street block	
	aptsize	Crowdedness	Apartment sizes of individual apartments	Housing unit	
SOCIAL	d_popdens	Deviation from surroundings	Deviation in population density from surroundings	Hectare grid	A
	d_kids		Deviation in share of children from surroundings	Hectare grid	
	d_students		Deviation in share of students from surroundings	Hectare grid	
	d_elderly		Deviation in share of elderly from surroundings	Hectare grid	
	d_hh_size		Deviation in household size from surroundings	Hectare grid	
	d_m2person		Deviation in living space per person from surroundings	Hectare grid	A/B
BUILT	d_layers		Deviation in building height from surroundings	Street block	B
	d_fsi		Deviation in floor space index from surroundings	Street block	
	d_gsi		Deviation in ground space index from surroundings	Street block	
	d_aptsize		Deviation in apartment size from surroundings	Housing unit	
PROCESS	patchsize	Transformation process	Size of densification project in m^2	Housing unit	B
	transformation type		Factor with levels: transformation of brownfields/grey fields, transformation of urban green, densification on residential areas, soft densification	Hectare grid	C

A - STATPOP2019, BFS GEOSTAT Switzerland (Downloaded November 2, 2021); Statistische gegevens per vierkant 2020, CBS Netherlands (Downloaded September 23, 2021)
B - Bundesamt für Statistik; Eidg. Gebäude- und Wohnungsregister Switzerland (Downloaded February 8, 2021); Basisregistratie Adressen en Gebouwen (BAG) kadaster Netherlands (Downloaded July 27, 2021)

C – Arealstatistik, BFS GEOSTAT Switzerland (Downloaded March 4, 2021), Bestand Bodemgebruik, CBS Netherlands (Downloaded March 4, 2021)

5.4 Results

K-prototype clustering detects five densification types, which we describe in Figure 7. Broadly, the results show that densification yields higher population densities, smaller apartment sizes, smaller household sizes and smaller shares of elderly than the existing urban context. See the Appendix with correlation analysis for dimensionality reduction (Figure S2) and Figure S3 for the choice of k.

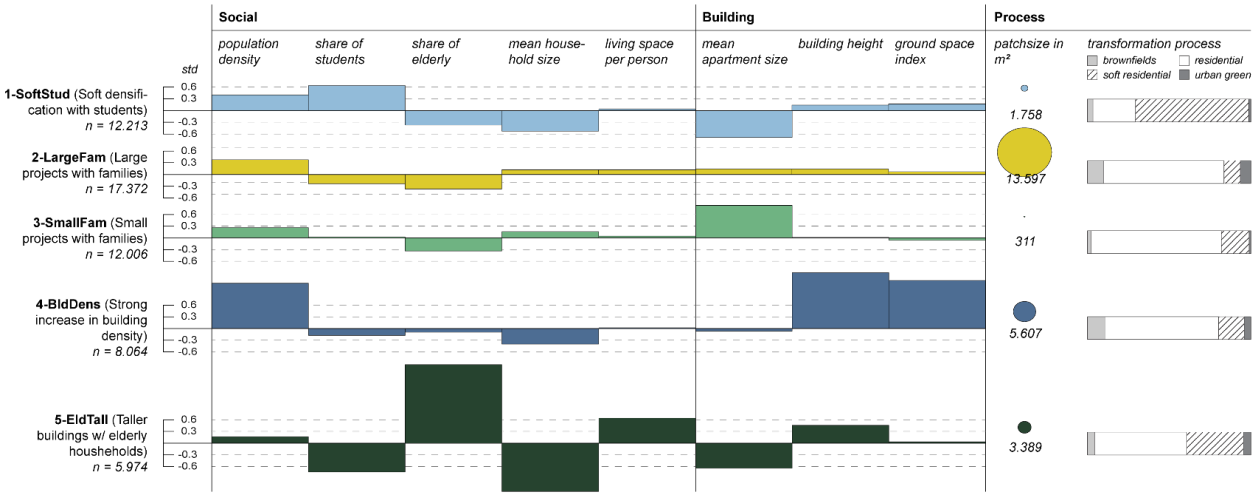


Figure 7 Densification types with the mean deviation of the associated housing units from their Social and Building surroundings and their Process with average patch size and the distribution of transformation processes. We further differentiate the characterization of densification types by comparing the variables' distribution within these types (see Figure S4).

The first cluster, *SoftStud*, contains primarily soft densification and conforms to the general observations, albeit with a higher share of students (std = 0.64).

The second cluster, *LargeFam*, describes large-scale densification projects. Though not differing strongly from its surroundings in terms of demography or morphology, it is one of two types where household and apartment sizes are on average larger than in their surroundings. *LargeFam* forms the largest of the five clusters, containing more than 30% of the housing units that entered the cluster analysis. Most transformations of brownfields and grey fields fall into this cluster.

In cluster three, *SmallFam*, household sizes are larger than their vicinity average, and it is the only cluster with substantially (std = 0.83) larger apartment sizes. Its makeup is mostly housing units within small-scale projects in existing residential areas.

Cluster four, *BldDens*, describes a densification type with unusually tall and densely built constructions (building height with std = 1.43; ground space index with std = 1.23), also featuring higher population densities (std = 1.16). Densification in residential areas and, to a lesser degree, transformations of brownfields fall into this type.

Cluster five, *EldTall*, describes a densification type with remarkably high shares of small, elderly households in much smaller apartments and buildings somewhat taller than their vicinity averages (share of elderly with std = 2.01; household size with std = -1.24). Here, population density increased only slightly as residents take up an unusually large amount of living space (std = 0.64). Just as in type one, this densification type is largely, but not predominantly, a result of soft densification.

5.4.1 Prevalence of densification types per region

In this study, we cover a total of 55.000 housing units constructed on urban land between 2011 and 2019 (32,000 in Utrecht and 23,000 in Bern). These are fractions of the total net increases in the number of housing units in the same period (63,000 in Utrecht and 50,000 in Bern). The densification types are distributed differently in the two regions (see Figure 8). Most of the housing units in 2-LargeFam and 5-EldTall were constructed in Utrecht, where they make up for around 60% of new housing units. In Bern, the most prevalent type is 3-SmallFam, accounting for circa 40% of the urban development in our dataset. This densification type is typical for Bern; it hardly occurs in Utrecht.

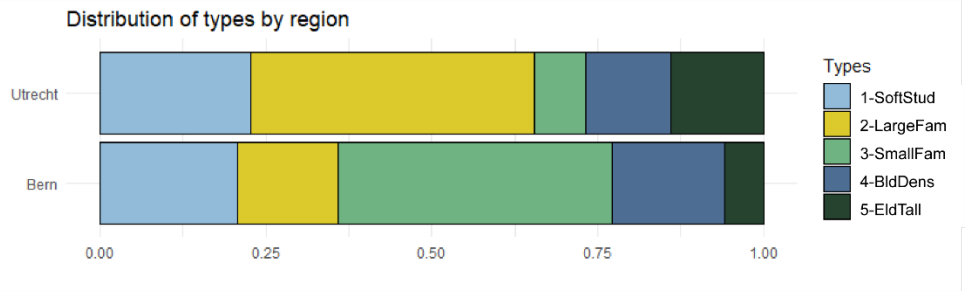


Figure 8 Distribution of types in Bern and Utrecht

5.5 Spatial distribution of densification types by case

Densification is most concentrated in the largest cities, in both case studies (see Figure 9). In the municipalities of Utrecht and Amersfoort, the concentration of new units per hectare is 4 times higher than the average in the province, while in the municipalities of Bern, Thun and Biel/Bienne, the concentration is 14 times higher than the cantonal average (see Table S2). Among all densification types, the types *1-SoftStud* and *4-BldDens* show the highest contrast between the largest cities and the regional average – their concentration in the largest cities is between 5 and 24 times higher than the average (see Table S2). *3-IndivFam* is concentrated predominantly in regional centres, but also in smaller towns. *2-ContFam* developments occur a lot in the center of Utrecht (4,887 units in the municipality). In the center of Bern, however, they are rather uncommon (125 units in the municipality) and emerged instead outside Bern city center, along the traffic corridor between Bern and Thun. Still, they did occur inside the smaller towns of Thun and Biel/Bienne. In both case studies, type *5-EldTall* typically occurs in smaller towns and surrounding regional centers. Among all housing units, the units of this type emerged furthest away from the centers of the largest cities (measured as the distance from their main stations, see Table S3). There is a remarkable concentration of this type *5-EldTall* in the south-eastern corner of the Province of Utrecht, caused by a reconstruction of two retirement complexes.

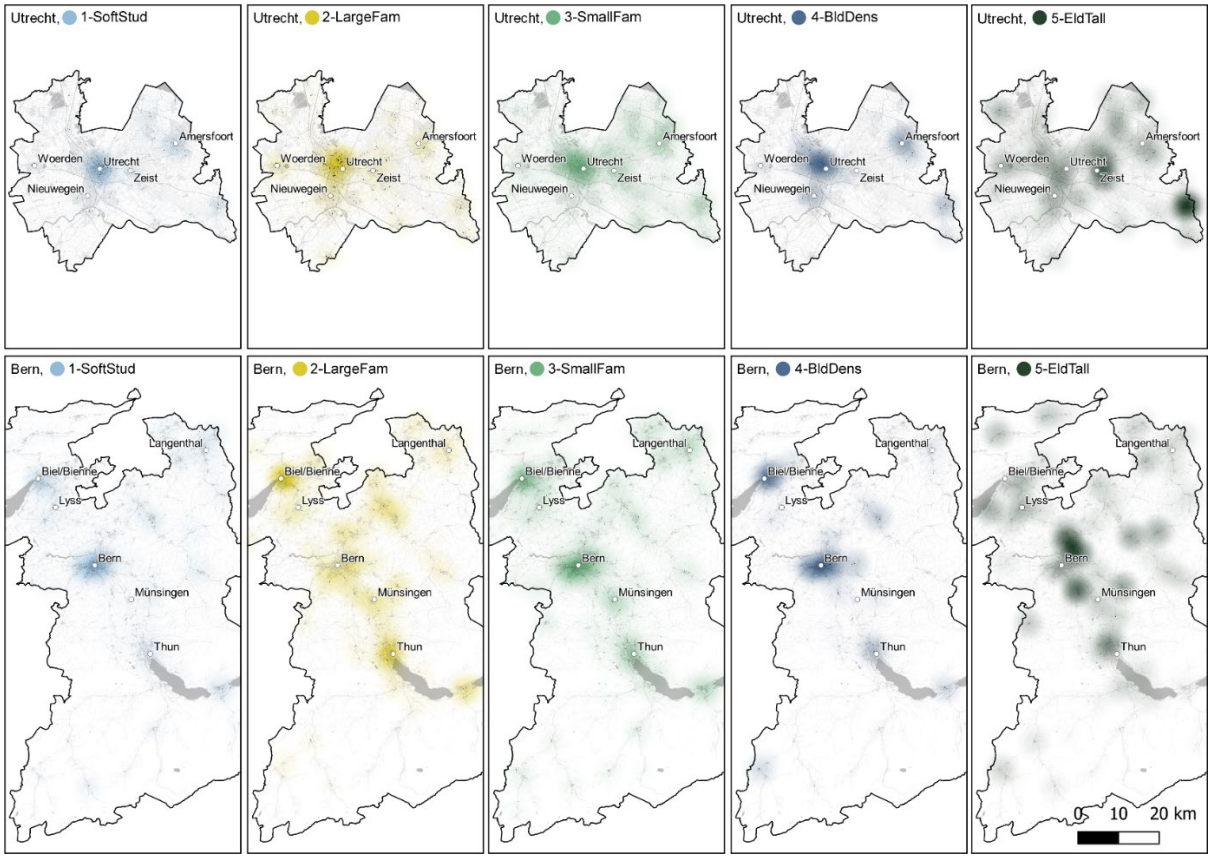


Figure 9 Spatial distribution of densification types in Utrecht and Bern

5.6 Discussion

We identified five densification types with varying spatial distributions within the case regions between 2011 and 2019. The most striking difference between Utrecht and Bern was the scale of densification projects (distribution of type *2-LargeFam* and *3-SmallFam*). In the following paragraphs, we discuss these results and develop working hypotheses on the possible effects of housing demands and institutional regimes on these patterns.

5.6.1 Densification types and their spatial distribution

To a large degree, the identified types and their spatial distribution follow general trends revealed in earlier studies. Densification leads to higher population densities, smaller household sizes, and smaller apartments compared to their urban context, supporting earlier findings by Burton (2000) and Holman *et al.* (2015). It is most concentrated in the largest cities, whose varied supply of amenities exerts a great attraction to new residents, causing increases in land prices and thus stimulating the transformation of urban land from other purposes to residential use (Broitman and Koomen, 2020; Claassens, Koomen and Rouwendal, 2020; Jehling, Schorcht and Hartmann, 2020). In addition, the concentration of densification with increased building heights and ground coverage is much higher in the largest cities than the regional average, further steepening urban-rural density gradients (Broitman and Koomen, 2020).

Densification rarely takes place through the transformation of brownfields and urban green spaces, possibly due to complex planning processes or lacking availability (Nabielek, 2011; Nebel *et al.*, 2017). Instead, it is most often an intervention in existing residential areas, both through hard and soft densification, supporting earlier studies in England (Bibby, Henneberry and Halleux, 2020). We observe large-scale densification projects (all the way into the city center of Utrecht) that could indicate the demolishing and rebuilding of housing blocks, often connected to the displacement of lower-income residents (Rérat *et al.*, 2010; Debrunner and Hartmann, 2020). Additional studies will need to include data on income or rent to complete the picture of potential gentrification effects. On the other end of the spectrum, small-scale, soft densification is highly concentrated in city centers, where it is paired with larger shares of young adults. The growing demand for centrally located apartments among this population group (Rérat, 2019) makes it attractive for private landlords to split and rent apartments to students (Rugg, Rhodes and Jones, 2002).

However, contradicting the general picture of smaller apartments and household sizes, our analysis found many new housing units that were larger than their surroundings, housing larger households than typical for their neighborhood. In Bern, comparatively large units are concentrated in smaller towns along the main transport line between Bern and Thun. These developments risk attracting larger households from more to less accessible areas, countering goals for compact urban development (Jehling, Hecht and Herold, 2018).

What also could be argued to run counter to densification goals is the comparatively larger living space per person in newly constructed housing units, reducing the added population density compared to what could potentially have been achieved. This contradicts previous concerns that densification diminishes the living space available per person (Burton, 2000; Bibby, Henneberry and Halleux, 2021). Yet, it is well in line with the generally observed rise in per capita living space and simultaneous shrinkage of household sizes – a demand that is catered to in housing construction (Haase, Kabisch and Haase, 2013).

More specifically, the densification type that shows the highest relative per capita living space is concentrated outside the larger cities and is associated with comparatively tall buildings and high shares of small, elderly households. Perhaps, these seemingly contradicting effects can be explained by the housing demand of an aging population in less urbanized areas. There, municipalities seek to provide the elderly (who occupy large single-family homes) with serviced apartments to make room for younger families (Götze and Hartmann, 2021). More generally, this finding corresponds to the observed housing preferences of elderly residents valuing community attachment and calm environments (Lauf *et al.*, 2012).

Our findings bind together earlier research on resident composition, building characteristics, and transformation processes in the context of densification. In addition to that research, the identified typology reveals processes running in parallel, such as soft densification and large-scale redevelopments. Furthermore, we demonstrate how processes deviate between the center and periphery – different housing types are created to meet different demands. This calls for a more

nuanced discussion of the effects of densification (Bibby, Henneberry and Halleux, 2020; Jehling, Schorcht and Hartmann, 2020).

5.6.2 Comparison between Utrecht and Bern

Our results suggest many similarities between Utrecht and Bern regarding the prevalence of densification types and their spatial distribution. The most significant dissimilarity between them concerns type *2-LargeFam*: In Utrecht, 40% of all new housing units were part of large-scale densification projects, compared to only 10% in Bern. In Utrecht, they also occurred in more central locations than in Bern.

On the Dutch side, this can be partially explained by subsidies, granted by the Dutch government in 2007 to redevelop deprived neighborhoods (Claassens, Koomen and Rouwendal, 2020). Four of these neighborhoods are located centrally in Utrecht and overlap with some of the large-scale redevelopments. More generally, in line with the theoretical reasoning on land policies in section 2, large-scale developments could be enabled by the larger share of corporation-owned apartments and the ability of Dutch municipalities to reassemble land through (the threat of) pre-emption and expropriation (Buitelaar and Bregman, 2016). Another reinforcing factor is the cultural expectation that landowners, if unwilling to develop, either sell their land, accept land exchanges, or be persuaded by more attractive development terms (Needham, 2014, p. 13).

In Switzerland, where smaller landowners, rather than corporations, are predominant, large-scale projects are not easily realized. In addition, citizens could be a crucial factor in preventing larger transformations of urban green spaces since rezoning proposals must legally be put to a vote. In light of the present arguments, we formulate the following working hypotheses: (1) Active land policy promotes large-scale densification projects, (2) if the land is distributed among many owners, individual plots are necessarily smaller on average, which complicates large-scale densification projects (especially given strong property rights), and (3) direct citizen involvement restrains unpopular land use changes (e.g. from urban green space to housing). Further research should be undertaken to investigate these potential institutional factors influencing the scale of densification projects. When discussing densification effects, the project scale is of importance since it can have implications for the loss of green spaces and jobs in industrial sectors, as well as the loss of existing residential building blocks. On the other hand, contiguous redevelopments could also offer opportunities for more holistic planning.

5.6.3 Reflections on the approach

While the approach resulted in convincing comparative findings, some limitations need to be considered for interpretation. For the two cases, national data had to be harmonized to allow for the comparability of metrics for social and built densification (section 3.1.1). For social metrics, the hectare level proved to be adequate in terms of availability and accessibility. Therefore, we assigned hectare values to each housing unit. These values represent well the residents of newly constructed housing units in case many units were constructed in a hectare cell. However, if only a few units were constructed, the hectare value is strongly influenced by pre-existing social structures. Since each housing unit represents one

data point, we argue that large densification projects of many housing units are more weighted in the analysis, thus compensating for this error.

A similar error occurred due to the mutual aggregation of land use to hectare cells. For instance, this led to wrongly attributing housing units in residential areas next to parks as “transformation of urban green spaces”. Since the transformation type is an important variable in the characterization of densification types, we covered that by only considering units at locations where land use has changed to “residential” or “construction site” by 2019. However, the latest land use datasets are from 2018 (Switzerland) and 2015 (the Netherlands), respectively. Therefore, housing units on brownfields or urban green spaces constructed towards the end of the period are filtered out as well. In total, around 30% of all new housing units (including expansion) in Utrecht and 40% of all new housing units in Bern were filtered out (see Figure S5).

Another concern regards the comparability of urban development in two regions with substantially different degrees of urbanization, age distributions, building traditions and landscapes. As a possible solution to this issue, we proposed metrics that characterize densification types in relation to their direct surroundings (Jehling and Hecht, 2021). We expressed densification as deviations from average values in a circle of 1 km^2 around each new housing unit. The results provide relevant information on the changes that densification inflicts on a neighborhood, independent of whether absolute values are the same in two regions. However, by using this approach, we pay the price of not being able to make any statements about absolute values. Still, since there is a strong correlation between absolute and relative values in our data, we can assume that an apartment that is larger than its surroundings is also a fairly large apartment.

Finally, the clustering algorithm chosen in this study had the advantage that the categorical variable “transformation process” could be included in the typology. K-proto cluster analyses are not being used very frequently, although, to a large part, they resemble the better-known k-means method (Bobkova, Berghauser Pont and Marcus, 2021). Since, in our analysis, the simple distance measure was weighted by a relatively small factor $\gamma = 1.4$, it results in mean values for clusters similar to k-means analysis, as it has been tested on the continuous variables of the same data set. In addition, visualizing the continuous variables of this study using principal components shows a reasonable delineation between the five densification types (see Object S6 for ordination with three principal components). Therefore, we assess that k-proto is a promising method to cluster large mixed-type datasets for urban analysis.

5.7 Conclusion

We presented an approach to characterize and compare social and building changes from urban densification, providing an empirical basis for policy evaluation. The method makes use of national datasets on socio-demography, residential buildings and land use changes. A k-proto cluster analysis revealed densification types describing (1) how new housing units deviate from their urban context, (2) how residents in new housing units deviate from their urban context, and (3) the construction process regarding the average project size and the transformation process through which the new housing units emerged. By describing densification in relation to its urban context, this method enables international

comparison. We successfully applied it to the cases of Utrecht (the Netherlands) and Bern (Switzerland) between 2011 and 2019 and identified five densification types whose frequency substantially deviates between the cases. Most strikingly, large-scale densification projects occur more often in Utrecht than in Bern, likely due to the prevalence of larger actors in the real estate market in combination with the ability of Dutch municipalities to apply strong instruments of active land policy. Future research could usefully explore the role of real estate market players in shaping densification patterns. Our findings suggest that the approach presented here is suitable for addressing causal relations between institutions (especially property rights and land policies) and densification. Furthermore, the approach revealed a diverse array of densification types and outcomes, challenging the widely held assumption that densification is a monolithic phenomenon. Ergo, a more differentiated discussion of the social, economic and ecological effects of densification is necessary.

6 For whom do we densify? Explaining income variation across densification projects in the region of Utrecht, the Netherlands[4]

While governments worldwide rely upon compact city policies to reduce land consumption from urban growth, recent studies have addressed the potential trade-off between densification and housing affordability. Concerns have been voiced that densification leads to a one-sided housing supply, structurally excluding low-income households. However, few studies address household income variation across densification projects, leaving us with a limited understanding of the circumstances under which exclusion occurs.

To this end, we explore household incomes in densification projects between 2012 and 2020 in the Province of Utrecht, the Netherlands, where urban development is traditionally strongly regulated through active land policy. At the same time, current shifts towards a more deregulated housing market make for an interesting case. Exceptional access to household-level and building data allows us to identify densification projects and assign them a median household income each. We investigate the influence of location and transformation process on household incomes through regression analysis and conduct qualitative case studies of projects whose median income was highly mispredicted by the regression model. This allows us to integrate non-quantified factors such as land ownership and public policy interventions in explaining such interesting cases.

For the Province of Utrecht, our study confirms that while households in densification projects earn significantly more than their neighbors, the range of incomes in densification projects is large. Project characteristics such as centrality, neighborhood status and transformation process explain only a small share of this variance. For cases where median incomes are much lower than predicted by the model, public land ownership, in combination with inclusionary zoning, is essential in ensuring housing affordability. Our approach highlights the necessity of supplementing densification policies with measures that secure affordable housing.

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6.1 Introduction

Urban densification is considered key to combat land take and urban sprawl. Therefore, governments globally have imposed restrictions on land supply for construction, concentrating urban development within existing built-up areas. While densification, or infill development, is generally regarded as a viable approach to sustainable urban development, concerns center around its connection to social sustainability, especially housing affordability (Teller, 2021). Although earlier studies acknowledge the potential benefits of densification, such as intensified interactions and improved access to public transport and job offers (Burton, 2000; Ahlfeldt and Pietrostefani, 2017), researchers stress the risk of densification creating a housing offer that deliberately excludes low-income households (Rérat *et al.*, 2010; Debrunner, Hengstermann and Gerber, 2020).

The perceived risk of exclusion is strongly associated with gentrification as densification projects take place in existing neighborhoods. Considerable studies have shown how former working-class neighborhoods have been redeveloped into upscale areas, diminishing housing affordability in densifying neighborhoods (Moos *et al.*, 2018; Cavicchia, 2021). Such exclusionary effects have been found regarding income, education level, migration background and age (Moos, 2016; Cavicchia and Cucca, 2020; Nachmany and Hananel, 2023). The fact that densification seemingly caters to young, highly educated, and small households appears to do little to stop young families or older people from moving or remaining in peripheral, low-density detached housing (Steinacker, 2003; Bromley, Tallon and Thomas, 2005; Moos, 2016).

While these insights have raised awareness of potentially negative social trade-offs of densification, the factors influencing the relationship between density and affordability appear largely unexplored. For instance, the age of the housing stock, city size and polycentricity can impact the effect of density increases on income segregation (Pendall and Carruthers, 2003; Garcia-López and Moreno-Monroy, 2018). Effects differ between brownfield redevelopments, the direct replacement of social housing blocks, or housing subdivisions (Troy, Easthope and Crommelin, 2017; Bibby, Henneberry and Halleux, 2021). Additionally, there are differences between local governments regarding the degree to which they combine densification with the goal of attracting higher-income households (Quastel, Moos and Lynch, 2012). Such land policy factors should receive greater attention when considering the conditions for achieving urban densification while maintaining an inclusive housing supply (Cavicchia, 2021). Therefore, approaches that combine empirical insights on spatial processes and land policy interventions (Jehling and Hecht, 2021) are highly promising to describe and explain the social effects of densification.

Against this backdrop, this paper aims to develop and test a novel approach to explain the variation of household incomes across densification projects, asking: *What is the distribution of household incomes across densification projects at the city-region level? How do project location, transformation type, land ownership, and planning interventions affect household incomes?* We argue that household income constitutes a promising indicator to operationalize our interest in studying the social effects of densification, as it allows us to analyze housing offers across renting and property markets and focuses

on those who live there. Access to exceptionally detailed Dutch income, building and land use data allows us to assign median household incomes to densification projects between 2012 and 2020.

Following a neo-institutional approach, we understand densification outcomes as resulting from the interplay between institutions and actors' strategies. Therefore, we perform a regression analysis tracing the effect of transformation type and location on household income. Then, following a multi-method approach (Seawright, 2016), we qualitatively examine interesting cases – namely projects where the model vastly mispredicted household incomes. This allows us to include further causes, such as landowner strategies or public policy interventions (Jehling, Schorcht and Hartmann, 2020).

The spatial level of the province offers a city-regional perspective with sufficient projects for statistical analysis. It is simultaneously small enough for in-depth qualitative analysis in a comparatively homogeneous regional housing market. The Netherlands offers an interesting planning context to study densification. The efficient use of scarce land has been a central tenet of Dutch land use planning in various national spatial planning policy documents. It was further solidified with the introduction of the Ladder of Sustainable Urbanisation in 2012, prioritizing developments within existing urban areas. In addition, against a backdrop of housing market deregulation and the shift away from municipal land ownership, the Netherlands provides an intriguing case for international observers, particularly in exploring the relationship between public land ownership and housing affordability in densification projects (Claassens, Koomen and Rouwendal, 2020; Musterd and Ostendorf, 2021). The remaining sections of the manuscript encompass the theoretical framework, methodology, results, a discussion of the findings and concluding remarks.

6.2 Explaining housing offers through property rights and public policies

Following a neo-institutionalist approach, we understand housing offers through densification as an outcome regulated by property rights and public policies. These two sets of rules determine how actors can gain access, use, or exploit resources such as land or housing. They, therefore, enhance or restrict actors' use interests (Gerber, Hengstermann and Viallon, 2018). Public policies, in particular, planning and housing policies in the context of this research, aim to regulate the behavior of landowners to solve issues in the distribution of housing (Knoepfel *et al.*, 2007). On the other hand, property rights aim to protect the individuals' interests from interference from the state. The two sources of formal rules and the appropriation strategies of actors thus shape the housing outcomes in densification projects.

6.2.1 Property rights: market forces influencing housing offer

Property rights enable actors to follow a market logic. Independently from public policy intervention, we expect the housing offer to reflect factors such as location, construction costs and developer strategies. Locational factors of a densification project encompass neighborhood status, centrality, and property prices. Since densification has been observed to occur predominantly in areas of high demand (where financial viability is given), it is also considered less affordable than other housing (Steinacker, 2003). As a form of risk management, developers mostly build similar to what already exists in the

neighborhood – except for gentrifying neighborhoods where a large rent gap opens up possibilities to attract higher socio-economic groups (Kim, 2016).

In addition, construction costs vary between different kinds of densification projects. As an extreme example, subdividing a house into two or more apartments is less costly than transforming a brownfield. As brownfields may be contaminated, redevelopment can be expensive, time-consuming and risky (De Sousa, 2000). Thus, more low-income residents are expected to live in subdivisions than in brownfield redevelopments. Different groups of developers with different business strategies perform different kinds of densification projects. Some developers, expecting a direct return, build owner-occupied units that they can sell immediately (Rérat *et al.*, 2010). As households in owner-occupied units are generally much wealthier than renters, this might lead to a higher average income in such projects (Arundel and Hochstenbach, 2020). Other investors, such as pension funds, are interested in long-term returns and incentivize the development of rental housing, also for the upper to the middle class (Rérat *et al.*, 2010), while individual, private landowners concentrate on subdividing and renting out smaller apartments (Bouwmeester *et al.*, 2023). Thus, different types of developers may make the provision of certain housing offers more likely than others.

6.2.2 Public policies: the impact of planning interventions

Public authorities can intervene in private developers' property rights through public policies. Public policies can be defined as decisions by public authorities to resolve a politically defined collective problem (Knoepfel *et al.*, 2007). Thus, policy objectives constantly change as the understanding of collective problems evolves and political majorities shift. For example, through affordable housing policies, public authorities can try to steer developers to provide housing for low-income residents through the municipal building code, the provision of subsidies or negotiated land use plans (Debrunner and Hartmann, 2020). Contrarily, city authorities can implement policies to attract wealthier residents and increase social mixing (usually at the cost of lower-income households) (Uitermark, Duyvendak and Kleinhans, 2007; Lees, 2008). However, the effectiveness of public policies can be questioned. Debrunner and Hartmann (2020) find that even though planning instruments exist that could force investors to provide affordable housing, municipalities often do not apply these instruments. One major obstacle is that many planning instruments are relatively weak in front of well-protected property rights. Landowners are especially powerful in the context of densification projects. As land is scarce, public authorities depend on landowners to implement policies.

This section discussed variables that can explain differences in housing offer (and ultimately resident structure) between densification projects. In the following section, after explaining how we detect densification projects, we will present how the variables discussed above will be used in the further analysis of income variation across densification projects.

6.3 Methods and data

6.3.1 Identifying and describing densification projects on the province and neighborhood level

We use information on former land use (t_0) and construction year to select housing units, i.e., apartments in multi-family housing and buildings in case of single-family housing, that were newly created at t_1. If the former land use was urban (i.e., no natural or agricultural land use), the housing unit is labelled as densification, otherwise as expansion. We further distinguish between the transformation processes “transformation of urban green spaces”, “transformation of brown- and grey fields”, “densification in residential areas”, “densification that included the demolishing of existing housing units (redevelopment)” and “soft densification” (Götze and Jehling, 2022). Contrary to “densification in residential areas”, which requires the construction of a new building, “soft densification” only covers housing units that were created within existing buildings, e.g., through the subdivision of apartments or transformation of offices, shops or attics (Bibby, Henneberry and Halleux, 2020).

Each housing unit is assigned information on its residents, including age, household size, personal living space, education, and household income. New housing units in spatial proximity are grouped into densification projects. We then analyze the distribution of socio-economic groups of the project compared to (1) all existing residents in the province and (2) existing residents in the respective neighborhood.

6.3.2 Explaining the distribution of household incomes in densification

We employ multiple regression analysis to measure the effects of location and transformation type on household income distribution. This analysis is supplemented with qualitative case studies to examine the influence of land ownership and municipal intervention on median income.

Choice of the dependent variable and aggregation to projects. We take the median standardized household income in densification projects as an indicator for the dependent variable. Such standardized household incomes correspond to disposable incomes adjusted for differences in household size and composition (Statistics Netherlands, 2018). Compared to housing prices, incomes represent directly who lives in a housing unit and covers both tenants and owners. This approach also considers that households in central locations may have the capacity to allocate more funds towards rent due to reduced reliance on car ownership for commuting (Aurand, 2010; Xiao, Orford and Webster, 2016). Since it is our aim to cover all socio-economic groups living in densification projects, we also keep students and retirees in the dataset. This allows us to find potentially constructed student dorms or retirement homes. Robustness checks indicate that students and retirees negligibly affect the significance and coefficients of the regression model (supplementary materials Figures S01 and S02). While the approach is well-suited for the aim of this article, it must be stressed that household income does not directly reflect affordability, as it ignores the share of income required for housing.

Densification projects are formed by aggregating ten or more households. This has several advantages. First, income variance within projects is often high, and reducing the information to a single median value per project reduces this noise. Second, we aggregate into projects to reduce spatial autocorrelation because the similarity of incomes among households in the same building can violate

the assumption of independence in regression analysis. This can potentially distort the relationships measured in the model. A disadvantage of this decision is that developments with less than ten households (often soft densification) fall out of the regression analysis. To cover their importance in densification (Bibby, Henneberry and Halleux, 2020), they are still considered when measuring the distribution of standardized household incomes across development types.

To group housing units into densification projects, we use a density-based clustering algorithm (DBSCAN). This algorithm clusters data points based on a maximum point-to-point distance (Eps) and a minimum number of points that can form a cluster (MinPts) (Ester *et al.*, 1996). We use a maximum point-to-point distance of 35m with a minimum number of ten units per cluster (Figure 10).

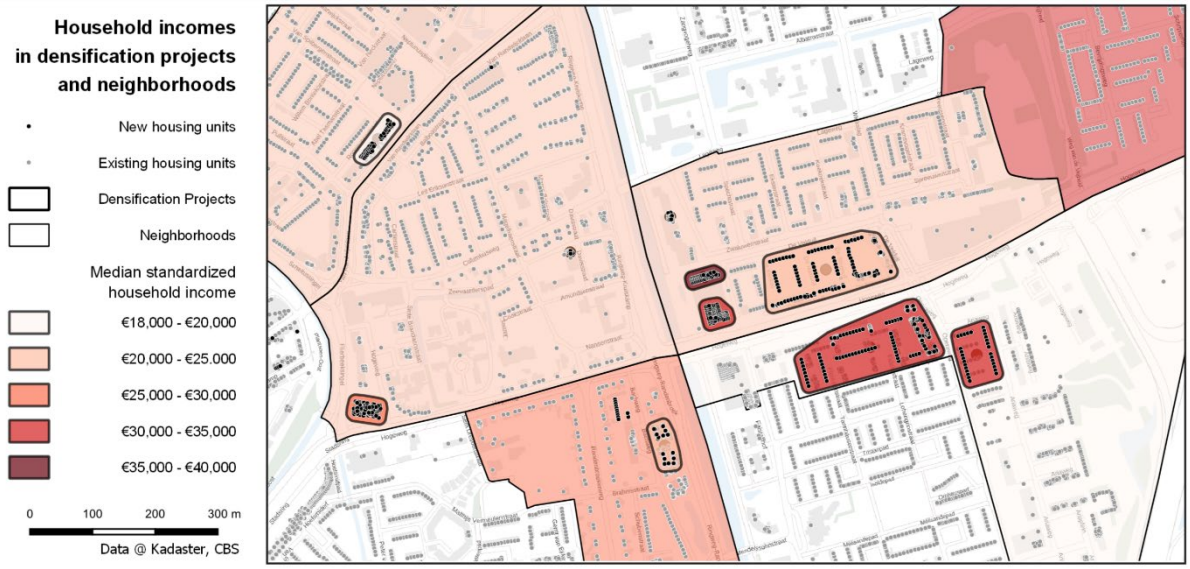


Figure 10 Median standardized household incomes in densification projects and neighborhoods, 2019

Multiple linear regression analysis based on actors' interests and policies. Multiple linear regression analysis estimates the effect of demand and construction costs on standardized household incomes. We use the following predictors: transformation process, centrality in 2011, neighborhood income 2011 and neighborhood income change 2011-2019. The centrality is measured as address density within a circle of 1 km^2 around each address in a neighborhood (Van Leeuwen and Venema, 2021). Neighborhoods are defined following the delineation of Statistics Netherlands. Neighborhood income 2011 and income change 2011-2019 represent their status and dynamics, indicating attractiveness for developers. The indicators are based on the median standardized household income per neighborhood in 2011. Neighborhood income changes, then, depict the difference between a neighborhood's median standardized income in 2019 and 2011, corrected for inflation. Residents in newly constructed addresses are filtered out of the calculation to avoid simultaneity bias (i.e., newcomers lifting average neighborhood income). For the same reason, the variables "centrality" and "neighborhood income" reflect measurements from 2011, before densification happened.

Qualitative case study analysis. We select projects where predicted income differs most from real income, i.e. residuals exceeding +/- €10,000 (following Garcia-Lamarca *et al.*, 2021). Analyzing such

deviant cases is valuable for hypothesis building since it allows for identifying further causal relations that explain densification outcomes (Lieberman, 2005; Seawright, 2016). To analyze these cases, we collected and analyzed legally binding documents, such as land use plans, visions, and official municipal decisions, as well as non-binding documents, such as meeting minutes of municipal councils, newspaper articles and strategic documents.

6.3.3 Data sources and data access

Housing units with construction year and surface area are retrieved as point data from the Dutch cadastre. Statistics Netherlands provides publicly accessible vector data on land use and neighbourhood aggregated data on address density (i.e., centrality). Access to non-public household-level microdata on income, age, household size and education was granted by Statistics Netherlands. To calculate neighborhood income, we aggregate income data to pre-defined neighborhoods.

Out of 57,633 housing units that were newly registered in the cadastre between 2012 and 2020, 38,376 are identified as densification (the remaining units as expansion). We aggregated these 38,376 housing units into 436 densification projects that were then used in the regression analysis. Of the 38,376 housing units, 5,437 are not part of densification projects and were thus excluded from the regression. In the supplementary materials, you can find summary statistics (Table S01) and a correlation matrix (Figure S03) for the variables that enter regression analysis.

6.4 Results

6.4.1 Distribution of standardized household incomes

With €30,800, the median standardized household income in densification projects (excluding soft densification) is slightly higher than the Province median of €30,700 and considerably lower than in expansion areas (€35,700) (Figure 11). Compared to existing households in the same neighborhood, the newcomers' incomes lie on average €3,700 above the neighborhood median.

The transformation types of soft densification and redevelopments in residential areas show the lowest incomes. In contrast, the transformation of urban green shows the highest incomes, comparable to those observed in expansion areas. Consequently, if we include soft densification, incomes in densification projects move below the province median but are still, on average, €2,000 higher than the neighborhood median.

Only in the case of soft densification projects and residential redevelopments do newcomers earn less or almost the same as the existing residents in the neighborhood. At the same time, projects in these categories that together make up 40% of all densification projects in the analysis, occur on average in neighborhoods with low median incomes of respectively €22,400 (redevelopment) and €21,800 (soft densification) (Table S02 in Supplementary Materials).

Households in green space transformations resemble those in expansion areas regarding household size and share of children. In contrast, households in other forms of densification projects are comparatively smaller than the province's mean. Households in green space transformations even

enjoy, on average, 5 m² more living space than those in expansion areas and 8 m² more than households in brownfield transformations (Table S03 in Supplementary Materials).

The highest share of main earners with tertiary education is reached in brownfield redevelopments. Also, residents in soft densification projects have, to a large degree, a completed tertiary education, distinguishing them from residents in residential redevelopment projects (i.e. demolish-rebuild) with whom they share low-income levels. In addition, soft densification projects show a remarkably large share of residents between 15 and 24 years of age, approximately five times higher than the provincial average.

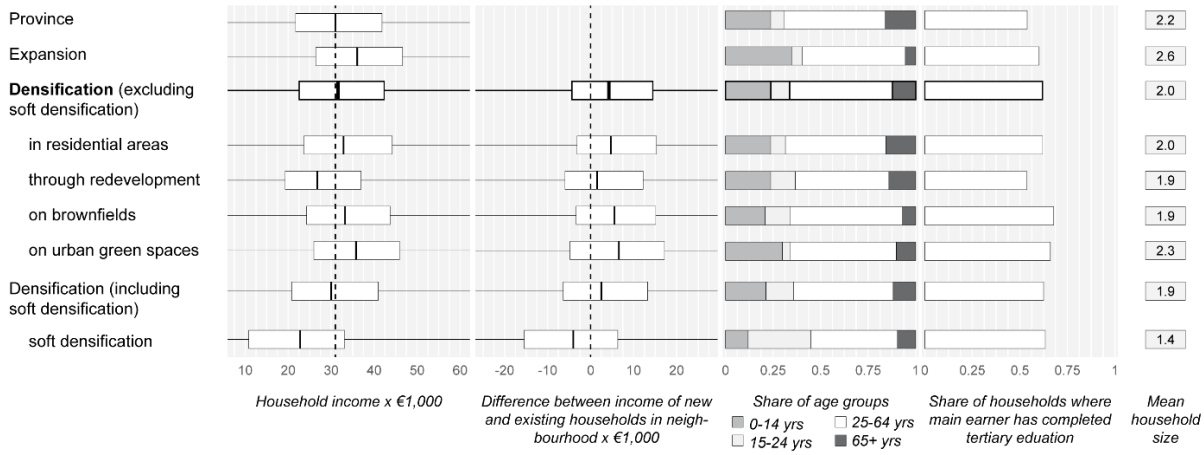


Figure 11 Socio-economic characteristics of residents at t1 grouped by transformation process[5].

6.4.2 Median standardized household income in densification projects of 10 or more households – explained by regression analysis

The median income in densification projects is significantly and positively related to centrality (i.e., address density) and neighborhood incomes (Table 4). Of the densification processes, residential redevelopments and soft densification show a significant negative, and transformations on urban green spaces and brownfields show a significant positive difference to the null hypothesis of densification in residential areas. The model's predictive power is limited, as indicated by a low adjusted R-squared of 0.21. However, the residuals are normally distributed and show a low Moran's I value for spatial correlation (Figures S04 and S05 in Supplementary Materials).

Table 4 Regression coefficients, standardized household income in infill projects

Dependent variable	Median Standardised Household Income 2019
Transformation process variables	
Redevelopment in residential areas	-2,544***
Soft densification	-6,523***
Transformation of brownfields	2,444**

[5] See for classification of education levels: https://www.cbs.nl/en-gb/our-services/urban-data-centres/labour-and-income/education-level#:~:text=Education%20levels%20can%20be%20broken,vocational%20education%20(MBO)%2C%20higher

Transformation of urban green spaces	2,716*
Neighbourhood variables	
Centrality 2011	1.04***
Median Neighbourhood Income 2011	0.68***
Change in median neighborhood income 2011-2019	0.39**
Intercept	13,160***
R^2	0.22
Adjusted R^2	0.21

*Notes: ***Significant at 1 per cent; **Significant at 5 per cent; *Significant at 10 per cent*

Concentrating on the residuals, we further examine the relationship between densification projects' income and neighborhood attributes. We focus first on projects with household incomes that we consider rightly predicted by the model (residuals of +/- €5,000) and later explain projects where incomes have been greatly mispredicted by the model (residuals of +/- €10,000). For a fifth of all projects, the regression model over- or underestimated median household incomes by over €10,000 (Figure 12).

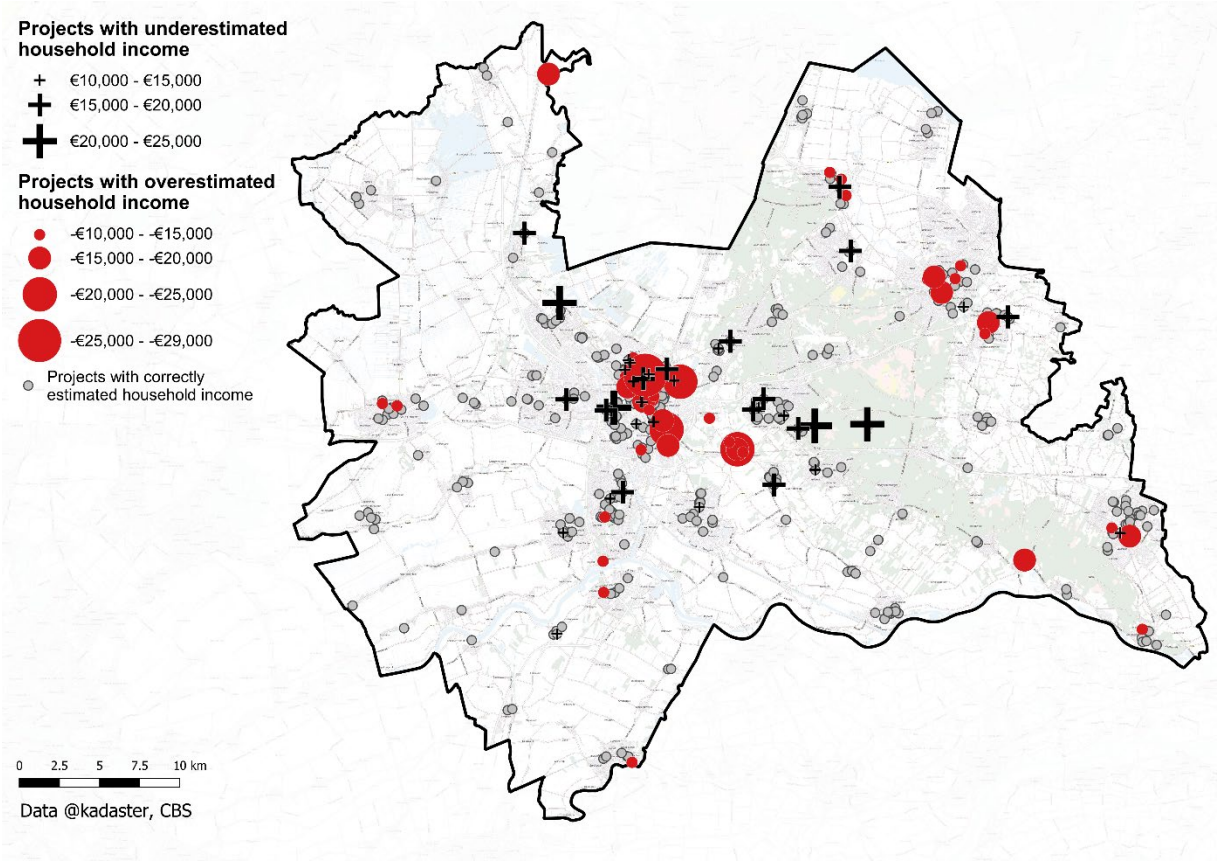


Figure 12 Under- and overestimated densification projects and rightly predicted projects.

6.4.3 Projects with correctly predicted household income

We start by investigating what characterizes projects with a rightly predicted median standardized household income in the lowest quartile (<€23,000). All of the 14 projects were instances of "densification that included the demolishing of existing housing units (redevelopment)" or "soft densification". Five are located in most central areas (top quartile), but none are in the highest income

neighborhoods (top quartile). Still, in 9 projects, newcomers earn less than their neighbors. There are also examples of low-income households moving to strongly gentrifying neighborhoods, but only through soft densification. The group of rightly predicted projects with the highest median incomes (top quartile, >€36,000) is made up almost entirely of brownfield and urban green space redevelopments and infill in residential areas. Only one project, situated in a top-income-quartile neighborhood, was created through redevelopment. Many high-income projects are in the most peripheral regions (lowest quartile). Only one project was constructed in a bottom-income-quartile neighborhood, and four were built in neighborhoods with a below-median income in 2011 (<€23,000). One of them, a transformation of sports fields in the city of Utrecht, produced rowhouses with a median income of €37,000.

6.4.4 Projects with a mispredicted household income – Case studies

To understand why the median incomes of certain projects have been mispredicted, we need to understand the policy context in which densification occurs in the Netherlands. Dutch planning authorities have traditionally had a strong influence on spatial developments and the housing market. Land uses have been tightly coordinated through the national government and the use of active land policy. After WWII, housing associations (not-for-profit actors) played an important role in rebuilding efforts. As a result, social housing was widely available for people of every socioeconomic status (Buitelaar, 2010). Housing associations still hold a sizeable percentage of ownership in early post-war neighborhoods (Priemus, 2006). However, new housing policies implemented after the crisis have led to a declining share of stock from 40% in 1990 to about 29% in 2022 (CBS, 2023). In addition, regulatory changes have limited housing associations' ability to acquire land as they can only hold it for five years, and extra taxes on social rent income have created financial pressure (Van Gent and Hochstenbach, 2019).

These changing policies are part of a general shift in ideas about the state's role in urban development and housing construction. On a municipal level, this is most obviously characterized by the shift away from the active land policy after the global financial crisis when municipalities made big losses on land development. Instead, local planning authorities take a more facilitating role and are expected to provide room for initiatives from the private sector (van Oosten, Witte and Hartmann, 2018). For most redevelopment projects, local planning authorities now renegotiate part of the relevant land use plan with the developer, making it more challenging to enforce inclusionary zoning. Still, municipalities have some instruments available to steer housing construction. In the region of Utrecht, some municipalities have included a rule in the land use plan that stipulates that a certain percentage (often 30%) of new construction needs to be social housing.

Projects with overestimated household income. Many of the projects with overestimated incomes are characterized by the fact that they were realized on (once) publicly owned land. A good example is a large redevelopment project in the east of Utrecht city called Veemarkt (Figure 13). Through public tenders, the municipality could implement objectives and ambitions such as sustainability. Another objective was to provide 40% social rent or affordable owner-occupied housing (Municipality of Utrecht, 2013). Since the municipality of Utrecht had made agreements on fixed land prices for plots on which

social rent would be developed, these plots did not have to be given out through a tender but were negotiated among different housing associations in Utrecht (Municipality of Utrecht, 2011a).

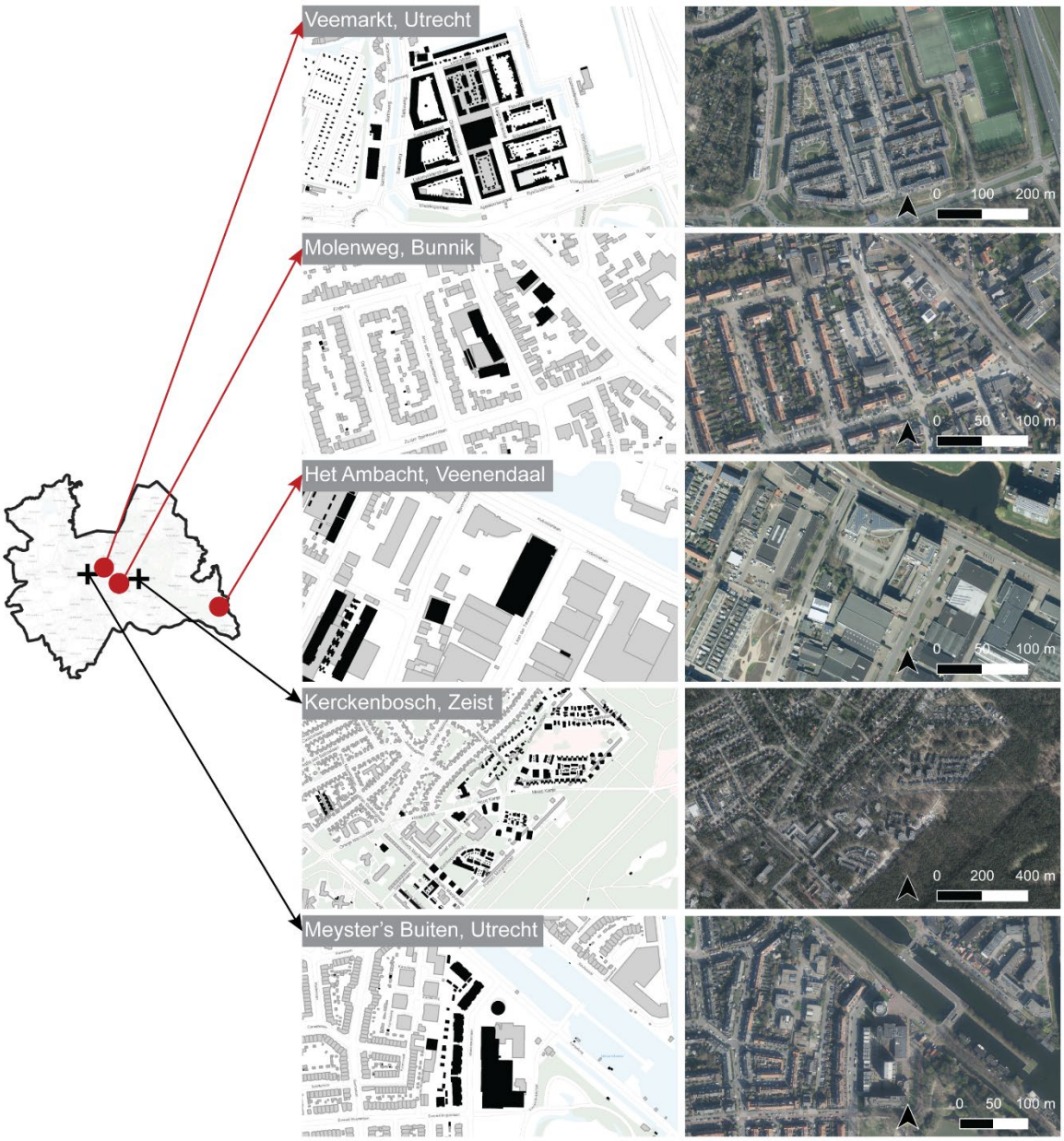


Figure 13 Case study. Data @Kadaster

Another project with a high overestimation – assisted living apartments for people with a disability – is located in a smaller town called Veenendaal and concerns the redevelopment of a plot in the industrial park Het Ambacht. The industrial park is one of the municipality's main redevelopment areas. In this project, land ownership was in the hands of a private developer and a housing association, who purchased the land because of the planned redevelopment of the industrial park. The two parties worked together to realize a residential care complex (Patrimonium Woonservice, 2016). In response to the initiative of the two parties, the municipality implemented a new land use plan in 2013, allowing for a change in function (Municipality of Veenendaal, 2013). In this case, incomes in the project are lower than expected because of the land ownership by a non-profit housing association.

Other projects with overestimated incomes can neither be explained through public land ownership, ownership by a non-profit private actor or through qualitative targets in public policies. An example is the Molenweg project in the small town of Bunnik. This neighborhood is dominated by owner-occupied housing, but a former industrial site was transformed into rental apartments. As stipulated by the housing vision, the municipality has a housing shortage in the higher-intermediate segment (€1,000-€1,200/month) for the elderly who want to move to more age-appropriate housing (Municipality of Bunnik, 2018). While initially, the project developer did research the possibility of realizing single-family housing in this location, the project developer and the local planning authority agreed that 24 rental apartments would be constructed in the higher-intermediate segment in 2019. This option was "more attractive because of the public housing task and market demand" (Van Wanrooij Projectontwikkeling, 2019, p. 1). The case shows that municipalities can sometimes negotiate the construction of comparatively affordable apartments with the developer.

Projects with underestimated household income. The project with the greatest underestimation of income achieved a median standardized household income of €69,000 (€24,000 above the modeled value). Residents thus belong to the 3% highest incomes in the Netherlands. The spacious single-family units mimic the style of the popular surrounding 1930s neighborhood *Oog in Al,* 1.5 km from Utrecht central station. Marketed as "royal mansions" (*Herenhuizen Meyster's Buiten*, 2011), the concerned row of houses is part of the larger transformation project *Meyster's Buiten*. In our analysis, however, the project was cut in two, separating the mansions from the denser, publicly owned, mixed-use development to the east (median income: €45,000). Meyster's Buiten is a collaboration between the municipality of Utrecht and two private developers. In 2011, after a fire destroyed most of the factory buildings and during the onset of the financial crisis, the three parties had to adapt the original development plan to increase profitability (Wong, 2015). In this context, planned apartment buildings were replaced by single-family units (Municipality of Utrecht, 2011b).

Another project with a highly underestimated median income concerns the redevelopment of social housing blocks from the 1960s at the forest edge in the neighborhood of Kerckebosch, east of Utrecht. Here, on land formerly owned by the Municipality of Zeist and a social housing association, approximately 700 social housing units were replaced by 1000 new units, of which 55% are social housing (Bosoni, 2020). Green wedges intersect the new building groups and are again registered as individual projects rather than contiguous ones. Correspondingly, many building groups show the expected low median household incomes, but one was underestimated by €23,000. This can be explained by the financing scheme of the redevelopment project. In this scheme, the construction of social housing during later construction phases is financed through the sale of condominiums in earlier phases. In this project, it was argued that changed circumstances after the financial crisis made it necessary to replace planned apartment buildings with more profitable single-family units (Municipality of Zeist, 2014).

6.5 Discussion

For the Province of Utrecht, our findings show that, while households in densification projects, on average, earn more than their neighbors, household incomes vary a lot between projects. Project characteristics, such as location and transformation process, only explain household incomes to a small degree. In many projects where the newcomers' income deviates a lot from expectations, municipalities were able to steer project outcomes through active land policy.

While supporting earlier studies showing that households in densification projects earn more than average (Rérat *et al.*, 2010; Cavicchia, 2021), our study additionally explores what factors explain differences in household income between densification projects. Not surprisingly, projects in more central locations and higher-income neighborhoods also show higher median household incomes. However, even centrally located projects in moderately wealthy neighborhoods can show below-average income levels, given they are soft densification or redevelopment projects.

In the case of soft densification, the resulting apartments (or rooms) are significantly smaller than those in their surroundings (Götze and Jehling, 2022). It is an inexpensive strategy of individual property owners in response to the high demand for housing in city centers. In the case of Utrecht, this practice is sometimes mentioned in the context of student rentals (Bouwmeester *et al.*, 2023). This is supported by the high shares of young adults in such projects, reflecting the rising popularity of high-density living among this age group (Moos, 2016; Rérat, 2019). At the same time, soft densification projects show comparatively high shares of residents with completed tertiary education. Both findings point to the need to include measures of age and education next to income in future studies of residential segregation (Boterman, Musterd and Manting, 2021).

For redevelopments (i.e. demolition-rebuild projects), low median incomes are likely explained by the fact that this transformation type is performed chiefly on rental housing blocks, of which, in the Netherlands, 70% are owned by non-profit housing associations. In this case, however, the redevelopment happens at the cost of existing affordable housing units and is often accompanied by the eviction of previous residents (Musterd and Ostendorf, 2021), additionally supporting concerns about gentrification effects. Further studies should, therefore, also employ socio-economic data of those who are displaced through densification. In general, densification predominantly occurs in less affluent but well-located areas, where large rent gaps make it profitable (Kim, 2016), while more affluent communities successfully prevent densification through their property rights (Charmes and Keil, 2015; Touati-Morel, 2015). This location bias and intervention in vulnerable neighborhoods set densification apart from greenfield development, which, while also targeting higher-income households, takes place on former uninhabited land.

Still, the location and transformation process explain only a small share of the variance in median household incomes, as reflected in the relatively low fit of the regression model comparable to earlier studies (Steinacker, 2003; Garcia-Lamarca *et al.*, 2021). Acknowledging that planning and housing policy in the Netherlands intervenes in housing markets quite significantly, this was to be expected since essential factors, such as public land ownership and planning interventions, were not covered by the

model. Consequently, we added a qualitative case-based explanation for interesting cases where the model strongly mispredicts median household incomes.

The case studies of projects where median household incomes were strongly overestimated reaffirmed the important role of municipal land ownership in providing affordable housing. Non-profit housing associations rely on land transfers from municipalities because they cannot usually compete with market players. This has to do with continually tightening regulations that make it increasingly difficult for housing associations to acquire land. The Housing Act of 2015 introduced stricter regulation concerning the involvement of housing associations in the non-social rent sector and their ability to speculate on future land developments. Simultaneously, it has become possible for private actors to supply social housing. With housing associations thus being limited in their ability to acquire new land, they have become more dependent on private developers to sell them newly constructed buildings. Alternatively, they can increase their housing stock through the densification of their existing plots (demolition-rebuilt). Still, as the case in Veenendaal shows, housing associations can sometimes secure land ownership in redevelopment cases without any public land ownership. In these cases, they have to act according to a financialised logic, using their equity or selling older housing stock to compete with commercial actors (Buitelaar, 2010; Aalbers, Loon and Fernandez, 2017). Our case study of underestimated projects has shown how both municipalities and housing associations have financed the construction of affordable housing by selling expensive condominiums within the same project. This was partly revealed through the applied approach to aggregate densification projects, which splits larger projects with cross-financialization into separate projects.

In addition, examples among projects with both over- and underestimated incomes showed that the financial crisis of 2007-2008 and the following drop in construction until 2014 made it difficult for municipalities to implement social housing quotas. Only recently, in the wake of an overheated housing market and, subsequently, rising house prices, did municipalities in the province start applying quotas to new construction projects. These quotas are likely to impact household incomes in densification projects but are not reflected yet in the data used in this paper.

The presented approach showed great potential for exploring the factors that influence household income in densification projects. Crucially, highly detailed income and building data allowed for a precise distinction of densification projects and their residents from their surroundings, covering a complete city region (Jehling, Schorcht and Hartmann, 2020; Götze and Jehling, 2022). In addition, combining regression analysis and qualitative case studies proved helpful in highlighting interesting cases (Seawright, 2016). While using the indicator “household income” had the advantage of covering both tenants and owners, it must be stressed again that it is not a direct representation of housing affordability.

6.6 Conclusion

Against the backdrop of concerns regarding the potential exclusion of low-income households due to urban densification, this study set out to explore factors accounting for differences in median household incomes across densification projects. Access to microdata allowed us to distinguish newcomers from

existing residents, making it possible to calculate median household incomes for individual densification projects. In addition, by combining multiple regression analysis with case studies of mispredicted cases in a multi-method approach, we can consider both quantitative factors (location and transformation type) and qualitative factors (land ownership and public policy interventions) in explaining income across densification projects.

While our findings for the Province of Utrecht have confirmed that households in densification projects earn more than their direct neighbors, we have also observed considerable differences between projects. Factors such as centrality, neighborhood status and transformation type explain household incomes only to a small degree, leaving 80% of the variance unexplained. Public land ownership has shown powerful in providing housing for lower-income households in the projects that we examined qualitatively. However, such case studies have also shown the vulnerability of financing schemes, even on publicly owned land, where the provision of affordable housing depends on the profitable sale of owner-occupied housing within the same project. Potential for further research lies in including measures of age and education, as well as displacement connected to various forms of densification. Our contribution shows that the relationship between density and housing affordability is inherently political, shaped by decisions about who should have access to land and housing.

7 Mapping municipalities' strategic application of flexible planning instruments for densification

Municipalities develop individual land policies and, therefore, also apply planning instruments differently – a circumstance rarely considered by geospatial analyses on the effects of planning on spatial development. This study focuses on Planned Unit Development (PUD), which allows for flexible zoning negotiations promoting densification. Using detailed zoning and building data for the Canton of Bern, Switzerland, between 2002 and 2023, we examine the variation in PUD application concerning the extent to which municipalities use it and the complexity and type of projects they apply it to (i.e., project size, building use, density (gain), mix and parcel structure). In a second step, we explain the observed variation based on the municipalities' function (i.e., urban core, small town, suburban, rural or touristic). We find that urban municipalities use PUD most frequently, and touristic municipalities' use of PUD is rapidly increasing, while rural municipalities use the instrument very little. Urban and suburban municipalities, in particular, seem to target the instrument to more complex projects and gain higher densities than when using conventional zoning. The observed differences in instrument application highlight the need to consider municipal strategies in institutional analysis.

7.1 Introduction

To learn more about sustainable planning approaches, it is crucial to understand the effect of planning on spatial development better. Therefore, a growing body of research addresses how the interplay between institutions and actors affects spatial development (Debrunner and Hartmann, 2020; Eichhorn *et al.*, 2024). Actors tend to pursue their individual interests in the resource land. Rules of the game (institutions) are needed to prevent conflicts and resource overuse. For example, Buitelaar and Leinfelder (2020) compare the compact development of the Netherlands to the sprawled development of Flanders and draw parallels to governmental institutions that support these differences. Likewise, Götze and Jehling (2022) compare densification patterns across Switzerland and the Netherlands and discuss possible institutional drivers that explain observed differences. On a more detailed level, researchers focus on the morphology of single-family neighborhoods across countries and possible connections to the respective institutional frameworks (Tennekes, Harbers and Buitelaar, 2015; Jehling and Hecht, 2021).

However, such large-scale studies often overlook the important role that municipal strategies play within the same institutional framework (Götze, Bouwmeester and Jehling, 2023; but see Eichhorn *et al.*, 2024). Even though instruments are being provided (by the institutional framework), municipalities can choose not to apply them or apply them for a different purpose (Debrunner and Hartmann, 2020).

Municipalities attempt to intervene in urban development to align it with democratically accepted goals. On top of standard planning instruments, such as zoning, municipal planners can activate other policy instruments to reinforce their position to achieve these goals. These instruments help them reach overall planning objectives, sometimes against the private interests of other stakeholders (e.g., landowners, developers or tenants). Municipalities, thus, strategically implement a mix of policy instruments to reach their planning goals. These municipal strategies are also referred to as land policy (Gerber, Hengstermann and Viallon, 2018). In this article, we examine municipalities' strategic application of policy instruments focusing on flexible planning instruments in the context of urban densification.

Densification is an interesting context because it addresses an intervention in the existing built-up area, where many goals compete. It is, at the same time, an important policy goal anchored in international sustainable development strategies (European Commission, 2011). Densification is also a context that requires municipalities to actively intervene in spatial development due to the many barriers to it (Nabielek, 2011). Generally speaking, densification happens when there is a demand for higher densities. However, some locations develop only a little, even though there is demand for more housing. This often concerns high-income, low-density neighborhoods where citizens fight against densification (Rousseau, 2015) or locations with fragmented ownership where redevelopment only happens when all landowners agree to develop (Buitelaar and Segeren, 2011). At the same time, densification is often not the main goal of municipalities but a means to reach their development goals (Giddings and Rogerson, 2021).

Planned Unit Development (PUD) is an especially interesting planning instrument in this context. PUD allows for a deviation from or an addition to the zoning plan, making developments subject to negotiation between the municipality and the developer. This makes PUD a potentially powerful instrument to allow for higher densities while safeguarding the quality of the development through detailed regulation. Flexible planning is supposed to break down barriers to densification and help municipalities keep control of what form densification takes on. However, the effects of the instrument depend on the municipal strategy. In the context of densification, questions remain on the purpose of applying the instrument. More specifically, the strategic application by municipalities defines whether PUD allows for higher densities and enables urban development under complex ownership and property rights conditions as they are typical for densification.

PUD is part of a larger trend towards project-based planning (Gerber, 2016) where planning regulations become more flexible and where there is more room for negotiation between municipality and developer. Several researchers warn against possible adverse effects that this flexibilization can have on the planning process, such as serious infringements on legal certainty, equal treatment and democratic participation (Buitelaar and Sorel, 2010; Gerber, 2016). Ultimately, project-based approaches such as PUD could lead to shifting the focus away from safeguarding public interests towards "narrowly defined finance-centered objectives" (Gerber, 2016, p. 15).

But what effects does PUD have on the spatial outcome of densification? On the one hand, the flexibility to deviate from and expand on land use plans is a chance for municipalities to steer development in

desired directions (Buitelaar and Sorel, 2010). Concretely, it can enable municipalities to achieve higher shares of affordable housing, public amenities and mixed-use (David, 2015). On the other hand, in the context of powerful landowners and investors, increased flexibility can lead to a deviation from public policy goals (Bouwmeester *et al.*, 2023; Verheij *et al.*, 2023). According to Debrunner and Kaufmann (2023) this could manifest in projects where developers maximize floor space without improving use density. One study criticizes the longer approval times through PUD, also referred to as discretionary planning, and possible negative effects on housing affordability (Manville *et al.*, 2023). Another study even finds that the use of PUD in Zurich, Switzerland, leads to less tree cover (Schmid *et al.*, 2024).

In summary, municipal strategies play an important role in mediating the effects of PUD on urban densification. Municipalities pursue different development goals and, therefore, also apply planning instruments differently (Gerber, Hartmann and Hengstermann, 2018; Meijer and Jonkman, 2020). However, such strategic application is scarcely considered in large-scale spatial analyses, although these would form an important contribution to the existing qualitative literature. Therefore, this article aims to develop a geospatial approach to capture differences in municipal strategies in applying PUD for urban densification, thereby pointing out avenues for further qualitative case studies.

To do so, we describe the application of PUD for densification as a dependent variable and municipal characteristics as the independent variable in their spatial distribution across municipalities to infer municipal strategies as a crucial intermediary variable. Specifically, we ask:

1. How does the application of PUD vary within a city-regional context compared to conventional zoning?
2. To what degree do municipal characteristics explain this variation?

In the following, we conceptualize municipal strategies, how they manifest in space and what they depend on. We then introduce our case, the Canton of Bern, Switzerland, for which we compare the application of PUD across municipalities between 2002 and 2023.

7.2 Municipal strategies

We expect municipalities to pursue different strategies depending on their location, function and socio-economic characteristics. Most prominently, their goals depend on their location in a region, affecting the problems they have to deal with. While centrally located municipalities have to find solutions for a housing shortage and general over-usage of public infrastructure, more peripherally located municipalities might fight to keep their residents against trends of aging and the younger population moving toward the centers (Götze and Hartmann, 2021). Municipalities also differ in the degree to which they embrace change. This can differ across suburban municipalities, of which some want to strengthen their role in the region and attract jobs and inhabitants, while other suburban municipalities want as little change as possible and remain residential (Touati-Morel, 2015). This is often also a question of whether we are dealing with a richer or a poorer municipality – while well-off municipalities usually want little change, poorer municipalities are observed to embrace development (Charmes and Keil, 2015;

Rousseau, 2015). Finally, municipalities can also differ politically – with economically liberal mayors being more reluctant to intervene in property rights than welfare-oriented mayors.

However, a municipality's characteristics also determine to which degree it has the power to assert its goals against those of other stakeholders. Since a municipality's location in the region affects demand for development, it also impacts its power to negotiate with developers. Municipalities with high demand for development have more leverage to negotiate than municipalities with low demand. In addition, larger municipalities generally have a larger and more professional planning department, enhancing their ability to use planning instruments to strengthen their position in negotiation with private actors. Small municipalities depend more on developers and are in a worse position to negotiate since they often lack the required knowledge and economic leverage (Debrunner and Hengstermann, 2023). In Switzerland, smaller municipalities can even leave the detailed planning to the involved landowners and investors, putting economic interests ahead of other concerns (Knoepfel *et al.*, 2012). In summary, we assume that the municipality's function in the region, its size, its socio-economic status and its demand for housing play a role in determining its strategy. We expect the municipal strategy to have an effect on the application of PUD (Figure 14).

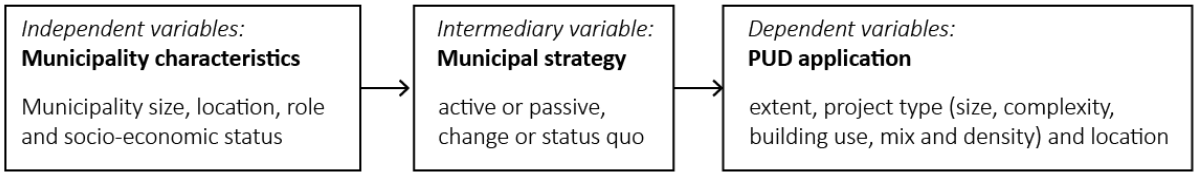


Figure 14 Conceptual framework

Based on this short literature review we further operationalize our variables. We expect municipal strategies to show in the extent to which a municipality applies the instrument, assuming that municipalities with less demand for development, less complex developments, and fewer capacities in the planning department apply the instrument less. Also, we expect municipal strategies to show in what kind of projects they apply PUD to. Here, we assume that municipalities target the instrument to projects of higher complexity. The complexity of a project could show in its size and, consequently the amount of landowners and complexity of parcel changes. It could also show in high use mixes, or the degree to which densification happens in locations where densification is normally stopped (i.e., high-income, low-density neighborhoods). Lastly, we assume that the municipal strategy shows in the achieved density and density increase.

7.3 The case: Planned unit development in Bern, Switzerland

We conduct our study in the Canton of Bern, Switzerland. In Switzerland, PUD is being widely used and was originally introduced to ensure high-quality, mixed development at strategic locations. The instrument has regained importance in the context of densification, which has become mandatory since a change in Federal planning law in 2014. In the federal context of Switzerland, cantons enjoy far-reaching autonomy in the choice and application of planning instruments. The study is therefore limited to the Canton of Bern, which is the largest Canton in Switzerland and allows for an analysis of PUD

application in a variety of spatial contexts, ranging from densely populated and urbanized municipalities (the capital city of Bern with a population of 150,000) to suburban, agricultural and touristic alpine municipalities.

Conventionally, spatial development in Switzerland is regulated through municipal zoning plans. Municipalities divide the buildable area into zones that define the allowed type and extent of use. Next to this basic ordinance (German: Grundordnung), municipalities can apply instruments of special land use planning (Sondernutzungsplanung), notably planned unit development (in Bern: Überbauungsordnung). A PUD overrides the zoning plan and allows for deviations from and additions to it. The instrument was established to help municipalities adapt building regulations in cases where construction should be particularly tailored to the landscape or settlement or which are especially significant for local development (e.g., building areas with potential for densification) (BauG Art 73 Abs 2). PUDs are developed collaboratively between the municipality and the developer.

However, a PUD is not a carte blanche. PUD still must adhere to Cantonal Building Regulations (Bauverordnung) that define, e.g., the number and design of playgrounds and parking spaces. Further, the Cantonal Building Law stipulates which elements of a construction project may be regulated in a PUD (e.g., type and extent of buildings, design of their environment and street layout) (BauG Art 88). Moreover, PUDs must be published for a public hearing phase and in some municipalities (like the city of Bern), the population can even vote on the adoption of a PUD.

7.4 Methods and data

The analysis is built on two steps – describing the distribution of PUD application and then explaining this distribution using municipality characteristics. In section 7.2, we concretized differences in PUD application across municipalities as (1) the extent to which a municipality applies the instrument to densification, (2) the characteristics of development projects to which PUD is applied (in terms of project size, building use (mix), density (change) and the complexity of parcel changes), and (3) the degree to which development projects differ from their neighborhoods in terms of building density. For each municipality, we compared the PUD application to the application of conventional zoning regulations. In the second part of the analysis, we attempted to explain observed differences in PUD application across municipalities using municipality types. The five types capital city, smaller town, suburb, agricultural municipality and tourist municipality were used as a proxy to represent municipal strategies.

7.4.1 Data preparation

In preparation for the analysis, we delineated urban densification projects and distinguished between PUD and conventional zone parcels. We defined densification as construction that happened on what was already urban land use in the year 2001 (t_0). To detect construction, we selected parcels that overlapped with buildings whose construction year was 2002 or above. We used cadastral point data representing buildings. Further, we filtered out parcels where all new construction consisted of garages or industrial buildings only.

To distinguish between infill and greenfield development, we used a layer depicting the settlement area in 2001, published by the Swiss topographical office. All construction outside of the settlement area was discarded. Then, to distinguish between conventional development and PUD, we used PUD perimeters from the zoning plan. We used zoning plans from four different points in time (2008, 2012, 2016 and 2020) to rule out the possibility that a building constructed on a conventional zone and only later overlaid by a PUD was registered as PUD construction.

We further delineated development projects and their corresponding neighborhoods. A development project consists of adjoining parcels (with a tolerance of 10 m) that all contain newly constructed buildings of the same planning type (i.e., no mix of PUD and conventional zoning, even if the parcels are adjoining). The neighborhood was then defined as all parcels within a radius of 25 m, with no new construction (also no greenfield development) and an FSI of at least 0.25 (empirically derived value to exclude streets and parks) (Figure 15).

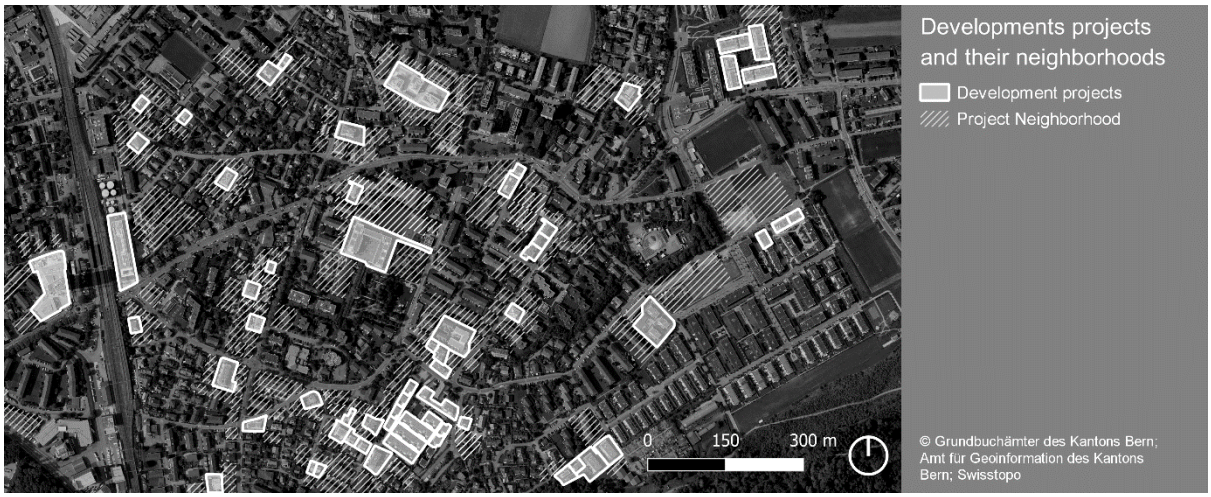


Figure 15 Development projects and their neighborhoods

7.4.2 Variation of PUD application

Municipalities' extent of PUD use for densification was calculated by dividing the total building floorspace created through densification by the building floorspace created through densification *and* on a PUD zone between 2002 and 2023. Likewise, the building use was computed by counting the occurrence of various building types on PUD-covered densification parcels for a whole municipality.

The use mix, on the other hand, was calculated per densification project, filtering out projects with less than 5 buildings. To calculate the use mix, we used Shannon's Evenness Index. The index, originally developed in ecology, has previously been applied to express the homogeneity of urban form (Jehling and Hecht, 2021). In our context, it served as a metric for the observed level of use mix, with maximum diversity achieved when all building types are distributed evenly.

We calculated the building density as the floor space index (FSI) per parcel. This was done by dividing the total building floor space by the parcel area. We also measured the density change between 2002 and 2023, expressed as building change pressure (BCP) (Schorcht, Jehling and Krüger, 2023). BCP measures the share of open space of a parcel that has been used for new construction, thereby

expressing densification in relation to remaining green or open space available for climate or recreational purposes. For this article, we applied a simplified version of BCP, considering the 2-dimensional space rather than the 3-dimensional one. As building densities correlate with the location of the development, we further corrected for the accessibility of the parcel using the Closeness Centrality Index, representing the travel distance from one point to all other points on the road network (Jehling, Krehl and Krüger, 2021).

To compare project to neighborhood density, we also calculated the average FSI for all parcels that together form the neighborhood of a project. We then compared this neighborhood FSI to the mean FSI of the corresponding project.

We examined the parcel structure at t_0 and its changes after development to express planning complexity. For each project, we counted the number of parcels it overlapped with at t_0. In addition, four types of parcel changes were examined by comparing the parcel structures at t_0 and t_1 at project level (Figure 16).

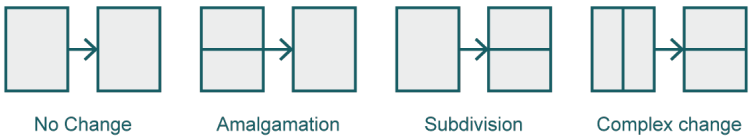


Figure 16 Parcel changes

7.4.3 Variation across municipality types

In the second part of the analysis, we attempted to explain the observed variation in PUD application with municipality types. For this, we divided the municipalities into functional categories, following the categorization into 9 types based on population, land use and commuter movement by the Swiss Ministry for Spatial Planning (ARE). For simplification, we decrease the number of categories to 5: the capital city of Bern (n = 1), small towns (n = 6), suburbs (n = 34), rural municipalities (n = 307) and touristic municipalities (n = 14). To test whether the effect of the planning type on FSI, BCP and deviation from neighborhood differs significantly *across* municipality types, we performed a two-way ANOVA with interaction. For this, we log-transformed the variables FSI and BCP to fulfill the condition of a normal distribution.

Finally, the results were discussed in a focus group setting with 5 practitioners from the municipalities of Bern and Biel, the Federal Ministry of Housing and the Swiss Association of Cities (Schweizer Städteverbund) on 2 July 2024. Their comments were included in the discussion section of this article.

7.4.4 Data

Historic parcel structures were available as point data from 2003 (allowing for counting the number of historic parcels for all projects with construction years 2004 and after). Parcel polygons, however, have only been available since 2010. Therefore, the analysis of parcel changes is only applicable to projects since 2010.

The variables with their source and descriptive statistics are summarized below (Table 5). We can see that infill development through PUD is more centrally located than conventional infill development. Also, PUD projects are larger than conventional projects, and the parcel heterogeneity in 2003 is higher.

Table 5 Descriptive statistics and data sources

		Conventional					*PUD*					
Variable	**Unit of analysis**	**n**	**min**	**max**	**mn**	**sd**	**n**	**min**	**max**	**mn**	**sd**	**Source**
Construction year	Building	46842	2002	2023	2010	6.5	13686	2002	2023	2010	6.3	A
FSI	Parcel	11130	0.3	22.8	0.7	0.7	3114	0.3	17.2	1	1	A
BCP	Parcel	11130	0	5433469	740	51569	3114	0	57780	574	2316	A
Parcel area	Parcel	11130	12	41436	882	1296	3114	64	112706	1182	3200	B
Historic parcels (number)	Project	5483	1	27	1.6	1.5	1011	1	32	2.3	3	C
Project Size	Project	5483	12	82541	1740	2580	1011	85	128992	3455	6775	A B
Centrality	Building	46842	0.04	0.97	0.69	0.15	13686	0.14	0.97	0.74	0.14	D

(A) Eidg. Gebäude- und Wohnungsregister 2024 © Bundesamt für Statistik
(B) Grundeigentumskategorien 2024 © Grundbuchämter des Kantons Bern; Amt für Geoinformation des Kantons Bern
(C) Digitale Parzellennummern des Kantons Bern 2003 © Amt für Geoinformation des Kantons Bern
(D) © Openrouteservice

7.5 Results

7.5.1 Variation in PUD application in comparison to conventional zoning

In most municipalities, less than 50% of the total floor space created through infill was planned using PUD (Figure 17a). PUD and conventional zoning are predominantly used to create housing (e). However, compared to PUD, conventional zoning is to a higher degree applied to construct industrial buildings, while shops, restaurants and bars overweigh among PUD. Surprisingly, the achieved use mix (expressed using the Shannon Index) among PUD projects is lower than among projects in conventional zones (f). Still, the complexity of PUD projects in terms of parcel changes (d) and, as shown above, in terms of project size (c) and original number of parcels is the highest (d). Finally, infill on parcels covered by PUD shows higher building densities (g) and higher increases in building density over time (BCP) (h), especially concerning parcels with high accessibility. The building density on PUD parcels also deviates more from the neighborhood density (i).

7.5.2 Variation across municipality types

When comparing PUD application across municipality types, only the capital city of Bern used PUD for the majority of its densification (Figure 18). In all other types of municipalities, PUD shares in densification lie under 50%. However, in touristic municipalities, the shares are increasing rapidly.

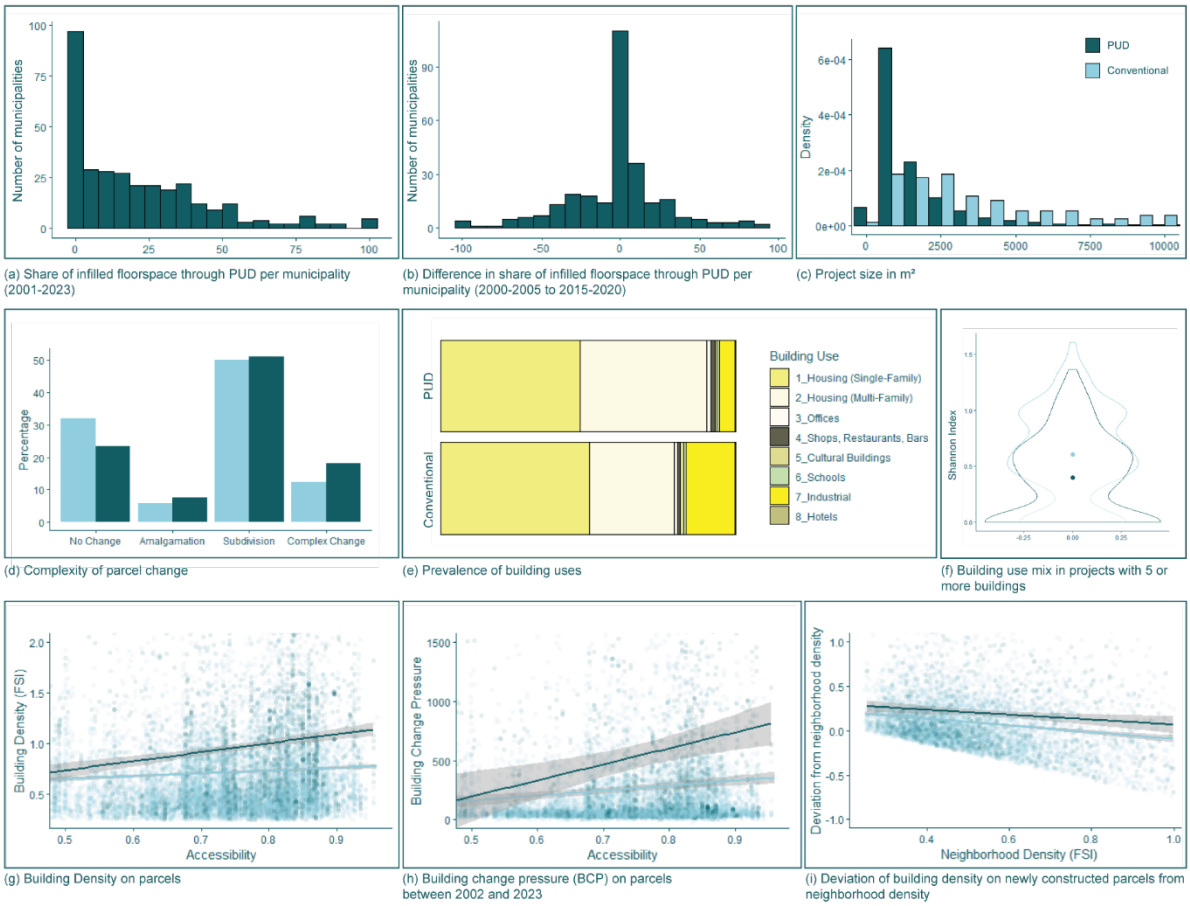


Figure 17 Variation in PUD application

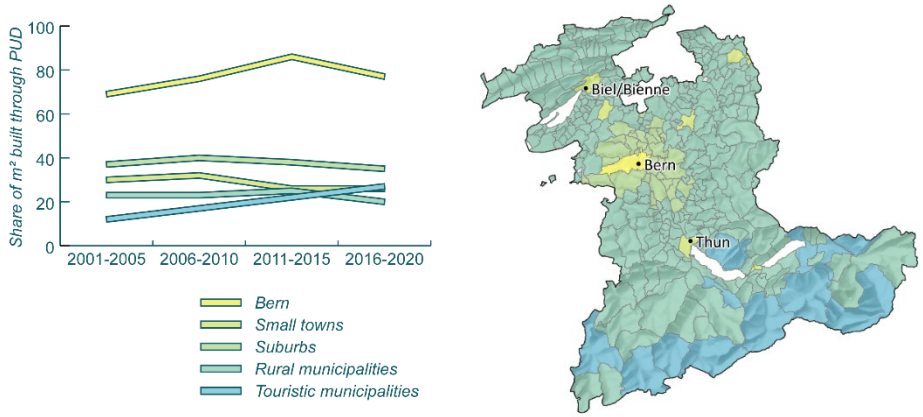
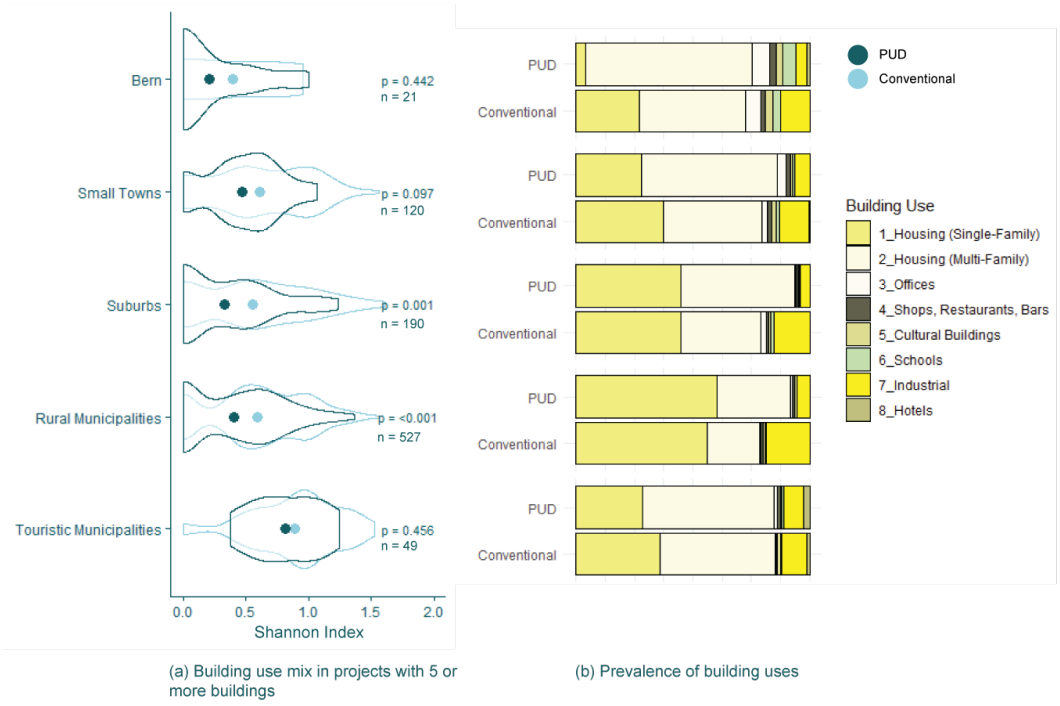


Figure 18 Share of building floorspace built through PUD by municipality type and period (infill only, including non-residential use

All municipality types apply PUD mostly for housing (Figure 19a). Municipalities do not seem to apply PUD to create projects with a higher use-mix (Figure 19b). However, the number of observations (projects with 5 or more buildings) in Bern and touristic municipalities is very low and the applied Wilcoxon rank-sum test did not result in p-values below the confidence level.

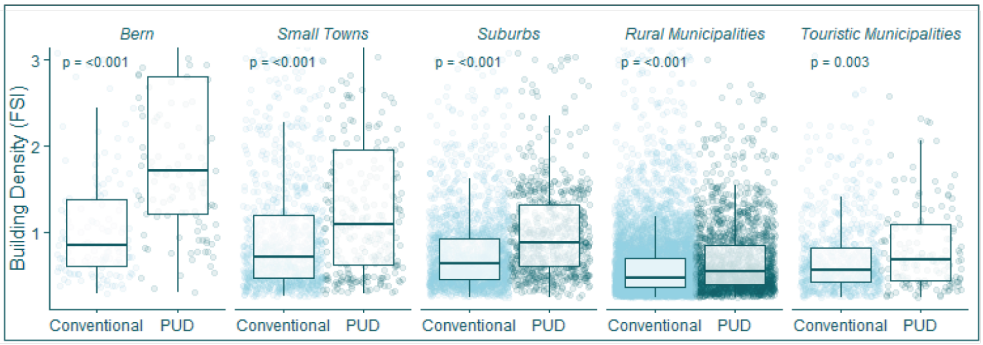


(a) Building use mix in projects with 5 or more buildings

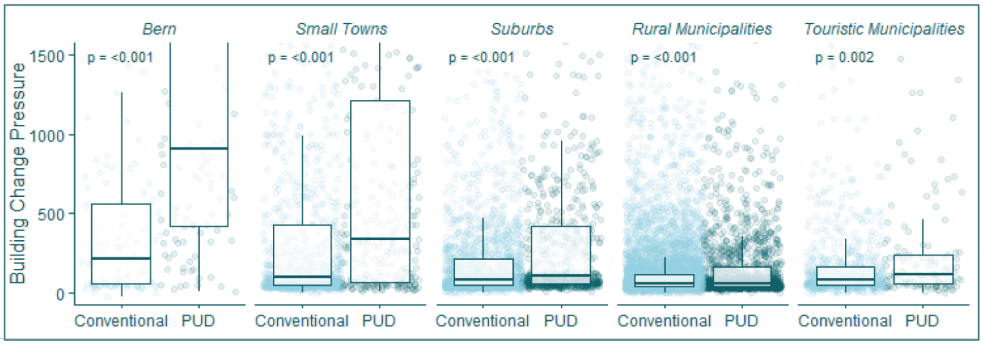
(b) Prevalence of building uses

Figure 19 Building use and use mix in infill projects

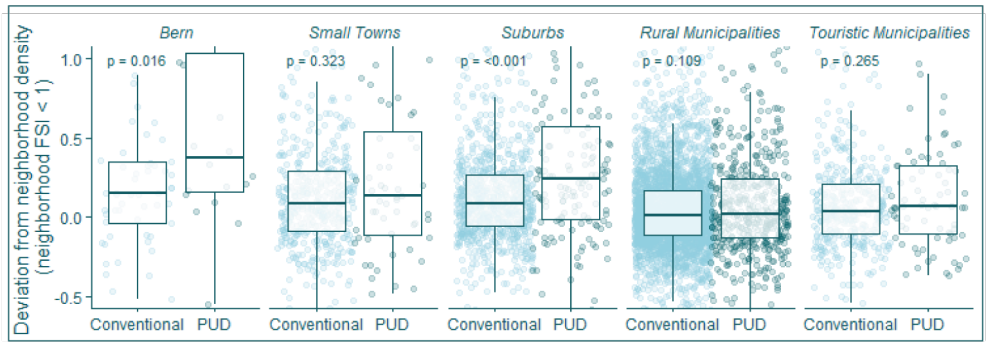
Across the municipal types, PUD parcels are denser than conventional parcels and are also connected to higher density increases on the individual parcels (Figure 20a and b). However, the differences are stronger in the urbanized municipalities than in the agricultural ones. The abovementioned observation that, compared to conventional zoning, PUD introduces higher building densities into low-density neighborhoods only holds true for Bern and suburban municipalities (c). The differences between PUD and conventional projects are insignificant for all other municipality types. The results of the two-way ANOVA show that observed differences are not only significant within municipality types but also across them. For the three tested variables, FSI, BCP, and density deviation from the neighborhood, the municipality types significantly affected the difference between conventional and PUD projects (p-value < 0.001). Lastly, project complexity is higher among PUD projects across all municipality types except touristic municipalities (d).



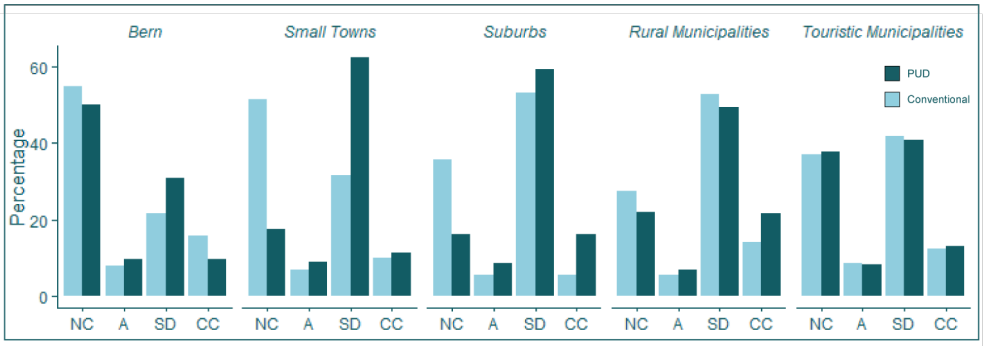
(a) Difference in building density (FSI) between PUD and conventional zoning



(b) Difference in building change pressure between PUD and conventional zoning



(c) Difference in deviation from neighborhood density between PUD and conventional zoning



(d) Difference in parcel change complexity between PUD and conventional zoning

Figure 20 Building density and project complexity across municipality types

7.6 Discussion

This article presented a geospatial method to capture municipal strategies in the application of flexible planning instruments, focusing on PUD application for densification. We conceptualized municipal

strategies in terms of the extent to which municipalities apply PUD, what kind of projects they apply PUD to, and in which kind of neighborhoods they apply it. The following section discusses the observed differences based on municipality characteristics and builds hypotheses for possible underlying policy strategies. It further reflects on the chosen approach and provides avenues for further research.

7.6.1 Inferring on municipal strategies

Comparing conventional and PUD projects across municipality types can hint at reasons why municipalities apply PUD. We have seen that municipalities of all types apply PUD for densification and predominantly do so for housing projects. They also share that PUD projects do not show higher degrees of use mix than conventional projects. This is somewhat surprising (David, 2015; EBP Schweiz, 2018). We had expected to see larger differences in the building use between conventional and PUD projects. Since PUD was developed to help municipalities coordinate complex projects, it seems surprising that they apply it to comparatively “simple” planning tasks like constructing single-family homes. It does, however, fit our expectation that the share of industrial buildings is higher among conventional projects because industry tends to be on the outskirts of a city with little necessity for detailed coordination between different uses.

Moreover, we expected the building use to differ across municipality types. For example, tourist municipalities could have used PUD to stack hotels, housing and commercial use. These differences do exist but are diluted by the overwhelming share of residential buildings across all types. The most unexpected finding remains the low use mix of PUD projects across municipality types, at least according to the used indicator, which, unfortunately, cannot capture use mix *within* buildings since every building was assigned one dominant use. But the finding could also hint at municipalities not applying PUD to reach higher use mixes and focusing instead on density or complex landowner structures.

Across all municipalities, PUD projects are significantly denser than conventional projects and have also led to more densification (i.e., change in building pressure) than conventional projects, which aligns with previous studies (David, 2015; Schmid *et al.*, 2024). PUDs can contribute to this by allowing for more efficient site development through improved street layouts and deviations from often high parking requirements. This does not necessarily mean municipalities apply PUD intending to reach higher building densities. While it is possible that municipalities strategically employ PUD for this purpose, developer motivations also play a significant role. This is further evidenced by the fact that the contrast in density between PUDs and conventional projects is most pronounced in centrally located municipalities, where demand for higher densities is typically higher. Conversely, peripheral municipalities exhibit smaller density differences, potentially due to a lack of demand for denser development in these areas. Alternatively, this disparity could be attributed to municipal strategy. In central municipalities with high demand, municipalities might grant increased density allowances in exchange for additional amenities provided by the developer. This bargaining power is likely absent in less-demanded peripheral areas. Further research is necessary to determine the extent to which municipalities leverage developer obligations to secure desired amenities in exchange for higher densities.

Interestingly, we also showed that municipalities seem to apply PUD to introduce (slightly but significantly) higher densities into low-density neighborhoods. This is an interesting finding because, especially in low-density neighborhoods, residents are usually more inclined to stop densification (Jehling, Schorcht and Hartmann, 2020). It could be that PUD provides better possibilities for citizen participation, thereby raising acceptance in low-density neighborhoods (Wicki, Hofer and Kaufmann, 2022). PUDs are more detailed than conventional zoning plans, allowing citizens to express their opinion on specific regulations regarding, for example, playgrounds, parking or biodiversity measures. However, the increased density gain in low-density neighborhoods is only significant in the city of Bern and suburban municipalities (many adjacent to Bern). Since these groups are experiencing the most pressure on the housing market, it could be that they use PUD strategically in low-density neighborhoods. However, more research is needed considering such neighborhoods' socio-economic status and homeownership rates.

Finally, our findings suggest municipalities apply PUD to projects with more complex ownership structures. In addition to measuring use mix, this is another way to examine project complexity. This complexity is shown in a higher average number of parcels at t_0 and more complex parcel changes in all municipality types but in touristic municipalities. It makes sense for municipalities to apply PUD to projects that involve more than one landowner to ensure coherence between the plans. It could be that through PUD when municipalities allow for higher densities, incentives are created that trigger densification in contexts of complex land ownership. The possibility of creating a larger project together with added density allowances can make development more profitable and thus motivate landowners to find a solution together, e.g. solve property questions through allocation. In touristic municipalities, the shares of parcel change types are evenly distributed between PUDs and conventional projects, which could be a coincidence due to the small number of projects.

By analyzing these differing applications of PUD across municipalities, we aimed to shed light on the motivations behind their use. Notably, the minimal difference in density between PUD and conventional projects in rural municipalities coincides with their lower overall utilization of PUD. Conversely, urban municipalities exhibit significant density contrasts and a higher frequency of PUD implementation. This likely correlates with the presence of larger planning departments in central areas, facilitating the use of PUD and the greater development pressure that necessitates them. In contrast, rural municipalities often hold a more conservative stance, preferring minimal intervention in development projects. Touristic municipalities present a unique case. The rise in PUD use within these areas is not fully clear. It could be attributed to growing development pressure in response to the ban on second homes, adopted in 2012, although some researchers doubt that this ban has had an actual effect on development practices (Gerber and Bandi Tanner, 2018).

Interestingly, despite the lack of clear quantitative benefits, it is evident that rural municipalities still find value in utilizing PUD. The true benefits of PUDs for (rural) municipalities might lie in achieving a higher qualitative standard of development. These qualitative aspects may be challenging to quantify but could include improved design integration with surrounding areas, the inclusion of previously missing uses within the neighborhood, or whether public access to green spaces was ensured through PUD

regulations. Conversely, without PUDs, developers might restrict access to these green spaces (Verheij et al., 2023). This aligns with the characteristics municipalities prioritize, such as preserving existing urban patterns, fostering high-quality urban design, and implementing locally tailored solutions (EBP Schweiz, 2018). PUDs could potentially function as a tool for municipalities to safeguard valuable urban environments by establishing regulations regarding aesthetics, thus having more of a preserving function (Schmid *et al.*, 2024). Further qualitative research is needed to comprehensively assess the quality of development achieved through PUDs. Understanding these discrepancies in PUD application and the resulting benefits across municipalities is crucial to better understanding the strategic use of the planning instruments (Hennig *et al.*, 2015).

Another reason why municipalities may use PUDs could be the obsolescence of existing building codes. Many municipalities have outdated building codes, but instead of renewing them entirely, they allow deviations from these outdated building codes through PUDs. Future research could examine the relationship between the age of a municipality's building code and its use of PUDs.

Furthermore, it is important to note that it can be in the interest of the private developers to apply PUD as well, and future studies should not only analyze PUD application from the municipalities' perspective. In Switzerland, PUDs can provide developers with planning certainty relatively early in the process. Once a PUD is approved, it is less likely that the municipal council will deny the building permit at the end of the planning phase. Therefore, PUD is not only an instrument used by progressive planning authorities but also benefits private developers.

7.6.2 Reflections on the approach

Grouping municipalities by their function in the region, rather than only their location, proved valuable since it revealed the diverging dynamics in touristic municipalities. However, other important drivers may remain hidden. For future research, it might prove fruitful to also consider the socio-economic status, demand for development or the political orientation of municipalities when comparing their use of planning instruments. In addition, it is important also to consider differences *within* the groups, which could explain, for instance, differences between rural municipalities that *do* apply PUD and those that do *not*. Ultimately, a spatial analysis such as the one presented here can give valuable insights in the variation in instrument application across municipalities, but it is important to combine these findings with further qualitative studies. Such studies are crucial to fully understand municipalities' strategies, which are more complex (and sometimes even ambiguous) than what can be represented quantitatively (Puustinen, Krigsholm and Falkenbach, 2022).

The project complexity metric employed in this study demonstrates broad applicability beyond the current research focus. Our conceptualization of complexity considered two key aspects: (1) the degree of densification occurring in areas traditionally resistant to it (low baseline density and high ownership fragmentation) and (2) the inherent complexity of the development process itself (e.g., analyzing parcel changes). Building upon this framework, future studies could incorporate additional dimensions like the duration parcels remain undeveloped or underutilized (Ehrhardt *et al.*, 2023). Project complexity is a valuable indicator of a municipality's capacity to facilitate densification under challenging conditions.

This approach holds significant promise for cross-national comparisons, potentially revealing which municipalities are best equipped to promote densification in complex environments.

7.7 Conclusion

Municipalities can forego available planning instruments or adapt their application, potentially deviating from their intended purpose. Their strategies, although an important intermediary variable between the institutional framework and actual spatial development, are often overlooked in spatial analysis. In this study, we contribute to filling this gap by examining the application of Planned Unit Development (PUD), an instrument designed to assist municipalities in ensuring quality of life within the complexities of densification projects. We measured differences in PUD application across municipality types within the Canton of Bern, Switzerland, focusing on densification projects undertaken between 2002 and 2023. PUD application was operationalized as the extent to which municipalities apply the instrument to the densification of existing urban areas and the kind of projects they apply it to.

Our findings reveal a disparity in PUD utilization across municipality types. In all municipality types, PUD use is connected to more complex parcel changes but not to higher degrees of use mix. Still, while centrally located municipalities leverage PUDs to achieve significant increases in density, peripheral municipalities do not exhibit the same trend. Supporting this pattern, urban and suburban municipalities apply PUD more than rural municipalities, and in touristic municipalities, PUD application has been increasing over the past 20 years. This disparity raises critical questions about why rural and touristic municipalities employ PUD. Also, not all observed differences could be attributed to municipal strategies. While the more widespread use in central municipalities and higher project complexity may suggest strategic decisions, the higher density of PUD projects is more difficult to interpret. Higher densities could both be desired by the municipality and an unintended side effect of stronger landowner participation. These questions warrant further investigation, highlighting the potential of geospatial approaches to identify intriguing cases for subsequent qualitative inquiry in a multi-method approach (Seawright, 2016).

For land policy research, our geospatial approach and results can give insights into the municipal practice of applying planning instruments. Geospatial approaches, such as the one presented here, can provide empirical evidence on the effectiveness of planning instruments and highlight possible barriers for municipalities to apply instruments in the way intended by the lawmaker, thereby pointing out avenues for necessary future research.

Notes

[1] Mean taxable income per municipality (BFS, 2020) https://www.atlas.bfs.admin.ch/maps/13/de/17825_9164_8282_8281/27598.html

8 Findings

In this dissertation, I posed the question, *"How does the comparison of densification patterns contribute to tracing land policy effects?"* operationalized by two sub-questions:

1. *What densification patterns emerge across countries and municipalities?*
2. *How does land policy possibly explain the observed differences?*

This chapter presents my findings, structured along the relationships studied in the three articles: (1) the effect of institutional regimes on densification patterns across countries, (2) the effect of applied policy instruments on the outcome of individual development projects, and (3) the effect of municipal strategies on the application of policy instruments. I reflect on the observed patterns and possible connections to land policy for each relationship. Ultimately, this chapter will answer my main research question, addressing the contribution of pattern comparison to tracing land policy effects. In addition to this last part, chapter 9 reflects on the limitations of the chosen approach and avenues for future research.

8.1 Institutional regimes and densification patterns

H1: The institutional regime determines what instruments municipalities can choose from to steer densification outcomes. This affects their ability to assert their interests against the interests of other actors, which is ultimately reflected in the evolving densification patterns.

Across countries, institutional effects will show in the prevalence of densification processes and spatial distribution of densification types regarding created density, housing offer, and resident structure. In contexts where municipalities have more control over development, the produced housing offer and targeted socio-economic groups will align more with policy goals. In institutional regimes where citizens control which development gets approved, less "unpopular" forms of densification will exist, such as redevelopments of urban green spaces or densification in high-income, low-density neighborhoods.

Contrary to my assumption, comparing the spatial distribution of densification patterns across Bern and Utrecht did not reveal great differences. There was not one densification type that occurred in one region but not in the other. Also, the spatial distribution of densification types was largely similar. The only remarkable difference between the two regions lies in the prevalence and spatial distribution of a densification type that is mainly characterized by its large project size. These large-scale densification projects occurred more often in Utrecht than in Bern and were more concentrated in the urban core of Utrecht while being more spread out in the Canton of Bern. Differences in the institutional regimes of Switzerland and the Netherlands provide possible explanations for this observation.

Development in the Netherlands is generally more consolidated than in Switzerland. In the Netherlands, municipalities can apply pre-emption rights, allowing them to assemble larger areas of land for development. Also, they often collaborate with developers to enable cohesive development. Another important difference to Switzerland lies in the generally more homogeneous landownership structures. The large redevelopments in Utrecht's city center in the past 20 years mainly happened on land owned by non-profit housing corporations. These corporations own large estates. Since the Dutch state reduced funding for housing corporations, they can no longer afford to buy new land. Their only way of growing is by redeveloping and densifying their social housing estates. This process is supported by nationwide policies for upgrading deprived neighborhoods. In this way, I build the hypothesis that a combination of (1) the availability of instruments to consolidate land, (2) cultural preferences for large-scale development, and (3) the distribution of actors in the real estate market and their funding, can explain the prevalence of large-scale densification projects in the Netherlands.

Apart from this, the densification patterns in Bern and Utrecht were largely similar. Densification types that introduced much higher building and population densities, with smaller apartments and household sizes, occurred exclusively in city centers, where demand for housing is high. Both countries also showed similar developments in suburban municipalities, where densification introduced relatively small apartments with very high shares of elderly residents. This is part of a larger trend of constructing serviced apartments for an aging population in suburban environments.

Thus, differences in densification patterns across Utrecht and Bern mainly did not show in the kind of housing offer being constructed. Housing offers, densities, and resident structures largely seemed to follow market demand, while project size was a more important indicator for revealing institutional effects.

8.2 Policy instruments and project outcomes

H2: By applying policy instruments to specific development projects, municipalities can increase their control over these projects' characteristics. Since municipalities are public actors, they are expected to pursue goals that are in the public interest. Therefore, municipalities will try to use their power to create more sustainable densification projects than what would happen without their intervention.

A project that deviates from market expectations toward the public interest is probably a project that a municipality interfered in.

In Utrecht, the median household income in a densification project significantly depends on the location and transformation process of the project. Projects in centrally located, high-income (or gentrifying) neighborhoods tend to also feature high median household incomes, especially in the case of redevelopments of brownfields or urban green spaces. Projects where the observed median income is much lower than expected (based on these variables) are often projects where the land is or was publicly owned. In these cases, the municipality transferred part of the land to non-profit housing corporations. This supports the hypothesis that municipalities use land policy instruments to make densification projects more inclusive. However, I could not trace back direct municipal interference in

all projects where the median income was lower than expected. This leads me to establish the next hypothesis that building dense rental housing units in a neighborhood otherwise dominated by high-priced owner-occupied houses can be a profitable real estate strategy that does not necessitate municipal interference.

More surprisingly, among the projects whose median household income was much higher than expected, some were realized on publicly owned land. The planning phase of these projects often overlapped with the global financial crisis, forcing municipalities to adapt original plans to keep the project financially feasible. Often, parts of the project were realized at a high price level to cross-finance the more affordable parts of the project. It seems that public landownership is not a silver bullet for creating inclusive densification projects.

8.3 Municipal strategies and instrument application

H3: Municipalities apply instruments according to their strategic goals. Their strategies vary in the degree to which (1) they are generally willing to intervene in property rights and (2) they support densification (in low-density neighborhoods). Strategies differ according to a municipality's location within a region: While central municipalities need to accommodate growth, suburban municipalities can actively prevent densification. Rural municipalities may not dare to intervene in property rights for fear of scaring off investors.

Differences across municipal strategies show in the degree to which they apply a specific policy instrument, the developments and the locations they apply it to, and the density they reach by applying it.

Planned unit development (PUD), an instrument that can help municipalities enable densification, is applied differently across municipalities in the Canton of Bern. There is great variation in the extent to which municipalities apply the instrument for densification, but also regarding what kind of projects they apply it to.

It is mainly the centrally located municipalities, but to an increasing degree, also touristic municipalities that apply the instrument to their infill projects. Especially the larger cities apply PUD to achieve higher densities, showing in a large difference in building density between PUD and conventional zoning development. These municipalities also successfully apply PUD to introduce high-density development to low-density neighborhoods. PUD does not seem to be applied to achieve a higher use mix by any of the municipality categories, but they all apply PUD to more complex projects, such as larger-scale projects with more complex parcel changes than can be observed under conventional zoning conditions.

To what extent do these observed differences allow conclusions to be drawn about municipal strategies? As expected, rural municipalities use the instrument less than urban municipalities. This may indicate that rural municipalities are more likely to want to avoid intervening in developer projects.

However, other factors influencing the negotiations, such as the lower need for detailed planning or the smaller administrative size, which makes negotiations more difficult, cannot be ruled out.

Municipal strategies can also be discussed based on the differences between PUD and conventional projects. For example, municipalities seem to use PUD for projects with more complex ownership structures actively. It is conceivable that the instrument helps them realize these projects, enabling better coordination of uses. The achieved building density also differs between PUD and conventional projects. However, it is more difficult to conclude that this is a strategic decision on the part of the municipalities. Developers could just as easily use their negotiating power to approve higher densities.

It remains unclear why rural municipalities, in particular, use PUD at all since they apparently achieve the same results as with conventional planning. They may be pursuing goals that I could not measure, such as protecting the cityscape through more detailed aesthetic guidelines. The question remains as to why tourist municipalities are increasingly using the instrument. This could be because they are less allowed to rezone new land and have to better coordinate different uses on the same plot of land.

New planning instruments are constantly being developed to achieve land-saving goals. It is very important to evaluate whether and how municipalities use these instruments. This can identify possible barriers to application.

8.4 Pattern comparison for tracing land policy effects

The previous sections answered my sub-questions by summarizing the findings of my three research articles. I will now move on to answering my main research question. This thesis explored how the comparison of densification patterns can contribute to building hypotheses on land policy effects. I argued that spatial analysis has great potential to contribute to this field. Yet, it is seldom applied to understand the effects of land policy on spatial development. A central spatial analysis tool for policy analysis is spatial pattern comparisons across time and space and between modeled and observed patterns. Throughout my thesis, I developed approaches that enable such comparisons. I collected an extensive data set for Switzerland and the Netherlands in sufficient detail to characterize individual densification projects. I established comparability across the two countries by controlling for the different data collection methods regarding time, scale, and indicator choice. Combined with a clustering approach, I managed to map and compare densification patterns across the two countries and within the individual regions.

Based on the performed comparisons, I conclude that measuring densification as a deviation from expectation is an especially valuable approach. A deviation from expectation can be seeing densification happen in areas where it is unlikely to occur or seeing densification take on unexpected forms. The former especially necessitates measuring densification as an outcome *and* a process. In the following sections, I want to highlight the two approaches of (1) measuring densification in terms of processes and (2) measuring densification outcomes in terms of how they deviate from expectations.

8.4.1 Comparing densification processes

While much research revolves around densification outcomes, few studies address different processes of densification. Measuring and comparing densification processes can tell us something about the degree to which municipalities can intervene in property rights and enable densification. In this context, assessing whether densification happens under difficult circumstances is especially insightful. Throughout my articles, I developed several indicators representing this complexity of densification processes that have shown value in discerning land policy effects.

As a first approximation, I used the project size, assuming that, all else being equal, larger developments are more complex than small developments. This is because large developments tend to include more landowners, a higher land use mix, and involve more stakeholders. For instance, in my first article, I found large-scale developments in Utrecht but not Bern. Moreover, in Utrecht, they even occurred in the city centers, which, as I discussed above, could hint at Dutch municipalities having better possibilities for land consolidation. Likewise, in the last article, I show that the application of planned unit development is connected to larger project sizes, which could have to do with the higher complexity requiring negotiation and detailed zoning regulation.

Similarly, transformation processes can range from less to more complex or expressed differently, from requiring little to much government intervention. On one end of the spectrum, soft densification requires little investment and can happen even without the government noticing. On the other end of the spectrum, brownfield redevelopments can require large investments in cleaning polluted soil and definitely need government intervention in the form of rezoning. As another example, the redevelopment of urban green spaces can induce citizen protests, requiring planning instruments to overcome such protests. Comparing across cities, the prevalence of urban green space redevelopments could thus indicate the degree to which a municipality can overcome citizen protests.

The likelihood of citizen protests is another important variable for assessing the degree to which densification occurred in unexpected places. I addressed this variable in article 3, concluding that planned unit development is connected to higher density increases in low-density neighborhoods, arguing that citizens are more inclined to oppose densification in low-density neighborhoods. In addition to the neighborhood density, other possible indicators for the likelihood of citizen opposition are the socio-economic status of the neighborhood (with wealthy neighborhoods being more likely to organize protests) and, connected to this, the share of homeownership (assuming that homeowners, as opposed to renters, have higher stakes in preventing a potential value loss due to densification).

Lastly, I also proposed using the complexity of parcel structures to indicate overall planning difficulty. In Article 3, I categorized projects according to the number of parcels at t_0 and the type of parcel change, ranging from no change to subdivision, amalgamation, and complex changes. In the article, I used this indicator to show that, compared to conventional zoning, municipalities apply planned unit development to realize more complex projects.

These indicators all express densification complexity. Comparing densification complexity across regions can give an indication of how well-equipped municipalities are to enable densification under

difficult conditions. However, it remains important to take into account other possible explanations. Even if instruments are available, it can be in the municipality's interest not to apply them. Also, sufficiently high development pressure could enable densification without municipal intervention.

8.4.2 Unexpected densification outcomes

A second way in which densification can deviate from expectation is via the outcome of individual projects. The outcome of individual projects can be surprising if they do not continue existing neighborhood characteristics or deviate from market expectations. Just as with the measurement of planning complexity, I developed methods to capture how unexpected the densification outcome is.

In Article 1, I expressed the characteristics of individual densification projects in terms of their deviation from the neighborhood. I assume that “normal” development mimics the existing neighborhood because this involves less risk for the developer and because residents generally oppose great changes in their neighborhood (Kim, 2016). If new development differs greatly from its surroundings, it can hint at municipal intervention by lifting existing regulations or stipulating new ones. Methodologically, describing densification in relation to the neighborhood requires delineating densification projects and their respective neighborhoods. It can be challenging to determine which newly constructed buildings belong to the same project, but I proposed several methods for doing so, ranging from DBSCAN clustering to simply joining adjoining parcels with newly constructed buildings on them. Depending on the variable of interest, the corresponding neighborhoods can range from the directly neighboring parcels to statistical neighborhoods or everything within a set radius.

I further developed the notion of an unexpected densification outcome in Article 2, where I propose a regression model that predicts median household incomes in densification projects “under normal circumstances.” It does so based on the neighborhood income, changes in neighborhood income (considering possible gentrification processes), the centrality, and the transformation process. By taking into account average deviation throughout the region, I thus go further than merely comparing an outcome to the neighborhood average. With the regression model fitted to my dataset, I could examine the spatial distribution of its residuals – the cases where it mispredicted household incomes. These are the projects where household incomes do not correspond to expectations, making it interesting to examine them further qualitatively. Thereby, the regression analysis contributed to pointing out cases worth further analyzing. The combination of qualitative and quantitative methods in Article 2 enabled me to go further than my stated goals by providing not only associative evidence but also tracing planning processes. Through this multi-level approach, I could unravel the effect of municipalities' cross-financing projects and face unexpected setbacks in terms of affordability.

In conclusion, my thesis presented ways of applying spatial analysis to policy analysis by comparing densification outcomes *and* processes across regions and across municipalities. I especially highlighted the value of measuring densification in terms of how it deviated from expectations, whereby the surprising element could lie either in the process or the project outcome. There is great potential in using spatial models to simulate development under market conditions and comparing such modeled outcomes to reality (as I will further elaborate in Chapter 9). Ultimately, this research underscores the

importance of finding synergies between quantitative and qualitative methods. By exploring how spatial analysis can be used to bridge the gap between quantitative and qualitative research methods, my thesis offers a valuable perspective for developing new research frameworks that leverage the strengths of both approaches.

8.5 Sustainability of densification outcomes

In the introduction, I argued that the social effects of densification depend on the specific form it takes and that little is known about the large variety of densification outcomes, their prevalence, and their spatial distribution. Throughout my articles, I contributed to this knowledge gap by mapping densification's morphological, procedural, and socioeconomic variation in Utrecht and Bern. I aimed to show that possible negative social effects of densification, such as eviction, crowding, and unaffordability, are not inherently connected to densification as a whole but to some forms it takes on in certain regions. Municipalities can mitigate its negative social effects by steering which kind of densification prevails.

In this section, I will revisit the social effects of different densification types. Thereby, I aim to contribute to evaluating densification efforts and allow for comparisons between countries. While I cannot state whether the planning system in the Netherlands or Switzerland leads to more sustainable outcomes, I can identify variations in the outcomes and discuss their social implications. This is the objective of this section.

In the first article, I show a large variation in the housing offer that is created through densification. Densification not only introduces high-density environments with tall buildings and small apartments for small households with little personal living space. Instead, it can also introduce larger apartments and higher shares of families to a neighborhood. In most cases, densification is not connected to crowding but to more personal living space than the neighborhood. In the past 10 years in the suburbs of Utrecht and Bern, densification mainly contributed to age-friendly apartments, and in peripheral regions, it keeps providing larger housing units occupied by families. Depending on where one lives within a region, one can experience densification very differently.

Moreover, with access to household-level socio-economic data for Utrecht, I was able to show a great variation in household income and education level across densification projects, thereby providing evidence against the critique of densification as a form of „new-build gentrification“ (Rérat *et al.*, 2010). On average, the median household incomes in housing constructed through densification are lower than in housing constructed through greenfield development. Although residents of densification projects are, on average, richer than their neighbors, this is not true for all densification types. In Utrecht, soft densification and replacement development even create housing for households with income levels below the neighborhood average, both with comparatively high education levels (students, in the case of subdivision) and comparatively low education levels (since in Utrecht, most replacement construction is performed by non-profit housing corporations). On the other hand, residents of housing that was created through the redevelopment of brownfields or urban green spaces feature comparatively high

incomes. These differences across transformation processes underline that municipalities can affect the affordability of urban densification by suppressing or promoting certain transformation processes.

Another important question concerns the spatial distribution of densification processes since this determines who is affected by densification. In the case of Utrecht, I observed large-scale redevelopments happening in the city center, especially redevelopments of social housing estates. This form of densification is especially harmful to the neighborhood as it can lead to direct eviction. It occurs not only in Utrecht but is also heavily criticized in Rotterdam and other larger Dutch cities (Uitermark, Duyvendak and Kleinhans, 2007). Also, in Switzerland, housing redevelopments are being criticized increasingly (Debrunner, Jonkman and Gerber, 2022; Kaufmann *et al.*, 2023), although unfortunately, in my own work, I did not measure the increase in redevelopments over time. It is crucial to conduct further research on the conditions under which this rise in housing redevelopment occurs.

9 Limitations and future research

This chapter delves into the limitations of the current study and explores avenues for future research. Here, I will discuss two key points: firstly, the impact of data availability on the research and the potential for incorporating new metrics. Secondly, I will consider the applicability of the presented approaches to address further research questions and its adaptability to different contexts.

9.1 Data (un)availability and metrics

One main limitation for my research was data availability and data comparability. This concerned various data sources. For example, land use data was unavailable at the same level of detail for Switzerland and the Netherlands. This impeded my comparative analysis of densification processes and led to numerous errors (i.e., wrongly attributed land use changes). However, the high level of detail and temporal depth at which land use data is available in the Netherlands is the exception rather than the rule. Generally, data availability issues concerning land use data can be addressed with methods from remote sensing. Satellite data can be leveraged for land-use classification through random forest or other deep-learning algorithms, thereby reducing reliance on governmental datasets.

However, I did not only experience limitations related to land-use data. Since my thesis focused on the social effects of densification, I relied on fine-grained socio-economic datasets with information on income, age demographics, and household compositions. While I was fortunate to access such data in Switzerland and the Netherlands, limitations persisted. Since I only got access to household-level income data in the Netherlands, I could not include this metric for defining densification types in Article 1. This underscores the broader challenge of assessing densification's (social) sustainability: many relevant metrics remain unmeasurable at the necessary level of detail. In addition, it is very time-consuming to gain an overview of available data sources and necessary infrastructures are not in place. For example, catalogues of available microdata for research, generalized procedures for accessing this data and security measures to help researchers handle this data safely would tremendously enhance research potentials in this field.

The potential for assessing the social effects of densification is far from exploited. Future research can focus even more on questions of where densification happens and who is affected by it. It would be relevant to compare the skewed focus of densification on low-income neighborhoods across countries and discern which densification types are most likely to happen in neighborhoods of different socio-economic statuses. This would also necessitate taking into account differences in income segregation across countries.

Next to detailed socio-economic data, a large potential lies in including landownership data in geospatial analyses of densification patterns. In my dissertation, I could consider general characteristics, such as the heterogeneity of landownership in a region or the prevalence of renting vs. homeownership. Including parcel-level landowner types could enrich analyses by elucidating what densification types are connected to what category of landowners. This question becomes even more relevant since the prevalence of landowner categories in the real estate markets keeps changing. The financialization of housing gives rise to both institutional investors and the buy-to-let market (Theurillat, Corpataux and Crevoisier, 2010; Aalbers *et al.*, 2020), and as land prices rise and investment requirements grow, the real estate market becomes increasingly concentrated in the hands of a few large landowners (Buitelaar and Van der Krabben, 2022). What effect do these changes have on urban development?

However, ownership data, even when available, presents several challenges. Firstly, landowner categorization can be inconsistent across countries, making comparisons difficult. Secondly, identifying the ultimate controlling entity behind companies can be complex. Finally, tracking ownership changes throughout a development process can be challenging, making it difficult to pinpoint the landowner with the most significant influence on the project's outcome.

9.2 Further application of the presented approach

It remains difficult to connect observed densification patterns to land policy on a large scale. This is because municipal development goals are unknown to us. For instance, if one municipality achieves higher building densities compared to another, it could be due to the municipality's effectiveness in enforcing land use regulations but also due to the actions of landowners, possibly against the municipality's interest. On a large scale, we can only guess the municipalities' goals, for example, by referring to national-level sustainability goals. To still be able to build hypotheses on land policy effects on the cross-regional level, I developed methods of measuring densification as a process and measuring densification as a deviation from expectation.

The presented approach of viewing densification in terms of its deviation from market expectations could be applied to map infill development that would not have happened without a certain policy effort – or, the other side of the coin: development that was stopped because of land policy (either because existing regulations did not allow for the development to happen, or because a municipality actively intervened to stop it). Since my thesis focused on densification issues connected to social equity, I spent less time analyzing the plain effectiveness of densification policies. Methodologically, this is a very interesting question. How can one map developments that did not happen or would not have happened under "normal" circumstances? Possible future studies could approach this question by, for example, comparing densification potentials at two points in time, analyzing underlying driving forces for development via regression analysis, and discussing why certain parcels remained undeveloped or were developed against expectation. This necessitates accounting for various market variables to accurately gauge the demand for densification, requiring interdisciplinary research between planning and real estate scholars. Another approach would be to focus on areas that are traditionally resistant to densification, such as suburbs, and to examine instances of densification in these neighborhoods. In

particular, such approaches can be used to examine the effectiveness of up-zoning. This would include mapping where municipalities apply up-zoning and to which degree developers exploit the new density potentials. In summary, applying spatial analysis to measure densification in terms of how much it deviates from expectation has the potential to point out cases where land policy interferes with market dynamics. Thus, spatial analysis can be a tool for selecting cases for qualitative research and can also be applied to comparisons across municipalities and regions.

In addition, the proposed comparative approach can be applied beyond the current context. In particular, a comparison with the UK, a country with high homeownership rates, would be interesting. Due to the ownership structure, we might expect fewer large-scale redevelopments there. The UK experiences alternative densification strategies, such as creating tiny apartments or office conversions (Remøy and Street, 2018). This suggests a higher pressure on the housing market than the current case study. Also, comparisons across time are crucial. Rising housing market pressure can incentivize densification for profit, not just for environmental reasons. This could lead to informal developments bypassing planning regulations, potentially creating new housing options “under the radar” of planning. As pressure mounts, we can expect an increase in redevelopments and subdivisions. By analyzing trends over time, we can better understand the driving forces behind these developments and develop more sustainable policy solutions.

10 Concluding remarks

In this thesis, I examined the contribution of spatial analysis to capture land policy effects on densification outcomes in Utrecht, the Netherlands and Bern, Switzerland. One of the major motivations for this thesis was to show the multifaceted nature of densification. Not all forms of densification are equally desirable, and alternative approaches exist. By studying densification in Utrecht and Bern, I could show that not all new developments exclusively address the wealthy and that densification is not necessarily connected to crowded, small units in apartment towers. Nor does it require eliminating green spaces like parks, sports fields, and allotment gardens.

Land policy plays a role in shaping these densification outcomes. Municipalities can remove barriers to certain forms of densification at strategic locations and restrict densification elsewhere. They strategically apply policy instruments to achieve their development goals. For Utrecht, I showed that if municipalities own land, they can help create more affordable housing. Also, institutions determine which tools governments can apply to assert their interests against the interests of other stakeholders. For instance, they determine whether citizens can vote down unpopular projects or how easy it is for landowners to cancel rental contracts for demolishing and replacing apartment blocks. Institutions ultimately also affect who the actors in the real estate market are – the share of renters and the existence of large landowners with the capacity for large-scale transformations.

Some of these institutions are easier to change than others, but being aware of them and their possible effects on urban development is a first step. It is crucial to understand these dynamics, the potential for different densification outcomes, and the possibilities for influencing them through land policy. In this dissertation, I provide methods for measuring densification in a way that allows for tracing land policy effects on a large scale – by comparing densification processes and outcomes across municipalities and countries and by measuring the degree to which densification deviates from expectations. Thereby, this dissertation offers valuable tools for questioning and critically analyzing densification processes across countries.

Literature

Aalbers, M. *et al.* (2020) 'The Death and Life of Private Landlordism: How Financialized Homeownership Gave Birth to the Buy-To-Let Market', *Housing, Theory and Society*, 00(00), pp. 1–23. doi: 10.1080/14036096.2020.1846610.

Aalbers, M. B., Loon, J. Van and Fernandez, R. (2017) 'The Financialization of A Social Housing Provider', in *International Journal of Urban and Regional Research*. doi: 10.1111/1468-2427.12520.

Ahlfeldt, G. M. and Pietrostefani, E. (2017) 'The compact city in empirical research: A quantitative literature review', *Spatial Economics Research Centre,London*, (June), p. 73. Available at: http://eprints.lse.ac.uk/id/eprint/83638.

Alterman, R. (2010) *Takings International. A Comparative Perspective on Land Use Regulations and Compensation Rights.* Chicago: ABA Publishing.

Angel, S. and Lamson-Hall, P. (2014) *The Rise and Fall of Manhattan's Densities, 1800-2010*.

Angel, S., Lamson-Hall, P. and Blanco, Z. G. (2021) 'Anatomy of density: measurable factors that constitute urban density', *Buildings and Cities*, 2(1), pp. 264–282. doi: 10.5334/bc.91.

Arundel, R. and Hochstenbach, C. (2020) 'Divided access and the spatial polarization of housing wealth', *Urban Geography*, 41(4), pp. 497–523. doi: 10.1080/02723638.2019.1681722.

Van Assche, K., Beunen, R. and Verweij, S. (2020) 'Comparative planning research, learning, and governance: The benefits and limitations of learning policy by comparison', *Urban Planning*, 5(1), pp. 11–21. doi: 10.17645/up.v5i1.2656.

Aurand, A. (2010) 'Density, housing types and mixed land use: Smart tools for affordable housing?', *Urban Studies*, 47(5), pp. 1015–1036. doi: 10.1177/0042098009353076.

Berghauser Pont, M. *et al.* (2021) 'Systematic review and comparison of densification effects and planning motivations', *Buildings and Cities*, 2(1), p. 378. doi: 10.5334/bc.125.

Berghauser Pont, M., Stavroulaki, G. and Marcus, L. (2019) 'Development of urban types based on network centrality, built density and their impact on pedestrian movement', *Environment and Planning B: Urban Analytics and City Science*, 46(8), pp. 1549–1564. doi: 10.1177/2399808319852632.

BFS (2020) *Wohnverhältnisse im Jahr 2020 und Eigentümertyp der Mietwohnungen im Jahr 2021 | Bundesamt für Statistik*. Available at: https://www.bfs.admin.ch/bfs/de/home.gnpdetail.2022-0072.html (Accessed: 9 August 2022).

Bibby, P., Henneberry, J. and Halleux, J. M. (2020) ‘Under the radar? “Soft” residential densification in England, 2001–2011’, *Environment and Planning B: Urban Analytics and City Science*, 47(1), pp. 102–118. doi: 10.1177/2399808318772842.

Bibby, P., Henneberry, J. and Halleux, J. M. (2021) ‘Incremental residential densification and urban spatial justice: The case of England between 2001 and 2011’, *Urban Studies*, 58(10), pp. 2117–2138. doi: 10.1177/0042098020936967.

Blatter, J. and Haverland, M. (2014) ‘Case Studies and (Causal-) Process Tracing’, in Engeli, I. and Rothmayr, A. C. (eds) *Comparative Policy Studies. Conceptual and Methodological Challenges*. Houndsmills Basingstoke: Palgrave Macmillan, pp. 59–83.

Bobkova, E., Berghauser Pont, M. and Marcus, L. (2021) ‘Towards analytical typologies of plot systems: Quantitative profile of five European cities Introduction: Relevance of plot system types’, *Environment and Planning B: Urban Analytics and City Science*, 48(4), pp. 604–620. doi: 10.1177/2399808319880902.

Bosoni, M. (2020) *The inclusion of natural capital in spatial development Need for improvisation in planning procedures*. Wageningen University and Research.

Boterman, W. R., Musterd, S. and Manting, D. (2021) ‘Multiple dimensions of residential segregation. The case of the metropolitan area of Amsterdam’, *Urban Geography*, 42(4), pp. 481–506. doi: 10.1080/02723638.2020.1724439.

Bouwmeester, J. *et al.* (2023) ‘Non-compliance and non-enforcement : An unexpected outcome of flexible soft densification policy in the Netherlands’, *Land Use Policy*, 126, p. 106525. doi: 10.1016/j.landusepol.2022.106525.

Boyko, C. T. and Cooper, R. (2011) ‘Clarifying and re-conceptualising density’, *Progress in Planning*, 76(1), pp. 1–61. doi: 10.1016/j.progress.2011.07.001.

Bramley, G. *et al.* (2009) ‘Social sustainability and urban form: Evidence from five British cities’, *Environment and Planning A*, 41(9), pp. 2125–2142. doi: 10.1068/a4184.

Bregman, A. *et al.* (2018) *Gebiedsontwikkeling in een nieuwe realiteit.* The Hague.

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

Broitman, D. and Koomen, E. (2020) ‘The attraction of urban cores: Densification in Dutch city centres’, *Urban Studies*, 57(9), pp. 1920–1939. doi: 10.1177/0042098019864019.

Bromley, R. D. F., Tallon, A. R. and Thomas, C. J. (2005) ‘City Centre Regeneration through Residential Development: Contributing to Sustainability’, *Urban Studies*, 42(13), pp. 2407–2429.

Buehler, R. (2011) ‘Determinants of transport mode choice: A comparison of Germany and the USA’,

Journal of Transport Geography, 19(4), pp. 644–657. doi: https://doi.org/10.1016/j.jtrangeo.2010.07.005.

Buitelaar, E. (2010) 'Cracks in the myth: Challenges to land policy in the Netherlands', *Tijdschrift voor Economische en Sociale Geografie*, 101(3), pp. 349–356. doi: 10.1111/j.1467-9663.2010.00604.x.

Buitelaar, E. and Bregman, A. (2016) 'Dutch land development institutions in the face of crisis: trembling pillars in the planners' paradise', *European Planning Studies*, 24(7), pp. 1281–1294. doi: 10.1080/09654313.2016.1168785.

Buitelaar, E., Galle, M. and Sorel, N. (2011) 'Plan-led planning systems in development-led practices: An empirical analysis into the (lack of) institutionalisation of planning law', *Environment and Planning A*, 43(4), pp. 928–941. doi: 10.1068/a43400.

Buitelaar, E. and Van der Krabben, E. (2022) *Woningbouw en marktconcentratie: een analyse van de structuur van de grond- en woningbouwmarkt*. Den Haag.

Buitelaar, E. and Leinfelder, H. (2020) 'Public design of urban sprawl: Governments and the extension of the urban fabric in flanders and the Netherlands', *Urban Planning*, 5(1), pp. 46–57. doi: 10.17645/up.v5i1.2669.

Buitelaar, E. and Segeren, A. (2011) 'Urban structures and land. The Morphological effects of dealing with property Rights', *Housing Studies*, 26(5), pp. 661–679. doi: 10.1080/02673037.2011.581909.

Buitelaar, E., Segeren, A. H. J. A. and Kronberger, P. (2008) 'Stedelijke transformatie en grondeigendom', p. 61. Available at: http://www.pbl.nl/sites/default/files/cms/publicaties/Stedelijke_transformaties_en_grondeigendom.pdf%0Ahttp://www.pbl.nl/publicaties/2008/Stedelijke-transformatie-en-grondeigendom.

Buitelaar, E. and Sorel, N. (2010) 'Between the rule of law and the quest for control: Legal certainty in the Dutch planning system', *Land Use Policy*, 27(3), pp. 983–989. doi: 10.1016/j.landusepol.2010.01.002.

Buitelaar, E. and Witte, P. (2011) *Financiering van gebiedsontwikkeling een empirische analyse van grondexploitaties*.

Burton, E. (2000) 'The compact city: Just or just compact? A preliminary analysis', *Urban Studies*, 37(11), pp. 1969–2001. doi: 10.1080/00420980050162184.

Buttenfield, B. P. (2022) 'GIScience through the looking glass', in Rey, S. J. and Franklin, R. S. (eds) *Spatial Analysis in the Social Sciences*. Edward Elgar, pp. 2–15.

Cavicchia, R. (2021) 'Are Green, dense cities more inclusive? Densification and housing accessibility in Oslo', *Local Environment*, 26(10), pp. 1250–1266. doi: 10.1080/13549839.2021.1973394.

Cavicchia, R. (2022) 'Urban densification and exclusionary pressure: emerging patterns of gentrification in Oslo', *Urban Geography*, 0(0), pp. 1–23. doi: 10.1080/02723638.2022.2100174.

Cavicchia, R. (2023) ‘Housing accessibility in densifying cities: Entangled housing and land use policy limitations and insights from Oslo’, *Land Use Policy*, 127(February). doi: 10.1016/j.landusepol.2023.106580.

Cavicchia, R. and Cucca, R. (2020) ‘Densification and school segregation: The case of Oslo’, *Urban Planning*, 5(3), pp. 217–229. doi: 10.17645/up.v5i3.3215.

CBS (2023) *Voorraad woningen; eigendom, type verhuurder, bewoning, regio*. Available at: https://www.cbs.nl/nl-nl/cijfers/detail/82900NED.

Chakraborty, A., Omrani, H. and Teller, J. (2022) ‘Modelling the Drivers of Urban Densification to Evaluate Built-up Areas Extension: A Data-Modelling Solution Towards Zero Net Land Take’, in *Computational Science and Its Applications – ICCSA 2022, 22nd International Conference, Malaga, Spain, July 4–7, 2022, Proceedings, Part II*. Springer International Publishing, pp. 260–270. doi: 10.1007/978-3-031-10450-3_21.

Charmes, E. and Keil, R. (2015) ‘The Politics of Post-Suburban Densification in Canada and France’, *International Journal of Urban and Regional Research*, 39(3), pp. 581–602. doi: 10.1111/1468-2427.12194.

Cheung, K. S., Monkkonen, P. and Yiu, C. Y. (2023) ‘The heterogeneous impacts of widespread upzoning: Lessons from Auckland, New Zealand’, *Urban Studies*, (July). doi: 10.1177/00420980231190281.

Churchman, A. (1999) ‘Disentangling the concept of density’, *Journal of Planning Literature*, 13(4), pp. 389–411. doi: 10.1177/08854129922092478.

Claassens, J., Koomen, E. and Rouwendal, J. (2020) ‘Urban density and spatial planning: The unforeseen impacts of Dutch devolution’, *PLoS ONE*, 15(10 October), pp. 1–20. doi: 10.1371/journal.pone.0240738.

Colsaet, A., Laurans, Y. and Levrel, H. (2018) ‘What drives land take and urban land expansion? A systematic review’, *Land Use Policy*, 79, pp. 339–349. doi: 10.1016/j.landusepol.2018.08.017.

Dantzig, G. B. and Saaty, T. L. (1973) *Compact City: A Plan for a Liveable Urban Environment*. W. H. Freeman.

David, N. P. (2015) ‘Factors Affecting Planned Unit Development Implementation’, *Planning Practice & Research*, 30(4), pp. 393–409. doi: 10.1080/02697459.2015.1015832.

Davy, B. (2012) *Land policy : planning and the spatial consequences of property*. Farnham: Ashgate.

Debrunner, G. and 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(April), p. 104993. doi: 10.1016/j.landusepol.2020.104993.

Debrunner, G. and Hengstermann, A. (2023) ‘Vier Thesen zur effektiven Umsetzung der

Innenentwicklung in der Schweiz', *disP - The Planning Review*, pp. 86–97. doi: 10.1080/02513625.2023.2229632.

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

Debrunner, G., Jonkman, A. and Gerber, J.-D. (2022) 'Planning for social sustainability: mechanisms of social exclusion in densification through large-scale redevelopment projects in Swiss cities', *Housing Studies*, 0(0), pp. 1–21. doi: 10.1080/02673037.2022.2033174.

Debrunner, G. and Kaufmann, D. (2023) 'Land valuation in densifying cities: The negotiation process between institutional landowners and municipal planning authorities', *Land Use Policy*, 132(July). doi: 10.1016/j.landusepol.2023.106813.

Dembski, S. *et al.* (2020) 'Introduction enhancing understanding of strategies of land policy for urban densification', *Town Planning Review*, 91(3), pp. 209–216. doi: 10.3828/tpr.2020.12.

Dunning, R., Hickman, H. and While, A. (2020) 'Planning control and the politics of soft densification', *Town Planning Review*, 91(3), pp. 305–324. doi: 10.3828/tpr.2020.17.

EBP Schweiz (2018) *Eine neue Generation der Nutzungsplanung im Kanton Bern*. Zurich. Available at: https://www.ebp.ch/sites/default/files/2019-06/Schlussbericht_181214_0.pdf.

EEA (2016) *Urban Sprawl in Europe − Joint EEA-FOEN Report*.

Eggimann, S. *et al.* (2020) 'Sustainable urban densification potentials: A geospatial analysis of Swiss post-war neighbourhoods', *IOP Conference Series: Earth and Environmental Science*, 588(2). doi: 10.1088/1755-1315/588/2/022040.

Ehrhardt, D. *et al.* (2023) 'Mapping soft densification: a geospatial approach for identifying residential infill potentials', *Buildings and Cities*, 4(1), pp. 193–211. doi: 10.5334/bc.295.

Ehrlich, M. V. and Overman, H. G. (2020) 'Place-based policies and spatial disparities across European Cities', *Journal of Economic Perspectives*, 34(3), pp. 128–149. doi: 10.1257/jep.34.3.128.

Eichhorn, S. *et al.* (2024) 'Understanding land take by low-density residential areas: An institutionalist perspective on local planning authorities, developers and households', *Land Use Policy*, 143, p. 107198.

Elvestad, H. and Holsen, T. (2020) 'Negative covenants and real-estate developers' modus operandi: The case of suburban densification in oslo, Norway', *Town Planning Review*, 91(3), pp. 325–342. doi: 10.3828/tpr.2020.18.

Eom, H.-J. and Cho, G.-H. (2015) 'Exploring thresholds of built environment characteristics for walkable communities: empirical evidence from the Seoul Metropolitan Area.', *Transportation Research Part D: Transport and Environment*, 40, pp. 76–86. doi: https://doi.org/10.1016/j.trd.2015.07.005.

Ester, M. *et al.* (1996) 'A Density-Based Algorithm for Discovering Clusters in Large Spatial Databases with Noise'. Available at: www.aaai.org (Accessed: 30 January 2023).

European Commission (2011) *Roadmap to a Resource Efficient Europe*. Brussels.

Garcia-Lamarca, M. *et al.* (2021) 'Urban green boosterism and city affordability : For whom is the " branded " green city ?', *Urban Studies*, 58(1), pp. 90–112. doi: 10.1177/0042098019885330.

Garcia-López, M. À. and Moreno-Monroy, A. I. (2018) 'Income segregation in monocentric and polycentric cities: Does urban form really matter?', *Regional Science and Urban Economics*, 71(May), pp. 62–79. doi: 10.1016/j.regsciurbeco.2018.05.003.

Van Gent, W. and Hochstenbach, C. (2019) 'The neo-liberal politics and socio-spatial implications of Dutch post-crisis social housing policies', *International Journal of Housing Policy*, 20(1), pp. 156–172. doi: 10.1080/19491247.2019.1682234.

Gerber, J.-D. (2016) 'The managerial turn and municipal land-use planning in Switzerland – evidence from practice', *Planning Theory and Practice*, 17(2), pp. 192–209. doi: 10.1080/14649357.2016.1161063.

Gerber, J.-D. and Bandi Tanner, M. (2018) 'The role of Alpine development regimes in the development of second homes: Preliminary lessons from Switzerland', *Land Use Policy*, 77(September 2017), pp. 859–870. doi: 10.1016/j.landusepol.2017.09.017.

Gerber, J.-D. and Debrunner, G. (2022) 'Planning with power. Implementing urban densification policies in Zurich, Switzerland', *Land Use Policy*, 123, p. 106400. doi: 10.1016/j.landusepol.2022.106400.

Gerber, J.-D., Hartmann, T. and Hengstermann, A. (2018) *Instruments of land policy*, *Instruments of Land Policy*. Edited by J.-D. Gerber, T. Hartmann, and A. Hengstermann. Routledge. doi: 10.4324/9781315511658-3.

Gerber, J.-D., Hengstermann, A. and Viallon, F.-X. (2018) 'Land policy: How to deal with scarcity of land', in Hengstermann, A., Hartmann, T., and Gerber, J.-D. (eds) *Instruments of Land Policy*. Routledge, pp. 8–26. doi: 10.4324/9781315511658-2.

Gerber, J. D., Lieberherr, E. and Knoepfel, P. (2020) 'Governing contemporary commons: The Institutional Resource Regime in dialogue with other policy frameworks', *Environmental Science and Policy*, 112(June), pp. 155–163. doi: 10.1016/j.envsci.2020.06.009.

Gerber, J. D., Nahrath, S. and Hartmann, T. (2017) 'The strategic use of time-limited property rights in land-use planning: Evidence from Switzerland', *Environment and Planning A*, 49(7), pp. 1684–1703. doi: 10.1177/0308518X17701916.

Giddings, B. and Rogerson, R. (2021) 'Compacting the city centre: densification in two Newcastles', *Buildings and Cities*, 2(1), pp. 185–202. doi: 10.5334/bc.74.

Giezen, M., Balikci, S. and Arundel, R. (2018) 'Using Remote Sensing to Analyse Net Land-Use Change

from Conflicting Sustainability Policies: The Case of Amsterdam', *ISPRS International Journal of Geo-Information*, 7(9), p. 381. doi: 10.3390/ijgi7090381.

Goertz, G. and Mahoney, J. (2012) *A tale of two cultures: Qualitative and quantitative research in the social sciences*, *A Tale of Two Cultures: Qualitative and Quantitative Research in the Social Sciences*. Princeton University Press.

Götze, V., Bouwmeester, J. A. and Jehling, M. (2023) 'For whom do we densify? Explaining income variation across densification projects in the region of Utrecht, the Netherlands', *Urban Studies*. doi: 10.1177/00420980231205793.

Götze, V. and Hartmann, T. (2021) 'Why municipalities grow: The influence of fiscal incentives on municipal land policies in Germany and the Netherlands', *Land Use Policy*, 109. doi: 10.1016/j.landusepol.2021.105681.

Götze, V. and Jehling, M. (2022) 'Comparing types and patterns: A context-oriented approach to densification in Switzerland and the Netherlands', *Environment and Planning B: Urban Analytics and City Science*, 0(0), pp. 1–15. doi: 10.1177/23998083221142198.

Greenaway-McGrevy, R., Pacheco, G. and Sorensen, K. (2021) 'The effect of upzoning on house prices and redevelopment premiums in Auckland , New Zealand', *Urban Studies*, 58(5), pp. 959–976. doi: 10.1177/0042098020940602.

Greenaway-McGrevy, R. and Phillips, P. C. B. (2023) 'The impact of upzoning on housing construction in Auckland', *Journal of Urban Economics*, 136(March), p. 103555. doi: 10.1016/j.jue.2023.103555.

Haaland, C. and van den Bosch, C. K. (2015) 'Challenges and strategies for urban green-space planning in cities undergoing densification: A review', *Urban Forestry and Urban Greening*, 14(4), pp. 760–771. doi: 10.1016/j.ufug.2015.07.009.

Haase, D., Kabisch, N. and Haase, A. (2013) 'Endless Urban Growth? On the Mismatch of Population, Household and Urban Land Area Growth and Its Effects on the Urban Debate', *PLoS ONE*, 8(6), pp. 1–8. doi: 10.1371/journal.pone.0066531.

Hartmann, T. and Spit, T. (2015) 'Dilemmas of involvement in land management – Comparing an active (Dutch) and a passive (German) approach', *Land Use Policy*, 42, pp. 729–737. doi: 10.1016/J.LANDUSEPOL.2014.10.004.

Hecht, R. *et al.* (2019) 'Mapping long-term dynamics of population and dwellings based on a multi-temporal analysis of urban morphologies', *ISPRS International Journal of Geo-Information*, 8(1). doi: 10.3390/ijgi8010002.

Hengstermann, A. (2018) 'Building obligations in Switzerland: overcoming the passivity of plan implementation', in *Instruments of Land Policy*. Routledge, pp. 175–188.

Hengstermann, A. and Hartmann, T. (2018) 'Instruments of land policy. Four types of intervention', in Gerber, J.-D., Hartmann, T., and Hengstermann, A. (eds) *Instruments of Land Policy*. Routledge, pp.

27–32.

Hennig, E. I. *et al.* (2015) ‘Multi-scale analysis of urban sprawl in Europe: Towards a European de-sprawling strategy’, *Land Use Policy*, 49, pp. 483–498. doi: 10.1016/j.landusepol.2015.08.001.

Herdt, T. and Jonkman, A. (2021) ‘Spatial justice and the NIMBY effect: An analysis of the urban densification debate in Switzerland and the Netherlands.’, in *International Forum on Urbanism*, pp. 25–27. doi: 10.24404/615ec0f601ef1c0009df6e3a.

Herenhuizen Meyster’s Buiten (2011). Available at: https://www.facebook.com/media/set/?set=a.268787269814166.86830.203418253017735 (Accessed: 1 March 2023).

Hill, A. B. (1965) ‘The environment and disease: Association or causation?’, *Journal of the Royal Society of Medicine*, 58(5), pp. 295–300. doi: https://doi.org/10.1177/0141076814562718.

Holman, N. *et al.* (2015) ‘Coordinating density; working through conviction, suspicion and pragmatism’, *Progress in Planning*, 101, pp. 1–38. doi: 10.1016/j.progress.2014.05.001.

Holtslag-Broekhof, S., Hartmann, T. and Spit, T. (2018) ‘Compulsory acquisition in the Netherlands’, in Searle, G. (ed.) *Compulsory Property Acquisition for Urban Densification*. London: Routledge, pp. 8–17.

Huang, Z. (1998) ‘Extensions to the k-Means Algorithm for Clustering Large Data Sets with Categorical Values’, *Data Mining and Knowledge Discovery*, 12, pp. 283–304.

Immergluck, D. and Balan, T. (2018) ‘Sustainable for whom? Green urban development, environmental gentrification, and the Atlanta Beltline’, *Urban Geography*, 39(4), pp. 546–562. doi: 10.1080/02723638.2017.1360041.

Jehling, M. and Hecht, R. (2021) ‘Do land policies make a difference? A data-driven approach to trace effects on urban form in France and Germany’, *Environment and Planning B: Urban Analytics and City Science*, 0(0), pp. 1–17. doi: 10.1177/2399808321995818.

Jehling, M., Hecht, R. and Herold, H. (2018) ‘Assessing urban containment policies within a suburban context—An approach to enable a regional perspective’, *Land Use Policy*, 77, pp. 846–858. doi: 10.1016/j.landusepol.2016.10.031.

Jehling, M., Krehl, A. and Krüger, T. (2021) ‘The more the merrier? Questioning the role of new commercial and industrial locations for employment growth in German city regions’, *Land Use Policy*, 109(July), p. 105653. doi: 10.1016/j.landusepol.2021.105653.

Jehling, M., Schorcht, M. and Hartmann, T. (2020) ‘Densification in suburban Germany: Approaching policy and space through concepts of justice’, *Town Planning Review*, 91(3), pp. 217–237. doi: 10.3828/tpr.2020.13.

Kabisch, N., Haase, D. and Haase, A. (2010) ‘Evolving Reurbanisation? Spatio-temporal Dynamics as

Exemplified by the East German City of Leipzig', *Urban Studies*, 47(5), pp. 967–990. doi: 10.1177/0042098009353072.

Kabisch, N., Haase, D. and Haase, A. (2019) 'Reurbanisation: A long-term process or a short-term stage?', *Population, Space and Place*, 25(8), pp. 1–13. doi: 10.1002/psp.2266.

Kaufmann, D. *et al.* (2023) *Erkenntnisse zum aktuellen Wohnungsnotstand: Bautätigkeit, Verdrängung und Akzeptanz*. Zurich.

Kent, A. J. and Specht, D. (2024) *The Routledge Handbook of Geospatial Technologies and Society*. Edited by A. J. Kent and D. Specht. Routledge.

Kim, J. (2016) 'Achieving mixed income communities through infill? The effect of infill housing on neighborhood income diversity', *Journal of Urban Affairs*, 38(2), pp. 280–297. doi: 10.1111/juaf.12207.

Klaus, J. (2020) 'Do municipal autonomy and institutional fragmentation stand in the way of antisprawl policies? A qualitative comparative analysis of Swiss cantons', *Environment and Planning B: Urban Analytics and City Science*, 47(9), pp. 1622–1638. doi: 10.1177/2399808319833377.

Knoepfel, P. *et al.* (2007) *Public Policy Analysis*. Bristol: The Policy Press.

Knoepfel, P. *et al.* (2012) 'Transformation der Rolle des Staates und der Grundeigentümer in städtischen Raumentwicklungsprozessen im Lichte der nachhaltigen Entwicklung Author (s): Peter Knoepfel , Patrick Csikos , Jean-David Gerber and Stéphane Nahrath Published by : Springer Sta', *Politische Vierteljahresschrift*, 53(3), pp. 414–443.

Koomen, E., Dekkers, J. and Broitman, D. (2018) 'Analyzing and Simulating Urban Density Exploring the Difference Between Policy Ambitions and Actual Trends in the Netherlands', *Advances in Geographic Information Science*, pp. 145–171. doi: 10.1007/978-3-642-37896-6_7.

Korthals Altes, W. K. (2019) 'Planning initiative: Promoting development by the use of options in Amsterdam', *Land Use Policy*, 83(January), pp. 13–21. doi: 10.1016/j.landusepol.2019.01.025.

Kremer, P., Haase, A. and Haase, D. (2019) 'The future of urban sustainability: Smart, efficient, green or just? Introduction to the special issue', *Sustainable Cities and Society*, 51(July). doi: 10.1016/j.scs.2019.101761.

Lauf, S. *et al.* (2012) 'Simulating demography and housing demand in an urban region under scenarios of growth and shrinkage', *Environment and Planning B: Planning and Design*, 39(2), pp. 229–246. doi: 10.1068/b36046t.

Lees, L. (2008) 'Gentrification and social mixing: Towards an inclusive urban renaissance?', *Urban Studies*, 45(12). doi: 10.1177/0042098008097099.

Van Leeuwen, N. and Venema, J. (2021) *Statistische gegevens per vierkant en postcode CBS Publicatie Statistische gegevens per vierkant en postcode*. Available at: https://redactie.cbs.nl/nl-nl/longread/diversen/2021/statistische-gegevens-per-vierkant-en-postcode-2020-2019-2018/1-

statistische-gegevens-per-vierkant-en-postcode.

Lieberman, E. S. (2005) 'Nested Analysis as a Mixed-Method Strategy for Comparative Research', *American Political Science Review*, 99(3), pp. 435–452.

Long, J. A. and Robertson, C. (2017) 'Comparing Spatial Patterns', *Geography Compass*, 12(2). doi: doi.org/10.1111/gec3.12356.

Lowndes, V. (1996) 'Varieties of new institutionalism: A critical appraisal', *Public Administration*, 74(2), pp. 181–197.

Lowndes, V. and Roberts, M. (2013) *Why Institutions Matter: The New Institutionalism in Political Science*. 1. publ. Basingstoke: Palgrave Macmillan.

Mahtta, R. *et al.* (2022) 'Urban land expansion: the role of population and economic growth for 300+ cities', *npj Urban Sustainability*, 2(1). doi: 10.1038/s42949-022-00048-y.

Manville, M. *et al.* (2023) 'Does Discretion Delay Development?: The Impact of Approval Pathways on Multifamily Housing's Time to Permit', *Journal of the American Planning Association*, 89(3), pp. 336–347. doi: 10.1080/01944363.2022.2106291.

Meijer, R. and Jonkman, A. (2020) 'Land-policy instruments for densification: The Dutch quest for control', *Town Planning Review*, 91(3), pp. 239–258. doi: 10.3828/tpr.2020.14.

Moos, M. (2016) 'From gentrification to youthification? The increasing importance of young age in delineating high-density living', *Urban Studies*, 53(14), pp. 2903–2920. doi: 10.1177/0042098015603292.

Moos, M. *et al.* (2018) 'Planning for Mixed Use: Affordable for Whom?', *Journal of the American Planning Association*, 84(1), pp. 7–20. doi: 10.1080/01944363.2017.1406315.

Municipality of Bunnik (2018) *Visie op wonen Bunnik 2017-2021*.

Municipality of Utrecht (2011a) *Ontwikkelingsstrategie Veemarkt*.

Municipality of Utrecht (2011b) *Raadsvoorstel Vaststelling bestemmingsplan Cereol/Mozartlaan*.

Municipality of Utrecht (2013) *Ambitiedocument Herprogrammering Woningbouwprogramma Veemarkt*.

Municipality of Veenendaal (2013) *Bestemmingsplan Industrielaan 24*.

Municipality of Zeist (2014) *Wijzigingsplan Kerckebosch*.

Musterd, S. and Ostendorf, W. (2021) 'Urban renewal policies in the Netherlands in an era of changing welfare regimes', *Urban Research and Practice*, pp. 1–17. doi: 10.1080/17535069.2021.1983861/FORMAT/EPUB.

Nabielek, K. (2011) 'Urban Densification in the Netherlands: National Spatial Policy and Empirical

Research of recent developments', *The 5th International Conference of the International Forum on Urbanism (IFoU)*, p. 9. Available at: http://globalvisions2011.ifou.org/Index/Group 2/FOUA00103-00120P2.pdf.

Nachmany, H. and Hananel, R. (2023) 'The Urban Renewal Matrix', *Land Use Policy*, 131, p. 106744. doi: 10.1016/j.landusepol.2023.106744.

Nebel, R. *et al.* (2017) *Schweizweite Abschätzung der Nutzungsreserven 2017*. doi: 10.3218/3883-5.

Needham, B. (2014) *Dutch land-use planning: The principles and the practice*, *Dutch Land-use Planning: The Principles and the Practice*. Ashgate. doi: 10.4324/9781315578262.

North, D. C. (1990) *Institutions, Institutional Change and Economic Performance*. Cambridge University Press. doi: https://doi.org/10.1017/CBO9780511808678.

van Oosten, T., Witte, P. and Hartmann, T. (2018) 'Active land policy in small municipalities in the Netherlands: "We don't do it, unless…"', *Land Use Policy*, 77, pp. 829–836. doi: 10.1016/J.LANDUSEPOL.2017.10.029.

Patrimonium Woonservice (2016) *Jaarstukken 2015*. Available at: https://veenvesters.nl/media/1247/jaarstukken-2015.pdf (Accessed: 1 March 2023).

Pendall, R. and Carruthers, J. I. (2003) 'Does density exacerbate income segregation? Evidence from U.S. Metropolitan Areas, 1980 to 2000', *Housing Policy Debate*, 14(4), pp. 541–589. doi: 10.1080/10511482.2003.9521487.

Priemus, H. (2006) 'Regeneration of Dutch post-war urban districts: The role of housing associations', *Journal of Housing and the Built Environment*, 21(4), pp. 365–375. doi: 10.1007/s10901-006-9055-4.

Puustinen, T., Krigsholm, P. and Falkenbach, H. (2022) 'Land policy conflict profiles for different densification types: A literature-based approach', *Land Use Policy*, 123(February), p. 106405. doi: 10.1016/j.landusepol.2022.106405.

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

Remøy, H. and Street, E. (2018) ''The dynamics of "post-crisis" spatial planning: A comparative study of office conversion policies in England and The Netherlands', *Land Use Policy*, 77, pp. 811–820. doi: 10.1016/j.landusepol.2016.12.005.

Rérat, P. *et al.* (2010) 'From urban wastelands to new-build gentrification: The case of swiss cities', *Population, Space and Place*, 16(5), pp. 429–442. doi: 10.1002/psp.595.

Rérat, P. (2019) 'The return of cities: the trajectory of Swiss cities from demographic loss to reurbanization', *European Planning Studies*, 27(2), pp. 355–376. doi: 10.1080/09654313.2018.1546832.

Rey, S. J. and Franklin, R. S. (2022) *Handbook of Spatial Analysis in the Social Sciences*. Edited by S. J. Rey and R. S. Franklin. Edward Elgar.

Rinkinen, J., Shove, E. and Smits, M. (2021) 'Conceptualising urban density, energy demand and social practice', *Buildings and Cities*, 2(1), pp. 79–91. doi: 10.5334/bc.72.

Robertson, C. and Long, J. (2022) 'Linking spatial patterns to processes', in Rey, S. J. and Franklin, R. S. (eds) *Handbook of Spatial Analysis in the Social Sciences2*. Edward Elgar, pp. 85–100.

Rohlfing, I. (2012) *Case Studies and Causal Inference*, *Case Studies and Causal Inference*. doi: 10.1057/9781137271327.

Rosol, M. (2015) 'Social mixing through densification? The struggle over the Little Mountain public housing complex in Vancouver', *Die Erde*, 146(2), pp. 151–164. doi: 10.12854/erde-146-13.

Rousseau, M. (2015) '"Many Rivers to Cross": Suburban Densification and the Social Status Quo in Greater Lyon', *International Journal of Urban and Regional Research*, 39(3), pp. 622–632. doi: 10.1111/1468-2427.12197.

Rugg, J., Rhodes, D. and Jones, A. (2002) 'Studying a niche market: UK students and the private rented sector', *Housing Studies*, 17(2), pp. 289–303. doi: 10.1080/02673030220123234.

Samsonov, T. (2024) 'Spatial analysis and modelling', in Kent, A. J. and Specht, D. (eds) *The Routledge Handbook of Geospatial Technologies and Society*. Routledge, pp. 263–290.

Schmid, F. B. *et al.* (2024) 'Effects of different land-use planning instruments on urban shrub and tree canopy cover in Zurich, Switzerland', *Urban Forestry and Urban Greening*, 94(August 2023). doi: 10.1016/j.ufug.2024.128272.

Schorcht, M., Hecht, R. and Meinel, G. (2018) 'Approaches to distinguish "real" changes from "unreal" changes based on multi-temporal 2d building footprint data', *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences - ISPRS Archives*, 42(4), pp. 623–630. doi: 10.5194/isprs-archives-XLII-4-559-2018.

Schorcht, M., Jehling, M. and Krüger, T. (2023) 'Where are cities under pressure? – An indicator for measuring the impact of building changes on urban density', *Ecological Indicators*, 149(February), p. 110142. doi: 10.1016/j.ecolind.2023.110142.

SCP (2020) *Wonen | De sociale staat van Nederland: 2020 - SCP*. Available at: https://digitaal.scp.nl/ssn2020/wonen/ (Accessed: 9 August 2022).

Seawright, J. (2016) *Multi-Method Social Science Combining Qualitative and Quantitative Tools*. Cambridge University Press.

Seto, K. C., Güneralp, B. and Hutyra, L. R. (2012) 'Global forecasts of urban expansion to 2030 and direct impacts on biodiversity and carbon pools', *Proceedings of the National Academy of Sciences of the United States of America*, 109(40), pp. 16083–16088. doi: 10.1073/pnas.1211658109.

Siedentop, S. and Fina, S. (2012) 'Who Sprawls Most? Exploring the Patterns of Urban Growth across 26 European Countries', *Environment and Planning A: Economy and Space*, 44(11), pp. 2765–2784. doi: 10.1068/A4580.

De Sousa, C. (2000) 'Brownfield redevelopment versus greenfield development: A private sector perspective on the costs and risks associated with Brownfield redevelopment in the Greater Toronto Area', *Journal of Environmental Planning and Management*, 43(6), pp. 831–853. doi: 10.1080/09640560020001719.

Statistics Netherlands (2018) *What is my spendable income?* Available at: https://www.cbs.nl/en-gb/background/2008/50/what-is-my-spendable-income- (Accessed: 7 March 2023).

Steinacker, A. (2003) 'INFILL DEVELOPMENT AND AFFORDABLE HOUSING Patterns from 1996 to 2000', *Urban Affairs Review*, 38(4). doi: 10.1177/1078087402250357.

Teller, J. (2021) 'Regulating urban densification: what factors should be used?', *Buildings and Cities*, 2(1), pp. 302–317. doi: 10.5334/bc.123.

Tennekes, J., Harbers, A. and Buitelaar, E. (2015) 'Institutional Arrangements and the Morphology of Residential Development in the Netherlands, Flanders and North Rhine-Westphalia', *European Planning Studies*, 23(11), pp. 2165–2183. doi: 10.1080/09654313.2015.1018437.

Theurillat, T., Corpataux, J. and Crevoisier, O. (2010) 'Property sector financialization: The case of swiss pension funds (1992-2005)', *European Planning Studies*, 18(2), pp. 189–212. doi: 10.1080/09654310903491507.

Touati-Morel, A. (2015) 'Hard and Soft Densification Policies in the Paris City-Region', *International Journal of Urban and Regional Research*, 39(3), pp. 603–612. doi: 10.1111/1468-2427.12195.

Troy, L., Easthope, H. and Crommelin, L. (2017) *It's not just the buildings, high-density neighbourhoods make life worse for the poor*, *The Conversation*. Available at: https://theconversation.com/its-not-just-the-buildings-high-density-neighbourhoods-make-life-worse-for-the-poor-82070 (Accessed: 6 December 2023).

Uitermark, J. L., Duyvendak, J. W. and Kleinhans, R. (2007) 'Gentrification as a governmental strategy: Social control and social cohesion in Hoogvliet, Rotterdam', *Environment and Planning A*, 39(1), pp. 125–141. doi: 10.1068/a39142.

UN-Habitat (2022) *World Cities Report 2022. Envisaging the Future of Cities*. Available at: https://unhabitat.org/sites/default/files/2022/06/wcr_2022.pdf.

Verheij, J. *et al.* (2023) 'Ensuring Public Access to Green Spaces in Urban Densification: The Role of Planning and Property Rights', *Planning Theory and Practice*. doi: 10.1080/14649357.2023.2239215.

Verstegen, J. A. and Goch, K. (2022) 'Pattern-oriented calibration and validation of urban growth models: Case studies of Dublin, Milan and Warsaw', *Land Use Policy*, 112, p. 105831. doi: 10.1016/j.landusepol.2021.105831.

VROM, LNV and V&Wand EZ (2004) *Nota Ruimte. Ruimte voor ontwikkeling.* The Hague.

Van Wanrooij Projectontwikkeling (2019) *Nota van beantwoording informatieavond woningbouwontwikkeling Molenweg*. Available at: https://bunnik.bestuurlijkeinformatie.nl/Reports/Item/78ce68b0-0711-4feb-8aca-4ad4f1b85244 (Accessed: 1 March 2023).

Wellmann, T. *et al.* (2020) 'Green growth? On the relation between population density, land use and vegetation cover fractions in a city using a 30-years Landsat time series', *Landscape and Urban Planning*, 202(June), p. 103857. doi: 10.1016/j.landurbplan.2020.103857.

Wicki, M., Hofer, K. and Kaufmann, D. (2022) 'Planning instruments enhance the acceptance of urban densification', *Proceedings of the National Academy of Sciences of the United States of America*, 119(38), pp. 1–10. doi: 10.1073/pnas.2201780119.

Wilmink, F. W. and Uytterschaut, H. T. (1984) 'Cluster Analysis, History, Theory and Applications', *Multivariate Statistical Methods in Physical Anthropology*, pp. 135–175. doi: 10.1007/978-94-009-6357-3_11.

Wong, W. (2015) *Meyster's Buiten – een wijk compleet na brand en crisis*, *Gebiedsontwikkeling.nu*. Available at: https://www.gebiedsontwikkeling.nu/artikelen/meysters-buiten-een-wijk-compleet-na-brand-en-crisis/ (Accessed: 1 March 2023).

Xiao, Y., Orford, S. and Webster, C. J. (2016) 'Urban configuration, accessibility, and property prices: a case study of Cardiff, Wales', *Environment and Planning B: Planning and Design*, 43(1), pp. 108–129. doi: 10.1177/0265813515600120.

Appendix

A1: Why municipalities grow: The influence of fiscal incentives on municipal land policies in Germany and the Netherlands[6]

Scientific article published in Land Use Policy, 2021

Authors: Vera Götze and Thomas Hartmann

Abstract. It is generally assumed that municipalities attract residents and businesses as a result of intermunicipal competition for tax revenues. This growth-oriented behaviour poses a serious problem considering internationally acknowledged goals to limit land take. Nonetheless, research on how fiscal incentives affect municipal land policies is scarce. Adapting a neoinstitutionalist approach, we compare the two contrasting fiscal systems of Germany and the Netherlands. While clear incentives can be deducted from the different sources of municipal income, complex balancing measurements and consequential infrastructure investments make it difficult to predict a project's profitability. According to the perspective of planning practitioners in municipalities around the growth centres of Utrecht and Berlin interviewed for this study, local pressures force them to keep allocating new building sites. In order to create effective policies to limit land take, it is important to understand not only the influence of fiscal incentives but also of place-specific pressures on municipal land policies.

Keywords. Land take, fiscal incentives, local governments, Germany, the Netherlands, local growth ambitions

Introduction

Land is a scarce resource. Its preservation is important for biodiversity, landscape preservation, food security, water management and carbon sequestration (European Commission, 2012). Therefore, governments in Europe and worldwide highly prioritize limiting land take, defined as "the change in the area of agricultural, forest and other semi-natural land taken for urban and other artificial land development" (European Environment Agency EEA, 2019). In its Roadmap to a Resource Efficient Europe, the European Commission (2011) sets the goal of fully preventing net land loss by 2050 in order to stop the contamination and irreversible erosion of fertile soils. Many national governments have adopted this goal. Simultaneously, governments on the local level often adopt a growth-oriented behaviour, which here is understood as an ambition to increase the amount of residential and industrial areas within a municipality (Wegener, 2016; Langer and Korzhenevych, 2018; Hartoft-Nielsen, 2018; Monstadt and Meilinger, 2020; Shao et al., 2020). This is problematic as local governments in many countries have the responsibility to translate national goals into legally binding land use plans.

While scholars and practitioners alike search for ways to overcome this "municipal egoism" (Christoffersen, 2019, p. 16), for example through better communication and participation processes

(van Zoest, 2010; Colombo et al., 2018; Fertner et al., 2016), through a transfer of power to higher levels of government (Wegener, 2016), or through equalization of development profits (see Henger and Bizer (2010) for Tradable Development Rights), the question remains relevant: why does it seem to be so important for a municipality to grow? Scholars generally assume that municipalities allocate new building sites to attract inhabitants and firms (Duranton and Puga, 2013) because inhabitants and firms come with tax revenues. As municipalities are interested in increasing their tax incomes, they compete with each other for growth (Monstadt and Meilinger, 2020; Colsaet et al., 2018; Henger and Bizer, 2010; Langer and Korzhenevych, 2018). This puts the fiscal system at the root of the problem. The fiscal system determines how municipalities generate revenues and makes some forms of land use more profitable than others. One can therefore assume that different fiscal systems incentivise different land use policies. Kaufmann (2018a) therefore recognizes local tax autonomy as a "game changer for locational policies agendas" (Kaufmann, 2018a, p. 22). He further underlines that this effect gains force with a more decentralized fiscal system, meaning a system where municipalities are more dependent on their own tax revenues. Higher tier governments have to take incentives from the fiscal system into consideration in order to effectively prevent land take (OECD, 2017). Despite its relevance, studies on the relation between land policies

and fiscal systems are rare. This contribution aims at revealing how different fiscal systems affect land policy goals of local governments. Which forms of land use are incentivised by different fiscal systems? Apart from generating revenues, what other reasons do municipalities have to grow? And what is the role of fiscal incentives compared to other influences on municipal land policies? Following a neoinstitutional approach, we not only use formal institutional rules to explain differences in land policies but also consider the effect of local arrangements and other place-specific circumstances (Debrunner and Hartmann, 2020; Kaufmann and Arnold, 2017). Therefore, a qualitative approach was chosen to gain in-depth insights into the motivations behind the land policies of selected municipalities.

Formal and informal institutional rules in policymaking

In this paper we are interested in what influences municipal land policies. Land policies are all political and legal measures that a municipality applies to regulate land use according to a politically defined goal (Hartmann and Spit, 2015). Following neoinstitutionalist theory, land policies, just as any other human actions, are guided by formal and informal rules (North, 1990). These rules constrain actor groups' scope of action and guide what individuals expect others to do (Scharpf, 1997; Hall and Taylor, 1996). Within public policy analysis, formal institutional rules are found in the democratic, constitutional framework (Knoepfel et al., 2007). They influence public policies as they determine which actors are involved in decision-making processes and what resources these actors can mobilize to enforce their interests. On the other hand, public policies are also shaped by the actors' own political and strategic interest (Gerber et al., 2018, p. xii). For example, Debrunner and Hartmann (2020) show how the application of policy instruments varies between Swiss municipalities, depending on local actors' arrangements.

In order to analyse influences on municipal land policies, we will therefore characterize and compare this interplay of institutional rules and local arrangements in two case study areas. We will do so using a framework from Multilevel Governance (MLG) analysis, which addresses that various levels of government develop policies simultaneously (Hooghe and Marks, 2003). Applied to urban politics, this implies that municipal policies are a result of interactions between actors at different scales (Kaufmann and Sidney, 2020). One can distinguish two main dimensions that describe the framework in which public policies emerge: a vertical and a horizontal dimension (Horak and Young, 2012). While municipalities are nested in a structured hierarchy of higher tier constraints and opportunities, the horizontal dimension accounts for their nesting in a wider metropolitan context and includes interactions with nongovernmental actors (Kübler and Pagano, 2012). Kaufmann (2018a) applies this framework to explain policy goals of secondary capital cities. On the vertical axis, he places features such as the degree of fiscal and political autonomy. On the horizontal axis, he places local actors' arrangements.

A high degree of fiscal autonomy is achieved in a decentralised fiscal system where local governments collect and keep local taxes. On the other hand, in a centralised fiscal system, tax revenues are collected and redistributed by the central government. Local governments, then, depend on national grants and are less autonomous. Generally speaking, fiscally autonomous local governments are expected to be more competitive and growth-oriented than local governments that depend on state grants (Kaufmann and Sager, 2018). Municipalities in centralised fiscal systems, on the other hand, have stronger incentives to pursue urban containment policies (OECD, 2017, p. 92). According to Kaufmann (2018b), the "degree of local tax autonomy is the best predictor of locational policies as it sets up the structures under which cities can raise funds" (p. 12). When analysing municipal land policies within different fiscal systems, one can also take into account local governments' political autonomy, which is determined by constraints from higher-level governments (Goldsmith, 1995). While a high degree of fiscal autonomy incentivizes competitive behaviour among municipalities in France, local spatial plans have to conform with development plans on a regional level (OECD, 2017).

On the horizontal axis, local business actors such as landowners, investors and developers can orient land policies towards more growth (Kaufmann, 2018a). By contrast, citizens can block further developments as they experience negative consequences of growth (Monstadt and Meilinger, 2020). Thus, strong influences at the local dimension can enable local governments to resist incentives from the vertical axis (e.g., incentives to grow) (OECD, 2017).

In the remaining paper we will use this analytical framework to describe influences on local land policies in two case study areas. For the case study analysis, we have chosen two countries with contrasting fiscal systems in order to highlight the distinctiveness of different national practices. While municipalities in Germany have a high degree of fiscal autonomy and a monopoly on local tax revenues, municipalities in the Netherlands depend on rate support grants from the national government. Additionally, it is common for Dutch municipalities to actively develop land. On the other hand, German municipalities predominantly pursue passive land policies. The national governments of both countries see the prevention of land take as crucial for their future spatial development (Die Bundesregierung, 2018; Ministerie van Binnenlandse Zaken en Koninkrijksrelaties, 2019). In both Germany and the

Netherlands, municipalities are responsible for creating legally binding land use plans. Their urban growth is regulated by higher tier governments (states and provinces, respectively). Within these two countries, we have chosen to focus our research on the municipalities surrounding the cities of Berlin and Utrecht. Though the metropolitan region of Berlin-Brandenburg counts about 5 times as many inhabitants as the region of Utrecht, the cases are comparable in the sense that they are both important growth centres within their national context. Additionally, the relationship between strongly growing core municipalities on the one side and surrounding municipalities that are more reluctant in terms of further urban growth on the other side is similar in both regions.

In the following, we will describe the Dutch and German fiscal system, based on an analysis of secondary literature, legislation, handbooks on municipal finance, city budgets and secondary statistical data. The focus lies on sources of municipal income that can be influenced by their land policies. Beyond that, municipal expenditures were included as they can eat up the profits of certain developments. This research is complemented by 11 semi-structured interviews that were conducted in the summer of 2020 with governmental representatives of various levels of government in both case areas (see Table A1 in the appendix for an anonymized list of interviewees). These interviews were dedicated to both understanding the land policy goals that municipalities were pursuing as well as the role that fiscal incentives play in the preparation of land policies next to other influencing factors. The interviews were transcribed, coded, and triangulated with the above-mentioned document analysis.

The fiscal system of Germany and the Netherlands compared

We will illustrate the distribution of incomes and expenditures based on average budgets of German and Dutch municipalities respectively. In general, these are comparable to the budgets of the municipalities in the observed regions. In a national comparison, municipalities surrounding Utrecht and Berlin are fiscally stable, considering a relatively low indebtedness, and – regarding the German municipalities – high tax incomes (BDO, 2020; Bertelsmann Stiftung, 2019).

Germany

German municipalities retrieve the largest part of their income from local taxes (Fig. 1). The three most important taxes are the business tax (44%), the income tax (37%) and the property tax (14%). On average, state rate support grants only constitute a third of the municipal budget (Scherf, 2010). Fees cover charges for waste (water) disposal and other services. In contrast to tax revenues, municipalities can only charge the exact amount that is needed to provide the respective service, or, in other words, they are earmarked and were therefore excluded from the analysis. Other revenues consist of (1) license fees paid by network operators for the right to use municipal streets and infrastructure as well as (2) revenues from economic activity. As they cannot be influenced by municipal land policies, they will not be regarded further. Table 1 illustrates the different sources of income and expenditures.

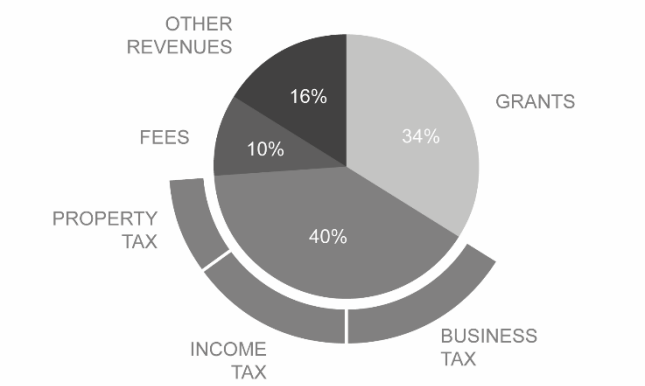


Figure 1 *Average municipal budget of a German municipality. Own figure based on Scherf (2010).*

Table 1 *Revenues and expenditures of German municipalities.*

Business tax	Based on business profits within the municipality, multiplied with a collection rate, which the municipality can determine. Although business tax revenues can play a substantial role in the municipal budget, they fluctuate with economic developments (Gesellschaft für Innovationsforschung und Beratung mbH & Deutsches Institut für Urbanistik gGmbH, 2012).
Income tax	Based on the income of the municipality's residents. Attracting wealthy residents promises high and steady future revenues from the income tax.
Property tax	Paid by owners of business and residential estate, based on the property value multiplied by a collection rate that can be determined by the municipality; consists of land value and value of the buildings.
Grants	Unconditional grants are paid by the state to fill in possible gaps between a municipality's expenses and its revenues. If the tax revenues of a municipality are increasing, it receives less financial support from the state. If a municipality earns more than it spends, it is no longer eligible for the grant. In some states, these municipalities must pay surplus revenues to the state for redistribution.
Expenditures	Among the different expenditures, social costs (e.g., unemployment benefits) are of relevance to municipal land policies. About 12% of the municipal budget is left for investments (Scherf, 2010). With these, a municipality must finance technical and social infrastructure, such as streets, schools and kindergartens as well as energy and sewage systems.

The Netherlands

About two thirds of the budget of an average Dutch municipality is derived from national grants (see Fig. 2). The national allocations can be divided into the unconditional grant and specific grants. The unconditional grant covers around 55% of the municipal budget and the specific grants cover an additional 10% of the municipal budget (CBS, 2020). While the specific grants are earmarked, the municipality can spend their unconditional grant freely (see Table 2).

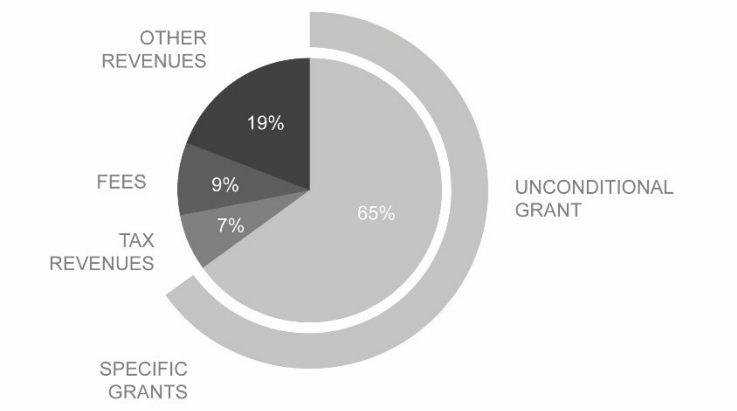


Figure 2 *Average municipal budget of a Dutch municipality. Own figure based on CBS (2020).*

Table 2 *Revenues and expenditures of German municipalities*

National grant	The extent of the unconditional grant depends on the size of the national grant pool as well as on the anticipated financial needs of the municipality. This financial need is calculated based on factors like population, built-up area, amount of young and elderly residents, but also local tax revenues, etc. Depending on their size, municipalities belong to a certain grant category. They move to a higher category as they grow.
Tax revenues	The most important municipal tax is the property tax that must be paid by the owners of business and residential real estate. It is calculated based on the value of the buildings and the value of the plot of land that the building is located on. Just as in Germany, the municipality can define its own collection rate. Generally, businesses generate more property tax revenues than residential use (Treasurer, municipality G, Utrecht).
Other revenues	Other sources of revenues are land exploitation and long-time land leases. In the Netherlands, many municipalities pursue an active land policy. This means that the municipality buys land, changes the zoning plan, prepares the land for development and sells it (Tennekes, 2018). The planning gain then stays in the municipal budget and can be spent on public services and infrastructure (Buitelaar, 2010).
Expenditures	The largest expenditures for Dutch municipalities are staff expenditures and social costs (CBS, 2020). Especially the social costs are rising with an increasing number of tasks being transferred to the municipal level from higher levels of government. Within this category, the expenses for unemployment benefits and allowances for nursing care are the highest (BDO,2020). To some degree, these social costs can be influenced by the chosen land policy of the municipality. When developing new residential areas, a municipality can avoid targeting elderly citizens, unemployed or citizens with a low income.

Incentivised forms of land use in Germany and the Netherlands

The different fiscal systems provide various incentives for municipalities in Germany and the Netherlands.

Germany. In the decentralized fiscal system of Germany, municipalities can keep revenues from local taxes. In general, this makes growth profitable. Although an increase in local revenues also leads to a lower allocation of state grants and higher regional contributions, the fiscal benefits of high revenues from local taxes are not completely outweighed. A municipality with high local revenues has more freedom of action than a municipality that is completely dependent on state grants.

If a German municipality is interested in generating more income, it can target its land use to maximize revenues from business and income taxes. Generally, tax revenues can be increased by attracting more businesses and more inhabitants to the municipality. More specifically, businesses with a high profit and inhabitants with high incomes lead to a larger tax revenue increase than small businesses and inhabitants with a low income.

In order to attract these target groups, the municipality can – amongst other things – provide the plots that these target groups demand. Given the assumption that large businesses have many employees and need much space, the municipality can primarily allocate large business areas. Given the assumption that wealthy inhabitants move to the suburbs in search of a large, detached house surrounded by nature, the municipality can primarily allocate large plots surrounded by nature for large, detached houses. In summary, increases in business and income taxes can incentivise municipalities to allocate large-scale business areas and large residential plots for spacious, detached houses, which only citizens with a high income can afford.

However, this simple equation must be scrutinised by also taking consequential costs into account. As mentioned above, increased local revenues do not stay in the municipal budget completely. To some degree, they are outweighed by lower state allocations and higher regional contributions. Also, consequential infrastructure investments must be considered: A growing population needs more kindergartens and schools; higher business activity puts more stress on transport infrastructure.

On the one hand, targeting new developments on high-income households can avoid comparatively high costs of disbursing unem- ployment and other social benefits. On the other hand, high-end, low-density residential developments lead to the issue that public infra- structure investments are used by fewer people. This can lead to decreased cost-efficiency of technical infrastructure, for example. Anticipating all consequential costs of a development can be challenging for a municipality.

Netherlands. The fiscal system of the Netherlands is centralized, meaning that most tax revenues go to the state and are distributed among the mu- nicipalities from there. Local growth is therefore expected to be rewar- ded to a lesser degree than in the decentralized fiscal system of Germany. Still, as a larger population can move a municipality to another category of the rate support grant, which allows municipalities to govern more efficiently, local governments in the Netherlands do have a fiscal incentive to grow.

That said, it is not easy to determine fiscal incentives that are more targeted towards certain developments. To move into a higher category of the rate support grant, it is sufficient to simply increase the population. The municipality can try to raise its local revenues to become less dependent on variable national grants and gain freedom of action that comes with a larger municipal budget.

To increase revenues from the local property tax, the municipality can choose to allocate areas for high-end residential developments or focus more on profitable business developments. Also, it can try to avoid expenses for social welfare by attracting wealthy inhabitants with little to no health issues and no children in the compulsory school age. But the tools to target such specific population groups are too coarse. Moreover, the national grant considers and covers social costs already. It is thus questionable whether these manoeuvres would really lead to a more profitable development.

Municipalities have different and easier ways to generate local tax revenues that are not necessarily connected to their land use policy. For example, they can collect a tourist tax, parking fees, or offer the service of collecting industrial waste (Treasurer, municipality G, Utrecht). The largest fiscal benefits, however, can be achieved by developing on municipality-owned land. Although it is a one-time income, land exploitation is fiscally very attractive for municipalities in the Netherlands, especially in cases where greenfields are transformed into urban land. Active land policy therefore constitutes an incentive for urban expansion. Still, Buitelaar and Leinfelder (2020) add that developing greenfields in the Netherlands is often costly due to the country's weak soil. They remark that active land policy "provides an incentive for consolidated sprawl" (p. 52).

Still, the use of land exploitation as an instrument has declined. Smaller municipalities in particular rarely own land that is suitable for development (Treasurer, Municipality G, Utrecht). Additionally, the financial crisis of 2007–2008 illustrated the high risks connected with active land development. Municipalities buy and develop land, but in times of economic decline, it is not certain whether private actors are willing to purchase it (van Oosten et al., 2018).

Reconsidering fiscal incentives

While it is possible to assume that both Dutch and German municipalities are rewarded for growth in general, it is difficult to prove which land use is the most profitable. One can expect that municipal officials in charge of spatial planning do not know all these details either. This became clear from the interviews we conducted. Nevertheless, it is possible that land policies are – to some degree – based on false expectations of profitability.

The policy goals of interviewed municipalities

We conducted interviews with planning practitioners on different levels of government to gain a better understanding of how fiscal incentives are perceived in practice. On the municipal level, most interviewees did not see strong relations between land policy goals and fiscal incentives. They recognized that their municipality has to generate revenues to cover its expenditures and also that sufficient revenues represent a precondition to achieving politically defined development goals. But the latter, politically defined goals were considered as much stronger in shaping land policies than fiscal incentives. While interviewed mayors and treasurers could point out developments that were especially profitable, planners were often not able to say how a certain project would affect the municipal budget. Although the German and the Dutch fiscal system are very different, interviewees in both case areas mentioned comparable land policy goals:

- *Stabilize housing prices*: Demand for housing is high in the popular suburbs of Berlin and in some municipalities near the city of Utrecht. In order to stabilize housing prices, municipalities in Brandenburg have tried to apply a rent cap. However, after evaluating the effectiveness of this instrument, they realized that housing prices cannot be controlled unless the supply follows the demand (Project manager, Brandenburg Ministry of the Interior). Around Utrecht too, growth is seen as a necessity to keep housing prices at an affordable level (Planner, municipality E, Utrecht).
- *Ensure a balanced population*: Another reason to grow is the political goal to create space for a more diverse population in the suburban areas near Berlin that are mostly characterized by single-family homes. Often, the grown-up children of the families that moved to these areas decades ago cannot afford a house at the beginning of their career and are forced to move away (Mayor, municipality C, Brandenburg). Additionally, municipalities with a high concentration of low-paying jobs (e.g., freight centre Grossbeeren and airport area Schönefeld) are interested in providing their workers with affordable housing opportunities (Mayor, municipality C, Brandenburg). The political focus on this issue also reflects the representation of certain political parties in the city council (Planner, municipality B, Brandenburg). In the province of Utrecht, rural municipalities with few job opportunities are expecting their population to age drastically in the coming years. They see growth as an opportunity to attract and keep young families in the municipality, which is a necessity for stabilizing the population and ensuring that schools, retail, sports clubs, etc. can function (Planner, municipality F, Utrecht).
- *Avoid high consequential costs and congestion*: The municipalities around Berlin have experienced a rapid, and mostly unregulated, growth in the past decades. Many municipalities have missed the opportunity to reserve areas and money for schools and kindergartens and have not sufficiently adapted their transport infrastructure (Planner, Joint planning Department Berlin-Brandenburg). After decades of shrinkage, they anticipated neither the sudden growth nor its high consequential costs (Mayor, municipality C, Brandenburg). Nowadays, many municipalities near Berlin report crowded schools and congested roads (Planner, Joint planning Department Berlin-Brandenburg). They are therefore hesitant to allow more growth as the increase in tax revenue does not cover the consequential costs of having to adapt the infrastructure (Planner, municipality D, Brandenburg). This is reflected in the political debate. Inhabitants and local politicians grow increasingly dissatisfied with insufficient infrastructure developments. They oppose further growth, as it would worsen, for example, the congestion of local streets.
- *Preserve natural assets*: Residents near Berlin actively block further developments to preserve the nature that enticed them back when they once moved there (Mayor, municipality A, Brandenburg). Also interviewed municipalities in the Province of Utrecht experience further urbanization as a danger to one of the province's greatest assets: open, natural landscapes (Planner, municipality E, Utrecht).

In the eyes of the interviewees, money plays a subordinate role in their municipality's land policy goals. Still, they were often able to name other municipalities whose interest in increasing revenues they

perceived as a more crucial factor for land policy. In fact, the degree to which profitability determines the land policy of a municipality seems to differ from municipality to municipality, even within the same fiscal system.

How can these differences be explained? Why do fiscal incentives and the desire to generate local revenues influence the land policies of municipalities within the same fiscal system differently? How can it be that the same municipalities that pursued expansive spatial policies in the 1990s are no longer interested in growth? Which factors influence the weighting of different interests in municipal land policies?

Discussion

We have now analysed influences on municipal land policies both in a vertical and a horizontal dimension. At first, a comparison of revenues of Dutch and German municipalities suggested strong incentives for their land policies, as was already anticipated by Kaufmann (2018a). But when also taking into account the (indirect) costs that follow urban development, as well as the effect of increasing revenues on the extent of supralocal grants, it becomes more difficult to point out which policies are more profitable to a municipality than others. Still, it is possible that profit-seeking municipalities are seduced by a quick boost in revenues without always taking into account the costs that will follow upon urban expansion in the long term. History has shown this lack of foresight. When allocating large new residential and business areas in the 1990s, municipalities around Berlin did not anticipate the high costs for infrastructure investments that would be needed once the buildings were occupied.

The challenge of anticipating consequential costs still exists today. Of course, both Dutch and German municipalities make budget plans. But while the profitability of a single construction site can be calculated more or less precisely, it can be difficult to predict the fiscal viability of a newly allocated building zone. As the example of the municipalities around Berlin has showed, this effect compounds if a long time passes between a building zone's allocation and its residential use. It is ques- tionable whether a municipality can even predict the exact usage and therefore future costs of a residential zone. Several German states offer calculation tools to give planners an overview of infrastructure investments that a new building zone will cause. But the costs of a new school or kindergarten are often not taken into account when deciding upon the profitability of a development project.

Also, when assessing the influence of fiscal incentives on municipal land policies, one would expect municipalities with a weak fiscal position to act more in accordance with fiscal incentives than municipalities with a strong fiscal position. Although more research is required, the interviews did not indicate any such relationship. Interviewed planners and municipal representatives doubted that the fiscal position of a municipality determines its inclination to follow fiscal incentives. They often referred to the municipality of Schönefeld – one of the richest municipalities in Brandenburg – that is widely known for its expansive development.

In the perspective of interviewed planners, local pressures weighed much heavier than fiscal incentives on the vertical dimension. On the one hand, this local dimension covers local business actors, such as developers, who negotiate land use plans with municipal governments. In these negotiations,

municipalities can have a strong position if the demand for housing is high, which makes investments in housing projects profitable and safe. Larger municipalities that own public housing societies can even avoid negotiations with private developers. In smaller municipalities, on the other hand, planners admit that profitability plays a larger role in planning (Planner, municipality D, Brandenburg). Next to local business actors, citizens were also said to have a strong influence on land policy formulation. Municipalities around Berlin have experienced rapid growth in the past decades. As a consequence, transport infrastructure is lagging behind, schools are too small and residents have problems finding kindergarten spots. Further growth would worsen the situation and additionally decrease the natural values of the areas. The relatively wealthy inhabitants therefore actively engage in local politics and block further developments (Mayor, municipality A, Brandenburg). Also, Monstadt and Meilinger (2020) observe that municipalities with high income tax revenues oppose further urban development. Citizens are not only critical towards urban expansion but also dense inner-city developments, although these would comply with national goals to prevent further land take. In some municipalities, dense forms of living have a negative connotation. It is argued that multi-story dwellings will attract low-income, or even unemployed, residents who will disturb the social coherence in the municipality. This form of framing can hinder the emergence of space-saving spatial policies.

As described in Kübler and Pagano (2012), also the nesting of a municipality within the metropolitan region has an impact on land policy formulation. This could be observed in Utrecht, where municipalities followed the lead of a single municipality that was fast at attracting young residents after detecting an ageing population trend (Planner, municipality F, Utrecht).

As concluded by Kaufmann (2018a), local arrangements have a strong influence on municipal land policies. Although they function within different fiscal systems, municipalities around Berlin and Utrecht face comparable local pressures that ultimately shape their land policies. Understanding incentives on both the vertical dimension and the horizontal dimension allows for a more holistic understanding of the way that municipalities develop spatial policies and thus a better answer to the question of why municipalities pursue growth-oriented land policies.

Conclusion

The aim of this research was to obtain a more differentiated understanding of the effect of fiscal incentives on local land policies and thereby to contribute to knowledge on causes of land take. The main research question of this study was, “How do different fiscal systems affect the land policy goals of local governments?”.

To answer the research question, we performed qualitative analyses in two metropolitan areas in Germany and the Netherlands: two countries with contrasting fiscal systems. Secondary research resulted in an understanding of the functioning of the two distinct fiscal systems, as well as the forms of land use that are especially profitable for a municipality. Semi-structured interviews with municipal representatives complemented this understanding of fiscal incentives together with the role they play in the development of municipal land policies.

At first sight, Germany and the Netherlands seem to be representative examples of respectively a decentralised and a centralised fiscal system. German municipalities collect local business and income taxes, which incentivize the development of business- and high-end residential areas. Dutch municipalities depend on national grants, seemingly rewarding growth-oriented behaviour to a lesser degree. But, having thoroughly analysed municipal revenues and expenditures, the differences between the two systems become more blurred. Growing Dutch municipalities benefit from larger allocations from the rate support grant, a higher degree of efficiency gained from infrastructure investments and can additionally profit from land exploitation. In Germany, on the other hand, profits from urban expansion have to be compared to increasing contribution costs to neighbouring municipalities, reductions of the state rate support grant and consequential investments in infrastructure. In planning literature, this aspect of balancing mechanisms in fiscal systems and (long-term) reactions of municipal budgets to growth are rarely taken into consideration when analysing effects of fiscal incentives on land policies. The latter is not only a blind spot in planning literature, but also in planning practice. When developers plan a building project, they calculate the balance between building costs and profits from selling the completed units in finest detail. But when municipalities allocate new residential zones, many may not consider investments in, for example, social infrastructure that will be necessary in the future. This is especially so because a long time can pass between the allocation and the actual development of a residential area.

In the eyes of interviewed planners, fiscal incentives have little effect on their municipality's respective land policies. And although some municipalities strategically grow to increase their tax base, most interviewees underlined that other, local pressures shaped their land policy goals to a much larger degree. On the one hand, pressure on the housing market or an ageing population ask for further construction. On the other hand, local residents block new developments to preserve natural assets, social cohesion and prevent congestion.

This suggests that, in order to limit land take, one should not solely focus on fiscal incentives. Market-based solutions, such as fiscal counterincentives or instruments such as tradable development rights can support urban developments that are more desirable from a regional perspective, like brownfield redevelopments and dense residential areas. But they will not put an end to urban sprawl. To prevent land take, instruments must also address issues of demographic change, growing housing prices or the decreasing support of infrastructure services in shrinking areas.

In our paper, we were asking what influence fiscal incentives have on municipal land policies. We expected that the contrasting fiscal systems would be clearly recognizable in the land policy goals of interviewed municipalities. In fact, interviewed planners had little insight into the fiscal consequences of their municipalities' respective development plans. Mayors and municipal treasurers could say more about the connection between their development strategies and the municipal budget. In future research, it will be fruitful to have more interviews with the latter group, as this will shed more light on which land policies municipalities can pursue to expand their budget or deal with long-term debt or profit. In combination with quantitative research, this might give a generalizable picture of correlations between fiscal incentives and urban development. In addition, this study points at the need to explore

the relation between municipal land policy and fiscal incentives on a broader level – i.e., a national or state planning level. This can give a more general perspective on the role that fiscal issues (should) play in planning education and practice.

Supplementary data

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.landusepol.2021.105681.

CRediT authorship contribution statement

Vera Götze: Conceptualization, Methodology, Formal analysis, Investigation, Writing – original draft, Visualization. Thomas Hartmann: Writing – review & editing, Supervision.

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.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.landusepol.2021.105681.

References

BDO. (2020). *BDO-Benchmark Nederlandse Gemeenten 2020: Financiële veenbrand: Tekorten lopen op, meer gemeenten in 't rood.* Retrieved November 24, 2020, from https://herbertraat.files.wordpress.com/2020/04/bdo-benchmark-nederlandse-gemeenten-2020.pdf

Bertelsmann Stiftung. (2019). *Kommunaler Finanzreport 2019.* Gütersloh: Bertelsmann Stiftung. Retrieved May 6, 2021, from https://www.bertelsmann-stiftung.de/fileadmin/files/Projekte/Kommunale_Finanzen/Finanzreport-2019-gesamt.pdf

Buitelaar, E. (2010). Window on the Netherlands: Cracks in the Myth: Challenges to Land Policy in the Netherlands. *Tijdschrift voor economische en sociale geografie, 101*, 349-356. doi:10.1111/j.1467-9663.2010.00604.x

Buitelaar, E., & Leinfelder, H. (2020). Public design of urban sprawl: Governments and the extension of the urban fabric in Flanders and the Netherlands. *Urban Planning, 5*(1), 46-57. doi:10.17645/up.v5i1.2669

CBS (2020). StatLine, the electronic databank of Statistics Netherlands. Retrieved June 27, 2021, from http://statline.cbs.nl/Statweb

Christoffersen, H. (2019). The municipality first. *Byplan nyt*, 16.

Colombo, F., van Schaick, J., & Witsen, P. P. (2018). *Kracht van Regionaal Ontwerp: 25 jaar vormgeven aan Zuid-Holland.* De Nieuwe Haagsche.

Colsaet, A., Laurans, Y., & Levrel, H. (2018). What drives land take and urban land expansion? A systematic review. *Land Use Policy, 79*, 339-349. doi:10.1016/j.landusepol.2018.08.017

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*. doi:10.1016/j.landusepol.2020.104993

Die Bundesregierung. (2018). *Deutsche Nachhaltigkeitsstrategie: Aktualisierung 2018.* Berlin: Presse- und Informationsamt der Bundesregierung. Retrieved 24, 2020, from https://www.bundesregierung.de/resource/blob/975292/1559082/a9795692a667605f652981aa9b6cab51/deutsche-nachhaltigkeitsstrategie-aktualisierung-2018-download-bpa-data.pdf

Duranton, G., & Puga, D. (2013). *The growth of cities.* Organisation for Economic Co-operation and Development. Retrieved from https://www.oecd.org/economy/growth/Growth_of_cities_Duranton.pdf

European Commission. (2011). *Roadmap to a Resource Efficient Europe* . Brussels.

European Commission. (2012). *Guidelines on Best Practice to Limit, Mitigate or Compensate Soil Sealing.* Brussels: European Commission. Retrieved November 24, 2020, from https://ec.europa.eu/environment/soil/pdf/guidelines/pub/soil_en.pdf

European Environment Agency (EEA). (n.d.). *Land take in Europe. Indicator Assessment*. Retrieved May 7, 2021, from https://www.eea.europa.eu/data-and-maps/indicators/land-take-3/assessment

Fertner, C., Jørgensen, G., Nielsen, T. S., & Nilsson, K. (2016). Urban Sprawl and growth management -- drivers, impacts and responses in selected European and US cities. *Future Cities and Environment, 2*(9). doi:https://doi.org/10.1186/s40984-016-0022-2

Gerber, J.-D., Hartmann, T., & Hengstermann, A. (2018). *Instruments of Land Policy: Dealing with Scarcity of Land.* Routledge.

Gerber, J.-D., Hartmann, T., & Hengstermann, A. (2018). Preface. In J.-D. Gerber, T. Hartmann, & A. Hengstermann (Eds.), *Instruments of Land Policy: Dealing with Scarcity of Land* (pp. xi-xii). Routledge.

Gerber, J.-D., Hengstermann, A., & Viallon, F.-X. (2018). Land Policy: How to deal with scarcity of land. In J.-D. Gerber, T. Hartmann, & A. Hengstermann (Eds.), *Instruments of Land Policy: Dealing with Scarcity of Land* (pp. 8-27). Routledge.

Gesellschaft für Innovationsforschung und Beratung mbH & Deutsches Institut für Urbanistik gGmbH. (2012). *Regionalwirtschaftliches Gutachten zu den Auswirkungen des Flughafens Berlin Brandenburg auf die Entwicklung der Kommunen im Flughafenumfeld (RG FU BER).* Deutsches Institut fuer Urbanistik. Retrieved from https://difu.de/publikationen/2012/regionalwirtschaftliches-gutachten-zu-den-auswirkungen-des-flughafens-berlin-brandenburg-auf-die

Goldsmith, M. (1995). Autonomy and City Limits. In D. Judge, G. Stoker, & H. Wolman (Eds.), *Theories of Urban Politics* (pp. 228-252). SAGE.

Hall, P. A., & Taylor, R. C. (1996). Political sciences and the three new institutionalisms. *Political studies, 44*(5), 936-957.

Hartmann, T., & Spit, T. (2015). Dilemmas of involvement in land management – Comparing an active (Dutch) and a passive (German) approach. *Land Use Policy*, *42*, 729-737. doi:10.1016/j.landusepol.2014.10.004

Hartoft-Nielsen, P. (2018). *Kampen om stationsnærhedspolitikken: Bedre målopfyldelse med forenkling af Fingerplanens regler.* Aalborg Universitetsforlag.

Henger, R., & Bizer, K. (2010). Tradable planning permits for land-use control in Germany. *Land Use Policy*, *27*(3), 843-852. doi:10.1016/j.landusepol.2009.11.003

Hooghe, L., & Marks, G. (2003). Unraveling the Central State, but how? Types of multilevel governance. *American Political Science Review, 97*(2), 233-243.

Horak, M., & Young, R. (2012). *Sites of governance: multilevel governance and policy making in Canada's big cities.* McGill-Queen's University Press.

Kaufmann , D., & Sager, F. (2018). How to organize secondary capital city regions: Institutional drivers of locational policy coordination. *Governance, 32*(1), 63-8*1*. doi:10.1111/gove.12346

Kaufmann, D. (2018). Capital cities in interurban competition: Local autonomy, urban governance and locational policy making. *Urban Affairs Review*, 1-38. doi:https://doi.org/10.1177/1078087418809939

Kaufmann, D. (2018). *Varieties of capital cities: The competitiveness challenge for secondary capitals.* Edward Elgar Publishing.

Kaufmann, D., & Arnold, T. (2017). Strategies of cities in globalised interurban competition: The locational policies framework. *Urban Studies, 55*(12), 2703-2720. doi:10.1177/0042098017707922

Kaufmann, D., & Sidney, M. (2020). Toward an urban policy analysis: Incorporating participation, multilevel governance, and "seeing like a city". *Political Science & Politics, 53*(1), 1-5.

Knoepfel, P., Larrue, C., Varone, F., & Hill, M. (2007). *Public Policy Analysis.* The Policy Press.

Kübler, D., & Pagano, M. A. (2012). Urban politics as multilevel analysis. In K. Mossberger, S. E. Clarke, & P. John (Eds.), *The Oxford Handbook of Urban Politics* (pp. 114-129). Oxford University Press.

Langer, S., & Korzhenevych, A. (2018). The effect of industrial and commercial land consumption on municipal tax revenue: Evidence from Bavaria. *Land Use Policy, 77*, 279-287. doi:10.1016/j.landusepol.2018.05.052

Ministerie van Binnenlandse Zaken en Koninkrijksrelaties. (2019). *Ontwerp Nationale Omgevingsvisie: Duurzaam perspectief voor onze leefomgeving.* Den Haag: Ministerie van Binnenlandse Zaken en Koninkrijksrelaties. Retrieved November 24, 2020, from https://www.rijksoverheid.nl/binaries/rijksoverheid/documenten/rapporten/2019/06/06/ontwerp-nationale-omgevingsvisie/ontwerp-nationale-omgevingsvisie.pdf

Monstadt, J., & Meilinger, V. (2020). Governing Suburbia through regionalized land-use planning? Experiences from the Greater Frankfurt region. *Land Use Policy, 91*, 1-12. doi:10.1016/j.landusepol.2019.104300

North, D. (1990). *Institutions, institutional change and economic performance.* Cambridge University Press.

OECD. (2017). *The Governance of Land Use in OECD Countries: Policy analysis and recommendations.* Paris: OECD Publishing. Retrieved November 24, 2020, from https://read.oecd-ilibrary.org/urban-rural-and-regional-development/the-governance-of-land-use-in-oecd-countries_9789264268609-en

Scharpf, F. W. (1997). *Games real actors play: actor-centered institutionalism in policy research.* Westview Press.

Scherf, W. (2010). Die kommunalen Finanzen in Deutschland. In A. Kost, & H.-G. Wehling, *Kommunalpolitik in den deutschen Ländern.* Springer.

Shao, Z., Bakker, M., Spit, T., Janssen-Jansen, L., & Qun, W. (2020). Containing urban expansion in China: the case of Nanjing. *Journal of Environmental Planning and Management, 63*(2), 189-209. doi:10.1080/09640568.2019.1576511

Tennekes, J. (2018). Negotiated land use plans in the Netherlands: A central instrument in Dutch ‘active’ and ‘passive’ land policy. In J.-D. Gerber, T. Hartmann, & A. Hengstermann (Eds.), *Instruments of Land Policy: Dealing with Scarcity of Land* (pp. 101-113). Routledge.

van Oosten, T., Witte, P., & Hartmann, T. (2018). Active land policy in small municipalities in the Netherlands: "We don't do it, unless…". *Land Use Policy, 77*, 829-836. doi:10.1016/j.landusepol.2017.10.029

van Zoest, J. (2010). Metropolitan landscapes as a test case for regional planning. In N. Meijsmans (Ed.), *Designing for a Region* (pp. 105-114). Sun Academia.

Wegener, M. (2016). Government or governance? The challenge of planning for sustainability in the Ruhr. In T. Hartmann, & B. Needham (Eds.), *Planning By Law and Property Rights Reconsidered* (pp. 157-170). Routledge.

A2: Planning-related land value changes for explaining instruments of compensation and value capture in Switzerland[7]

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Authors: Andreas Hengstermann and Vera Götze

Abstract

As a public policy, planning seeks to achieve politically defined policy objectives such as sustainable spatial development. To effectively attain these objectives, it is essential to consider the impact of planning decisions on land values. A comprehensive understanding of the connection between planning and land values is imperative for making well-informed choices regarding the management of land use and spatial development sustainably and responsibly. While instruments of planning law are intensively debated within the planning community, their implicit effects on land values are rarely considered. This study contributes to the field by demonstrating the crucial connection between planning-induced land value changes and value capture instruments in Switzerland. Our analysis shows significant value changes in the planning process. It connects these to redistributive instruments of the Swiss planning regime, which come into play to compensate for disproportionate planning-induced advantages or disadvantages of landowners. Due to the exceptionally significant change in value while zoning, which is present in Switzerland, there are remarkable redistributive instruments – both in terms of value increase (added value capture) and value decrease (compensation). Our study shows that knowledge of planning-related land value changes can help understand redistributive mechanisms, thereby contributing to best-practice debates.

Introduction

Land is a commodity that can be traded between private parties at market conditions (Gerber and Gerber, 2017). Accordingly, land is attributed to a price. This value is derived from a combination of factors, ranging from local conditions (e.g., soil quality) to macroeconomic developments (e.g., financial policy, economic development) (Hong and Brubaker, 2006). One essential factor that determines land values is planning (Buitelaar and Sorel, 2010). Concretely, every planning phase, from agricultural land to a plot ready for construction, increases the land value. National planning regimes – through defining planning phases – thus affect when land values rise, how much, and who profits from these value increases. Understanding the interdependence between planning interventions and land values is a precondition for reaching ecological and social policy goals (Dransfeld and Voß, 1993). The planning law contains two levers that regulate value development: the defined planning phases and the redistribution of planning-related value gains.

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1. As a piece of agricultural land runs through the various planning phases, from zoning, via land readjustment and servicing to issuing a building permit, each phase marks a significant land value change.
2. The planning law regulates who reaps these profits by introducing public value-capture instruments. Given that these instruments are adjusted to planning-induced value developments, they contribute to sustainable spatial development.

Cross-country comparisons can show how various planning regimes align these two levers. However, few studies combine an analysis of planning phases with an analysis of instruments of public value capture. Earlier research has compared forms of and shown essential preconditions for successfully implementing public value capture (Alterman, 2011). Still, such studies neglect the role of planning-induced value increases in explaining what instruments of value capture a government employs. The impact of planning on land values is extensively studied from an urban economic perspective. Individual factors and their influence are examined (Büchler and Ehrlich, 2023), and various models are applied to land markets (Rodas et al., 2018). The effects of specific regulations on certain subsectors of planning have also been studied, such as housing prices (Huang and Tang, 2012; Ihlanfeldt, 2007; Jalali et al., 2022; Lin and Wachter, 2019). Ahlfeldt and Pietrostefani (2019) synthesise the economic effects of density, including the impact of planning regulations on land values. While the paper does not focus solely on Europe, it offers valuable insights into the relationship between planning and land values in European urban contexts.

The impacts have rarely been explicitly examined from a planning law perspective. A notable exception is Jaeger (2006), who applies economic models to Oregon planning law. However, these studies do not include a political science interpretation of planning law regarding the different planning phases and redistributive instruments. Against the backdrop of this gap, we aim to shed light on the interdependence between planning phases as defined in planning law, the resulting land value development, and the instruments applied to deal with such value changes.

To this end, we apply a model of Bonczek and Halstenberg (1963), initially describing planning phases and their effects on land values in Germany, to the context of Switzerland. Switzerland is one of the few countries worldwide that apply a direct form of public value capture (Munoz Gielen and van der Krabben, 2019; OECD, 2022; Scheiwiller and Hengstermann, 2022). Notably, we ask: (1) What value increases are caused by the planning phases defined in the Swiss planning law, and (2) how are these value increases treated in the planning law?

Applying the model to Switzerland, we find that direct value capture is employed in a planning phase whose resulting value increase is much higher than was foreseen in the German model. This suggests that, amongst the factors observed in earlier studies, planning-induced value increases help explain what forms of value capture are chosen.

Planning-induced land value changes

Planning is one of several factors affecting land values (Büchler and Ehrlich, 2023). These factors were earlier divided into four categories: intrinsic factors (e.g., soil quality), external factors, public investment,

and user investment by Hong and Brubaker (2006). They pointed out that the central political question is whether respective changes in value were caused by the actions or investments of the landowner or are due to developments independent of the landowner. However, Hong and Brubaker do not distinguish between public investments directly linked to the land (e.g., servicing) and public investments near the affected land (e.g., school infrastructure). Moreover, they see regulation merely as a general external factor. Here, however, a more precise distinction is necessary between general abstract regulations (e.g., national public policy) and the concrete regulations related to a specific property, whereby the latter can then be differentiated again concerning various planning phases.

Planning phases and their impact on land values were extensively described by Bonczek and Halstenberg (1963). For the first time, they examined the effects of planning phases on land values (see Fig. 1). With their model (’staircase model’), they illustrated on the one hand that the public sector already captured specific value increases during land readjustment (through the reallocation advantage and the transfer of land). On the other hand, they showed that a large part of the value increases remained untouched. They, therefore, explicitly understand their model in the context of a debate on a fair and feasible regulation for the general capture of planning-related added value, as was the case in England at the time. The law was intended to ensure that landowners are neither disadvantaged nor advantaged by public planning measures.

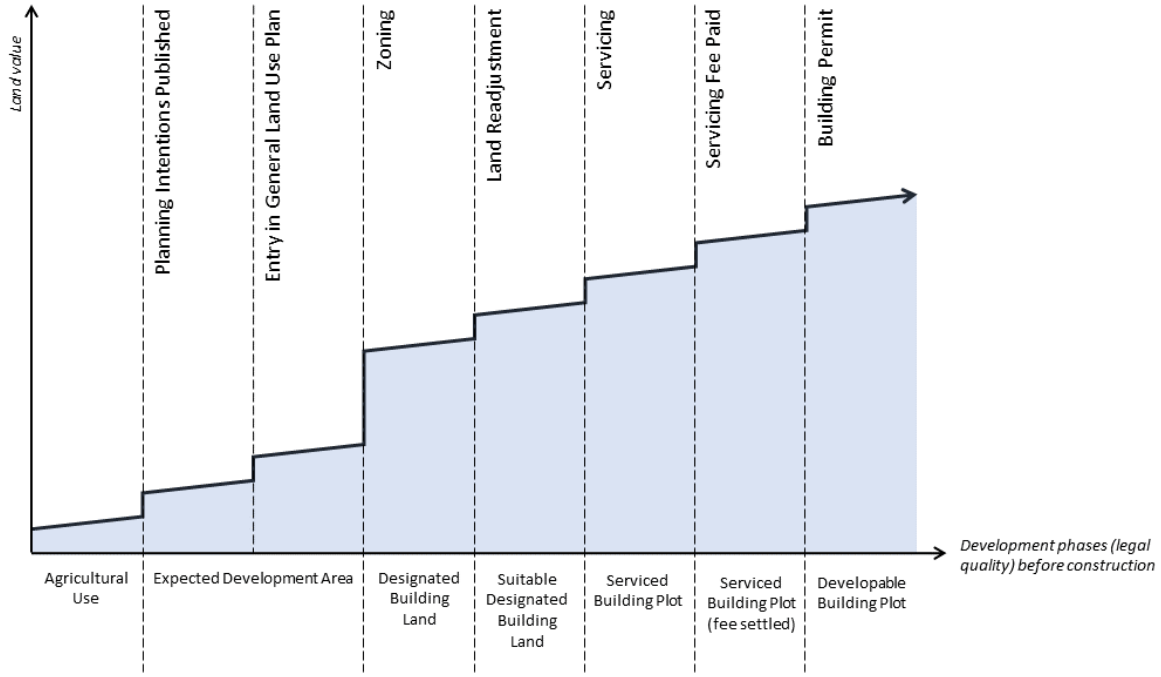

Fig. 1. *Model of planning phases after Bonczek and Halstenberg (1963)*

Several authors have revisited this model in recent years and applied it to analyse land value development in several countries and contexts. Davy (2018) applies the model in a 4-step version to German legislation to explain the difference between planning and land policy. Christensen (2014) uses the model with a specific focus on municipal planning in Denmark. Kalbro and Mattsson (2018) use the model both to analyse the institutional regime at the national level in Sweden and as an analytical

framework for selected case studies. Finally, the model has been used as a framework for comparative research, such as the five-country comparison by Dransfeld and Voß (1993) and the most recent comparison by Halleux et al. (2022), covering 29 European countries.

Dransfeld and Voß (1993) compared five European countries and their land markets. They examined the extent to which the various state regulations influence the respective land market systems so that spatial development takes place in the desired locations – regarding ecological and social goals of spatial planning. They, therefore, considered the planning influence on land values as an implementation mechanism for indirectly achieving public objectives by influencing the behaviour of landowners.

Halleux et al. (2022) used the model to specifically analyse the regulations dealing with value capture and compare them between 21 European countries. The work follows a series of studies that represent a renaissance of scholarly interest in public value capture, starting with Alterman (2011), who discusses preconditions for successful value capture. Her analysis of 14 countries unveils two approaches that she calls direct and indirect instruments. This division was taken up and developed further by Munoz Gielen and van der Krabben (2019), who, in their cross-country comparison, focus on the application of (non-) negotiable developer obligations.

The instrument of value-added capture is seen as a redistributive counterpart to the compensation that occurs when development rights are withdrawn (see with particular reference to the case of Belgium: Lacoere et al., 2023). Alterman (2010) has conducted a comparative study that shows compensation mechanisms in various countries. As much as they differ in detail, the study reveals that compensation mechanisms are much more common than value-added compensation mechanisms. However, the findings are not linked to planning phases. Overall, the literature review shows that planning phases, their effects on land values and redistribution of value changes have been discussed in their parts but not considered in their entirety. This study addresses these interdependencies within the Swiss planning regime, which represents an interesting case due to its very high land prices and rigorous planning system.

Planning phases in Switzerland

In the subsequent section, we will apply Bonczek's model of planning phases to the Swiss context. The planning phases in Switzerland are derived from the Swiss Spatial Planning Act (SPA). Unfortunately, we cannot utilise nationwide land value data due to its restricted accessibility. As a result, the depicted price jumps in the graph are indicative and rely on case studies, Swiss planning practitioners' journals, and newspaper articles for reference.

The Swiss planning system distinguishes buildable and non-buildable zones (art. 1 SPA). While construction is generally permitted in the buildable zone unless there is an explicit rule to the contrary (negative planning), development is generally not allowed in the non-buildable zone unless there is an explicit exception (positive planning) (Griffel, 2017). This stringent restriction limits growth but does not prohibit further development, as agricultural land can also fall within the buildable zone. In fact, between 2009 and 2018, the settlement area in Switzerland expanded by 6% (FSO, 2022).

We distinguish between seven planning phases (see Fig. 2). The phases may contain further sub-steps, which cannot always be precisely demarcated from each other and are, therefore, not shown by us as separate phases. The model is based on the classical linear land development sequence– from agricultural area to the issuing of a building permit. Possible variants arising from less linear processes in practice or deviating situations (e.g., brownfield development) are not considered.

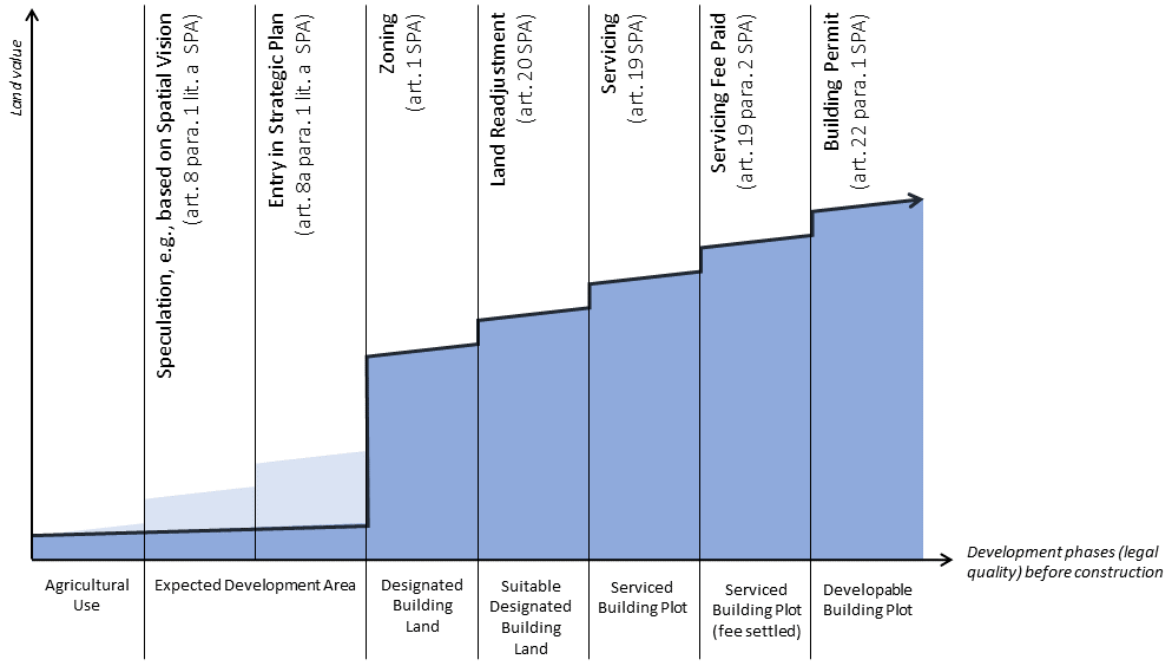

Fig. 2. Planning phases adapted to Switzerland. Value increases and phase length indicative.

Agricultural use and expected development area

The first tier comprises land in the non-buildable zone, mostly land used for agricultural production, which is why this land is also referred to as an agricultural zone (Art. 14 para. 2 SPA). In addition, this category includes land that is important for the landscape or is ecologically valuable (Art. 16 para. 1 SPA) (Ruegg and Letissier, 2015). Land value within the agricultural zone is measured based on agri-

cultural profitability, depending on factors such as soil quality, shape and location. A unique characteristic is that the agricultural land value in some Alpine regions can even be negative, as the cultivation produces more costs than direct profits. In these cases, cultivation only makes sense because of the external effects, e.g., to reduce natural hazards caused by landslides. In such cases, the public sector finances the management or ownership of such areas. In addition to the Spatial Planning Act, agricultural land is subject to further legal provisions that influence land value, particularly by eliminating speculation on future developments. The most important legal source is the Peasant's Land Act (BGBB), which contains two relevant regulations (Braun, 1983). First, this act limits speculations on land value by prohibiting land transfers with more than a +5–15% value increase – calculated in relation to the adequate price for agricultural land (Art. 66 BGBB). Second, it outlaws non-agricultural persons' purchase of agricultural land (Art. 61 para. 1 & 2 BGBB).

The regulations result in the market for agricultural land being severely restricted. On the one hand, the circle of potential purchasers is heavily limited. On the other hand, price fixing is subject to state control – and relies on agricultural land use. All in all, this means that the land value of agricultural land is entirely determined by the agricultural sector – not by potential future development. Land speculation known from other countries regarding future building developments is mainly absent. Even if cantonal structure plans designate corresponding land as future development areas (art. 8 para. 1 lit. a SPA), the Peasant's Land Act prevents speculation.

Designated building land

The next formal planning phase is initiated by zoning (art. 15 SPA). According to Swiss law, basic building right is granted at this stage, even if further steps are necessary until the site is ready for a building permit (art. 22 SPA) (Aemisegger et al., 2016; Griffel, 2017). From then on, the owner has the right to use their land for construction if no public interests are opposed (Aemisegger et al., 2016).

Transferring a specific plot of land from the non-buildable to the buildable zone is referred to as zoning and requires a change in the plot's allocation in the zoning plan (art. 15 para. 4 SPA). Since this regulation is binding for everyone and equals a law, this decision must be presented to the electorate for approval. In the Swiss planning system, zoning marks the highest increase in value. The scope of this increase is difficult to estimate because land value data is not publicly available in Switzerland. It can be assumed that including land in the buildable zone increases its value from 5 to 10 CHF/m2 (for agricultural land) to between 300 CHF/m2 in less attractive regions to more than 5000 CHF/m2 in the most attractive regions (for comparable values see Müller-Jentsch, 2013, p. 7).

Suitable designated building land

Land readjustment marks the following planning phase (art. 20 SPA). This step is intended to ensure that plots of land are arranged according to their future land use. A building permit can only be issued if each plot of land is serviced (Art. 22 para. 2 lit. b SPA). Due to the change from agricultural to residential building land, these development requirements change in plot layout. Readjusting takes these new requirements into account. In addition, the plot layouts are optimised regarding aspects of construction or aspects of marketing. Cantonal laws regulate the exact procedure for building land readjustment, which differs accordingly. Planning law includes the possibility of land reallocation being ordered ex officio (Art. 20 SPA), i.e., against the will of the landowners. This occurs very rarely in Switzerland. More often, developers buy several parcels and do the readjustment in an internal procedure (Shahab and Viallon, 2021).

Serviced building plot

The following planning phase begins with servicing a plot of land. Land is considered serviced if there is sufficient transport access for the use in question and necessary water, energy, and sewage systems have been built (Art. 19 para. 1 SPA). Swiss planning law defines servicing as technical infrastructure only (Ruegg, 2022). The municipality must provide the servicing no later than 15 years after zoning (Art. 15 para. 4 lit. B SPA).

Usually, municipalities issue a servicing programme that provides for staged servicing of all building plots within the zoning plan's 15-year planning horizon. The stages provided in this programme determine the land value within this planning phase. The closer to the expected date of full servicing by the municipality, the sooner the land's valorisation and thus the higher the land value – which is represented in our model by the price range within a phase (ascending line).

Serviced building plot (fee settled)

The following planning phase is initiated by paying the servicing charge, called 'landowner's contribution'. The charges for servicing vary depending on cantonal legislation. It is usually up to 50% of the actual costs for ordinary projects (see e.g., BSG 732.123.44, 2017). In the case of large projects, an infrastructure contract is usually concluded, containing the exact technical details and the cost allocation (Lambelet and Viallon, 2019). The land value depends on whether this service fee has been paid or is still outstanding. Paying the charge causes a further increase in land values.

Developable building plot

The building permit initiates the next and final planning phase. Having addressed zoning, land readjustment and servicing, our analysis of planning phases ends with issuing a building permit. Swiss planning law defines that a building permit must be granted if the land is serviced and the building project complies with the legal provisions of its zone (Art. 22 para. 2 SPA). No other conditions can be imposed. This means the landowner is entitled to a building permit when these conditions are satisfied. Accordingly, the increase in land values at this stage is comparatively insignificant (Perren, 2004). Usually, developers have three years to complete construction before the permit expires (see, e.g., art. 42 para. 2 Bau/BE).

Redistributive mechanisms in the Swiss planning regime

Changes in land value occur in the transition between planning phases. Bonczek's planning phase model illustrates these steps, making it possible to identify how value changes are dealt with politically and legally (see Fig. 3). One can consider both value increases (from left to right) and decreases (from right to left). Land value changes are a recurring subject of political and academic debates and planning literature. In the realm of planning literature, various viewpoints emerge, including advocating for the complete capture of land value (Bernoulli, 1946), of planning-related added values (Halleux et al., 2022) and compensation for value losses, such as in cases of regulatory takings (Alterman, 2010). Applied to the Swiss planning regime, two aspects are of particular relevance: (a) The most significant value change caused by changing the land's zoning and its redistributive instruments, and (b) the differences in value determination for expropriation between agricultural land versus zoned land.

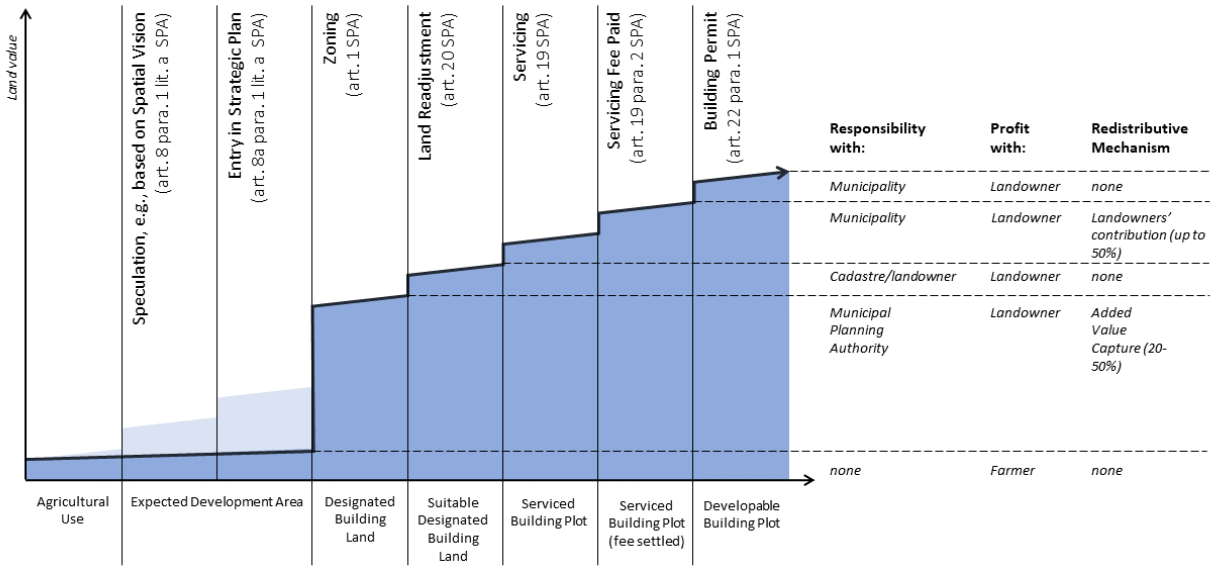

Fig. 3. Planning phases and redistributive mechanisms.

Value changes due to zoning

As can be seen from the model, granting (or removing) development rights is associated with the most significant value change. It is initiated by zoning, hence the initial assignment of the land to the buildable zone (from left to right), as well as by de-zoning, hence the downgrading to the non-buildable zone. Accordingly, this stage is the most interesting. Switzerland is one of the countries that has enacted planning law rules in both directions here. In Switzerland, this value change is particularly significant for two reasons:

1. The Peasant's Land Act restricts land speculation on agricultural land. This protection no longer applies as soon as the land is zoned. The value increase is particularly significant because the initial values are shallow.
2. Due to the regulatory planning system in Switzerland, building rights are generally already granted at the time of zoning. With the zoning, land values rise to a point close to the final values. The increase in value is significant because the values after the zoning are exceptionally high.

Since zoning causes significant value changes, it is not surprising that the Swiss planning regime has special rules for dealing with these changes. Both cases can be distinguished: Regulations on value increase in the case of zoning (from left to right) and regulations on value decrease in the case of de-zoning (from right to left).

Redistributive regulations in the case of zoning. Added value capture instrument has been incorporated into Swiss planning law since 1979 (Viallon, 2018) and was significantly enhanced in the 2012 Spatial Planning Act reform. Since then, at least 20% of the planning-related value increase will be captured (Art. 5 para. 1 SPA) (Hengstermann and Viallon, 2023). Exceptions may only be granted for minimal amounts for which the administrative effort needed is not in a reasonable proportion (Art. 5 para. 1quinquies SPA) or if public land is affected ('rob Peter to pay Paul') (Viallon, 2018). Planning law does

not provide an upper limit, but 60% has become established as the maximum capture rate in planning practice in Switzerland since it was approved by the Federal Court (Hengstermann and Scheiwiller, 2021). Thus, part of the value increase, which is induced by changes in the legal quality of the land (and not, for example, to services provided by the landowner), is returned to the general public. In contrast to other international examples of a betterment tax of this kind (Alterman, 2011; Halleux et al., 2022; Mu˜noz Gielen and van der Krabben, 2019), Swiss capturing does not serve to finance specific infrastructure projects (Scheiwiller and Hengstermann, 2022). "Such a compensation [=added value capture] corresponds to a postulate of justice and, in particular, equality under the law: the changes in land value caused by public land use planning occur without the owner's involvement in the sense of his contribution or misconduct; this effect, which cannot be attributed to the owner, is to be neutralised to a certain extent." (Riva, 2016, p. 72 Authors' translation). Hence, the instrument's political narrative in Swiss politics aims to reduce injustice, namely the unearned increment of the landowner.

Redistributive regulations in case of de-zoning. If the land is deprived of its buildability, this is accompanied by considerable losses in value. This happens in the case of de-zoning or material expropriation ('regulatory takings'). Like most international planning laws (Alterman, 2010), Swiss law provides for compensation in this case. According to Art. 26 of the Federal Constitution, property is guaranteed and cannot be restricted unless compensation is granted. Art. 5 para. 3 SPA specifies that this compensation must be total. Accordingly, the loss of value must also be determined for the case of de-zoning. The Swiss system provides court-hearing-like negotiations lead by a voluntary expert commission. However, the commission's task is not to determine a land value as objectively as possible (in the sense of finding the truth) but to negotiate a compromise between the parties' opposing interests (in the sense of out-of-court agreements). The land value thus arises because of arbitration and is based exclusively on the compromise of the two parties concerned in the individual case.

Different value determination for expropriation

Applying Bonczek's and Halstenberg's staircase to the Swiss planning regime reveals another peculiarity: the different handling of compensation for agricultural land versus zoned land in the case of expropriation. In principle, all three legal sources – the Federal Constitution (SC), the Spatial Planning Act (SPA) and the Expropriation Act (EA) – specify that expropriations must be fully compensated (art. 26 para. 2 SC, art. 5 SPA, art. 19 lit. a EA). However, since 2021, agricultural land is compensated at three times its market value (art. 19 lit. abis EA), whereas zoned land is to be compensated at its actual market value. This difference stems from a political demand by farmers' lobby organisations to adapt compensation mechanisms to more realistic market conditions. Initially, this entailed a demand for a six times greater value (Sibel et al., 2018).

This difference in compensation for agricultural land versus zoned land in cases of expropriation may appear as mere favouritism. However, a deeper understanding can be achieved with Bonczek's adapted staircase model. Due to the Peasant's Land Act regulations mentioned earlier, the value increase for expected future development land is left out. Accordingly, the values in this phase are pretty low compared to unregulated land markets, where development speculation already occurs on

agricultural land. Since expropriation compensation takes the value before a planning measure as a reference point, Swiss farmers incur low absolute values. The triple compensation is, therefore, comparatively low in absolute values, as the base value in the staircase model is low.

Discussion

Our results highlight interdependencies between planning phases, land value changes and the instruments that redistribute such planning gains and losses. We have illustrated that the planning phases in Switzerland differ from the original model. Of the resulting value increases, the first is more significant than foreseen in the model, while the remaining steps are more minor. Swiss planning instruments deal with the value changes caused by land use decisions.

Significant increase and significant response

The abrupt transition from agricultural to designated building land causes a sudden value increase, which, in Switzerland, is met by far-reaching regulations on how this profit is captured by the public sector or – in the reverse case – how the owner is compensated in the event of a transition back to non-buildable land. A possible explanation lies in the Swiss direct democratic system. Based on a pronounced understanding of justice, this system counteracts excessive preferential treatment of individuals (Hengstermann, 2021). The instrument of value capture then also enjoys the necessary legitimacy (Alterman, 2011) because the voting population has accepted it.

It is also possible that the generally high price difference between buildable and non-buildable land in Switzerland legitimises direct forms of value capture (Scheiwiller and Hengstermann, 2022). Similarly, other countries employ public value capture, especially in regions with high land prices (Kaufmann and Arnold, 2018; Vejchodska and Hendricks, 2023).

One must add that well-developed compensation schemes match the far-reaching value capture mechanisms in reaction to planning losses. In this way, redistributive mechanisms are justified by the fact that property owners should neither benefit excessively nor be disadvantaged by official state decisions. The model shows very clearly that this is particularly relevant for zoning. While in the other stages, value increases correspond to actual expenses (e.g., servicing), zoning-induced value changes are based purely on the legal quality of the land. Therefore, the political desire for equitable compensation would entail a symmetrical redistribution of unearned advantages and undeserved disadvantages. However, the system is asymmetrical. While 100% of planning losses are compensated, only 20–50% of planning gains are captured (Hengstermann and Viallon, 2023).

Swiss planning phases in international comparison

Our findings are fascinating compared to planning regimes in countries like Germany, where Bonczek's model was initially developed. As described above, the absence of a phase of expected buildable land is a notable feature of the Swiss planning regime, distinguishing it from other planning regimes such as the British, Dutch or Belgian (Lacoere and Leinfelder, 2022; Shahab et al., 2021). We see a possible explanation for this in the high esteem in which agricultural land is held in Swiss politics and society (Ruegg and Letissier, 2015). In Swiss logic, the planning system and public intervention in property

rights are legitimised by the goal of preventing urban sprawl, ultimately protecting agricultural production areas (Lendi, 2008). This attitude is rooted in the collective experience of the two world wars and is intended to ensure food supply during the war (Art. 104a SC; Art. 1 para. 2 lit. d & 16 SPA). In this sense, planning was initially subordinated to the Military Department (Lendi, 1996).

Compared to other countries with regulatory planning regimes (e.g., Germany), the significant value increase caused by zoning occurs early. Compared to Switzerland, German land value increases induced by the designation of land as development land in the municipal land use plan (Flächennutzungsplan) and the issuing of the detailed land-use plan (Bebauungsplan) cause less significant value increases (Hendricks et al., 2017). On the other hand, land readjustment has a more significant effect in Germany than in Switzerland. In Germany, land readjustment functions as the primary public value capture mechanism in the form of land shares and readjustment benefits (Hendricks, 2022). In Switzerland, by contrast, the most significant gains are already captured during zoning. Compared to countries with a discretionary planning regime (e.g., the United Kingdom), the value increase provoked by issuing the building permit is minimal (Dembski et al., 2021; Munoz Gielen and Tasan-Kok, 2010; Valtonen et al., 2017b). Despite special land use plans for projects or areas of exceptional importance, the Swiss regime leaves no room for negotiation at this point. Therefore, the land value is hardly affected. In the UK, on the other hand, the right to build is granted only in the context of building permit negotiation (Dembski and O'Brien, 2023). Therefore, the British system has a more extended phase of land speculation and a significant increase as part of issuing the building permit (Fowles et al., 2022). Similarly, the Dutch planning regime knows extensive developer negotiations preceding the building permit (Hendricks et al., 2021). These negotiations can result in obligation and thus severely impact land values. In addition, land speculation occurs intensively before zoning – driven by private developers and the public sector (van der Krabben, 2021; van Oosten et al., 2018).

Importance of land value data

In general, planners should know land values and the impact of planning on land values as they play an essential role in the logic of owners and their behaviour. In concrete terms, however, the model also shows that at various points in the planning process, it is necessary to establish land values in a just and court-proof manner. For instance, the administrative decree on the amount to be paid regarding the added value capture depends on the difference between the land value before and after the zoning. Accordingly, it is important to determine both values. Likewise, it is essential to have accurate land values in the context of compensation for de-zoning and expropriation.

However, a public land value reference system like in Germany (Voß and Bannert, 2018) does not exist in most regions of Switzerland. Only 2 of the 26 cantons have such an instrument (Basel-Stadt and Zürich). The remaining cantons rely on private-sector appraisals, which allow market comparison values through systematic purchase price collections. However, the exact data basis and calculation methods are not published and are subject to corporate secrecy. This is questionable from the point of view of the state of law. One plausible explanation could be that Switzerland does not have a transparency culture, as in Scandinavia (Valtonen et al., 2017a), but has traditionally cultivated a high degree of bank-

client confidentiality. As a neutral and stable country, the Swiss land market is one of the premium investment markets in global real estate portfolios (Falkenbach, 2009; Oikarinen and Falkenbach, 2017).

Conclusions

In this study, we have applied Bonczek's and Halstenberg's (1963) planning phase model to Switzerland. In contrast to previous studies, we transferred the model and adapted its phases to Swiss planning law. These revealed differences concerning both phases and value increases. Differences in planning phases are reflected in the scope of instruments that capture planning gains and compensate for planning losses. Since agricultural land prices are strictly regulated in Switzerland, transferring a plot into the buildable zone causes a comparatively high value increase. This planning gain is encountered by remarkably far-reaching value capture mechanisms.

Our findings shed light on the interdependence between planning phases defined in planning law, the resulting land value development and the instruments applied to deal with such value changes. The planning phase model of Bonczek and Halstenberg has proven viable to illustrate these interdependencies and shows potential for its application in further cross-country comparisons. Further studies are needed that employ land value data to support our findings empirically. In addition, future studies could usefully explore mechanisms dealing with value changes induced by up- and re-zoning (such as brownfield development and densification) – processes that are gaining relevance in the continued effort to achieve compact urban development. Our study has shown that knowledge of planning-related land value changes can help to understand redistributive mechanisms, thus providing an important contribution to best-practice debates. In general, planning practice and research must increasingly consider land values, because understanding the link between planning and land values is a prerequisite for making informed decisions about using and developing land responsibly and sustainably.

CRediT authorship contribution statement

Vera Götze: Conceptualization, Methodology, Writing – original draft, Writing – review & editing. **Andreas Hengstermann**: Conceptualization, Methodology, Writing – original draft, Writing – review & editing.

Declaration of Competing Interest

The authors have no conflicts of interest to declare.

Data availability

No data was used for the research described in the article.

References

Aemisegger, H., Moor, P., Ruch, A., Tschannen, P., 2016. Praxiskommentar RPG: Nutzungsplanung (Band 1). Schulthess, Zürich.

Ahlfeldt, G.M., Pietrostefani, E., 2019. The economic effects of density: A synthesis. J Urban Econ 111, 93-107. https://doi.org/10.1016/j.jue.2019.04.006

Alterman, R., 2011. Land-Use Regulations and Property Values: The “Windfalls Capture” Idea Revisited, in: Brooks, N.D.K.K.J.-G. (Ed.), The Oxford Handbook on Urban Economics and Planning. Oxford University Press, Oxford, pp. 755–786. https://doi.org/10.1093/oxfordhb/9780195380620.013.0034

Alterman, R., 2010. Takings international: A comparative perspective on land use regulations and compensation rights. ABA Press, Chicago. https://doi.org/10.1080/14649357.2014.902907

Bernoulli, H., 1946. Die Stadt und ihr Boden, Verlag für Architektur, Erlenbach-Zürich.

Bonczek, W., Halstenberg, F., 1963. Bau-Boden: Bauleitplanung und Bodenpolitik. Systematische Darstellung des Bundesbaugesetzes. Hammonia-Verlag, Hamburg.

Braun, A., 1983. Raumplanung und bäuerliches Bodenrecht. Mensuration, Photogrammetrie, Genie Rural 8.

BSG 732.123.44, 2017. Dekret über die Beiträge der Grundeigentümer an Erschliessungsanlagen und an weitere öffentliche Werke und Massnahmen (Grundeigentümerbeitragsdekret/GBD). Systematische Sammlung Kanton Bern (BSG).

Büchler, S., v. Ehrlich, M., 2023. Quantifying land-use regulation and its determinants. J Econ Geogr. https://doi.org/10.1093/jeg/lbad009

Buitelaar, E., Sorel, N., 2010. Between the rule of law and the quest for control: Legal certainty in the Dutch planning system. Land use policy 27, 983–989. https://doi.org/10.1016/j.landusepol.2010.01.002

Christensen, F.K., 2014. Understanding value changes in the urban development process and the impact of municipal planning. Land use policy 36. https://doi.org/10.1016/j.landusepol.2013.07.005

Davy, B., 2018. Land market/land policy, in: Handwörterbuch Der Stadt- Und Raumordnung. ARL – Akademie für Raumentwicklung in der Leibniz-Gemeinschaft, Hannover, pp. 267–278.

Dembski, S., O’Brien, P., n.d. The quest for certainty: Introducing zoning into a discretionary system in England and the European experience. Raumforschung und Raumordnung | Spatial Research and Planning. Forthcoming.

Dembski, S., Sykes, O., Couch, C., Desjardins, X., Evers, D., Osterhage, F., Siedentop, S., Zimmermann, K., 2021. Reurbanisation and suburbia in Northwest Europe: A comparative perspective on spatial trends and policy approaches. Prog Plann 150, 100462. https://doi.org/10.1016/j.progress.2019.100462

Dransfeld, E., Voß, W., 1993. Funktionsweise städtischer Bodenmärkte in Mitgliedstaaten der Europäischen Gemeinschaft: ein Systemvergleich. Bundesministerium für Raumordnung, Bauwesen und Städtebau, Bonn.

Falkenbach, H., 2009. Market Selection for International Real Estate Investments. International Journal of Strategic Property Management 13, 299–308. https://doi.org/10.3846/1648-715X.2009.13.299-308

Fowles, S., Manns, J., Vida, M., 2022. United Kingdom, in: Halleux, J.-M., Hendricks, A., Nordahl, B., Maliene, V. (Eds.), Public Value Capture of Increasing Property Values across Europe. vdf, Zürich, pp. 259–266. https://doi.org/10.3218/4147-7

FSO, 2022. Arealstatistik der Schweiz, Federal Statistical Office. Neuchâtel.

Gerber, J.-D., Gerber, J.F., 2017. Decommodification as a foundation for ecological economics. Ecological Economics 131, 551–556. https://doi.org/10.1016/j.ecolecon.2016.08.030

Griffel, A., 2017. Raumplanungs- und Baurecht in a nutshell, 3. Auflage. ed. Dike Verlag AG, Zürich/St. Gallen.

Halleux, J.-M., Hendricks, A., Nordahl, B., Maliene, V., 2022. Public Value Capture of Increasing Property Values across Europe. vdf, Zürich. https://doi.org/10.3218/4147-7

Hendricks, A., 2022. Germany, in: Halleux, J.-M., Hendricks, A., Nordahl, B., Maliene, V. (Eds.), Public Value Capture of Increasing Property Values across Europe. vdf, Zürich, pp. 105–111. https://doi.org/10.3218/4147-7

Hendricks, A., Kalbro, T., Llorente, M., Vilmin, T., Weitkamp, A., 2017. Public Value Capture of Increasing Property Values – What are the “Unearned Increments”?, in: Erwin Hepperle, Dixon-Gough, R., Mansberger, R., Paulsson, J., Hernik, J., & Kalbro, T. (Eds.), Land ownership and land use development. vdf, Zürich, pp. 257–281. https://doi.org/10.3218/3804-0

Hendricks, A., Lacoere, P., van der Krabben, E., Oorschot, C., 2021. Limits of negotiable developer obligations. Sustainability (Switzerland) 13. https://doi.org/10.3390/su132011364

Hengstermann, A., 2021. Switzerland, ARL International - Country Profiles. https://doi.org/10.5281/zenodo.5910027

Hengstermann, A., Scheiwiller, L., 2021. Ausgleich planungsbedingter Mehrwerte - Analyse der aktuellen Ausgestaltung im kantonalen Recht vor dem Hintergrund der bundesrechtlichen Genese. UPR - Umwelt- und Planungsrecht 41, 85–91. http://dx.doi.org/10.48350/153968

Hengstermann, A., Viallon, F.-X., 2023. Something between 20 and 50 per cent: understanding heterogeneous implementation of added value capture in Switzerland. Town Planning Review 94, 149–172. https://doi.org/10.3828/tpr.2021.38

Hong, Yu-Hung, Brubaker, D., 2006. Integrating the Proposed Property Tax with the Public Leasehold Sysem, in: Man, J.Y., Hong, Y.-H. (Eds.), China's Local Public Finance in Transition. Lincoln Institute of Land Policy, Cambridge, pp. 165–187.

Huang, H., Tang, Y., 2012. Residential land use regulation and the US housing price cycle between 2000 and 2009. J Urban Econ 71, 93-99. https://doi.org/10.1016/j.jue.2011.08.001

Ihlanfeldt, K.R., 2007. The effect of land use regulation on housing and land prices. J Urban Econ 61, 420-435. https://doi.org/10.1016/j.jue.2006.09.003

Jaeger, W.K., 2006. The Effects of Land Use Regulations on Property Values. Environmental Law 36, 105-130.

Jalali, D., MacDonald, H., Fini, A.A.F., Shi, S., 2022. Effects of planning regulations on housing and land markets: A system dynamics modeling approach. Cities 126, 103670. https://doi.org/10.1016/j.cities.2022.103670

Kalbro, T., Mattsson, H., 2018. Urban Land and Property Markets in Sweden, Urban Land and Property Markets in Sweden. Routledge, London. https://doi.org/10.4324/9781351035903

Kaufmann, D., Arnold, T., 2018. Strategies of cities in globalised interurban competition: The locational policies framework. Urban Studies 55, 2703–2720. https://doi.org/10.1177/0042098017707922

Lacoere, P., Hengstermann, A., Jehling, M., Hartmann, T., 2023. Compensating Downzoning. A Comparative Analysis of European Compensation Schemes in the Light of Net Land Neutrality. Planning Theory & Practice 24, 190–206. https://doi.org/10.1080/14649357.2023.2190152

Lacoere, P., Leinfelder, H., 2022. Land oversupply. How rigid land-use planning and legal certainty hinder new policy for Flanders. European Planning Studies 1–23. https://doi.org/10.1080/09654313.2022.2148456

Lambelet, S., Viallon, F.X., 2019. The influence of politicization on the implementation of developer obligations in a federalist country, in: Muñoz Gielen, D., van der Krabben, E., 2019. Public Infrastructure, Private Finance - Developer Obligations and Responsibilities. Routledge, Abingdon, Oxon, pp. 100-110. https://doi.org/10.4324/9781351129169-9

Lendi, M., 2008. Raumplanung — ihr politischer Stellenwert in einer veränderten Welt. Raumforschung und Raumordnung | Spatial Research and Planning 66(5), 383–397. https://doi.org/10.1007/bf03183183

Lendi, M., 1996. Zur Geschichte der Raumplanung in der Schweiz. disP - The Planning Review 32(127), 24-26. https://doi.org/10.1080/02513625.1996.10556622

Lin, D., Wachter, S.M., 2019. Land Use Regulation and Housing Prices. SSRN Electronic Journal. https://doi.org/10.2139/ssrn.3363947

Müller-Jentsch, D., 2013. Führt die Teilrevision des RPG zu höheren Bodenpreisen? VLP-ASPAN InfoRaum 6–9.

Muñoz Gielen, D., Tasan-Kok, T., 2010. Flexibility in Planning and the Consequences for Public-value Capturing in UK, Spain and the Netherlands. European Planning Studies 18, 1097–1131. https://doi.org/10.1080/09654311003744191

Muñoz Gielen, D., van der Krabben, E., 2019. Public Infrastructure, Private Finance - Developer Obligations and Responsibilities. Routledge, Abingdon, Oxon. https://doi.org/10.4324/9781351129169

OECD Organisation for Economic Co-operation and Development, 2022. Global Compendium of Land Value Capture Policies. OECD. https://doi.org/10.1787/4f9559ee-en

Oikarinen, E., Falkenbach, H., 2017. Foreign investors' influence on the real estate market capitalization rate – evidence from a small open economy. Appl Econ 49, 3141–3155. https://doi.org/10.1080/00036846.2016.1254343

Perren, P., 2004. Gebührenerhebung im Baubewilligungsverfahren. Raum & Umwelt VLP-ASPAN 41–52.

Riva, E., 2016. Art. 5 Ausgleich und Entschädigung / I. Einleitung, in: Aemisegger, H., Moor, P., Ruch, A., Tschannen, P. (Eds.), Praxis-Kommentar RPG: Nutzungsplanung. Zürich/Basel/Genf, pp. 63–78.

Rodas, J.M.C., Gómez, J.M.N., Castanho, R.A., Cabezas, J., 2018. Land valuation sustainable model of urban planning development: A case study in Badajoz, Spain. Sustainability (Switzerland) 10. https://doi.org/10.3390/su10051450

Ruegg, J., 2022. Switzerland, in: Halleux, J.-M., Hendricks, A., Nordahl, B., Maliene, V. (Eds.), Public Value Capture of Increasing Property Values across Europe. vdf Verlag, Zürich, pp. 111–116. https://doi.org/10.3218/4147-7

Ruegg, J., Letissier, F., 2015. Landscape as a public action category? A discussion based on the revision of the Swiss planning act. Geo-Regards.

Scheiwiller, L., Hengstermann, A., 2022. Ideologischer oder pragmatischer Mehrwertausgleich? Eine interkantonale Untersuchung zum Einfluss der politischen Legitimation auf die Ausgestaltung des Ausgleichs planungsbedingter Vorteile in der Schweiz. Raumforschung und Raumordnung | Spatial Research and Planning 80, 451–464. https://doi.org/10.14512/rur.154

Shahab, S., Hartmann, T., Jonkman, A., 2021. Strategies of municipal land policies: housing development in Germany, Belgium, and Netherlands. European Planning Studies 29, 1132–1150. https://doi.org/10.1080/09654313.2020.1817867

Shahab, S., Viallon, F.-X., 2021. Swiss land improvement syndicates: 'Impure' Coasian solutions? Planning Theory 20, 44–62. https://doi.org/10.1177/1473095220923629

Sibel, A., Sidney, K., Giovanni, M., Beat, R., Karl, V., 2018. Geschäft des Bundesrates - Bundesgesetz über die Enteignung. Änderung (18.057).

Valtonen, E., Falkenbach, H., van der Krabben, E., 2017a. Risk management in public land development projects: Comparative case study in Finland, and the Netherlands. Land use policy 62, 246–257. https://doi.org/10.1016/j.landusepol.2016.12.016

Valtonen, E., Falkenbach, H., Viitanen, K., 2017b. Development-led planning practices in a plan-led planning system: empirical evidence from Finland. European Planning Studies 25, 1053–1075. https://doi.org/10.1080/09654313.2017.1301885

van der Krabben, E., 2021. De werking van de grondmarkt. Autoriteit Consument en Markt, Den Haag.

van Oosten, T., Witte, P., Hartmann, T., 2018. Active land policy in small municipalities in the Netherlands: “We don’t do it, unless….” Land use policy 77, 829–836. https://doi.org/10.1016/j.landusepol.2017.10.029

Vejchodská, E., Hendricks, A., 2023. Munich’s developer obligations as a legal transplant to the Czech institutional context. Town Planning Review 94, 193–214. https://doi.org/10.3828/tpr.2021.28

Viallon, F.X., 2018. Added value capturing in Switzerland: How much is enough?, in: Gerber, J.-D., Hartmann, T., Hengstermann, A. (Eds.), Instruments of Land Policy: Dealing with Scarcity of Land. Routledge, 1 Edition. | New York : Routledge, 2018. | Series: Urban planning and environment, pp. 57–69. https://doi.org/10.4324/9781315511658-7

Voß, W., Bannert, J., 2018. Reference land values in Germany, in: Gerber, J.-D., Hartmann, T., Hengstermann, A. (Eds.), Instruments of Land Policy. Routledge, 1 Edition. | New York : Routledge, 2018. | Series: Urban planning and environment, pp. 35–48. https://doi.org/10.4324/9781315511658-4

A3: Bilanz ziehen: Räumliche Verteilung von Kosten und Nutzen städtischer Verdichtung in den Regionen Utrecht und Bern

Book chapter (not peer reviewed) for Dresdner Flächennutzungssymposium, 2021

Authors*:* Vera Götze and Mathias Jehling

Abstract

Strategien zur Stadtverdichtung sind ein zentraler Baustein für eine nachhaltige Siedlungsentwicklung. Der Handlungsspielraum bei der Umsetzung von Verdichtungsstrategien ist aber begrenzt und Verdichtung kann lokal zu mehr Verkehr, weniger Grünflächen und erhöhten Wohnpreisen führen. Deswegen evaluieren wir anhand von kleinteiligen baulich-sozialen Daten, wie Kosten und Nutzen städtischer Verdichtung in zwei Beispielregionen - Utrecht und Bern - verteilt sind. Stadtverdichtung in Utrecht und Bern gestaltet sich unterschiedlich, da die Regionen in die kontrastierenden Planungssysteme der Schweiz und der Niederlande eingebettet sind. Unterschiede lassen sich sowohl zwischen den Regionen, aber auch innerhalb der Regionen beobachten. So werden unterschiedliche Landnutzungsflächen verdichtet, verschiedene Typen der Verdichtung unterscheiden sich hinsichtlich ihrer Einwohnerdichte, Altersverteilung und durchschnittlichem Einkommen, und der Verdichtungsdruck ist ungleich zwischen verschiedenen sozialen Gruppen verteilt. Mit unseren Analysen lassen sich mögliche soziale Folgen von Stadtverdichtung genauer erforschen. Auch können Erklärungen dafür gefunden werden, welche Verdichtungsstrategien zu welchen Resultaten führen.

The article can be downloaded here: https://www.ssoar.info/ssoar/handle/document/79033

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A4: Supplementary material

Supplementary material to “Comparing types and patterns: A context-oriented approach to densification in Switzerland and the Netherlands”

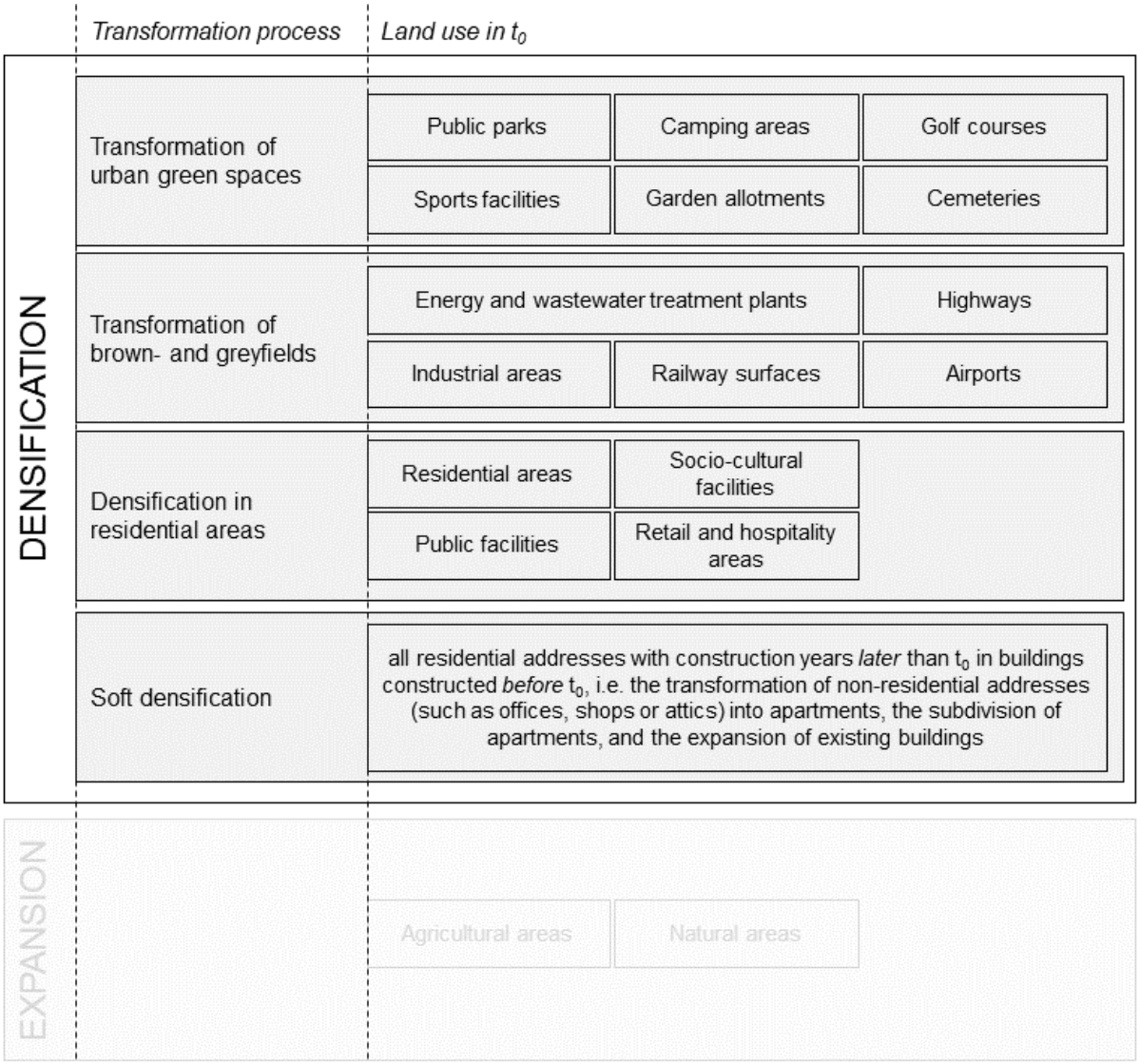


Figure S1: Transformation processes by former land use (at t_0)

Table S1: Metrics for densification with minimum, mean and maximum values.

	Name	Description	Aggregation level	Min	Mean	Max
SOCIAL	pop_dens	Inhabitants per hectare	Hectare grid	3	91.6	484
	per_kids	Share of children (age 14 and below) per hectare	Hectare grid	0	14.2	100
	per_students	Share of students (age 15 to 24) per hectare	Hectare grid	0	9.7	100
	per_elderly	Share of elderly (age 65 and above) per hectare	Hectare grid	0	20.9	100
	hh_size	Average household size per hectare	Hectare grid	1	2.1	6
	m2person	Sum of apartment sizes divided by population per hectare	Hectare grid	11.8	61.3	494.5
B	layers	Average number of storeys per street block	Street block	1	2.4	9

	fsi	Ratio between floor area and block area per street block	Street block	0.01	0.7	5.7
	gsi	Ratio between building footprint and block area per street block	Street block	0.01	0.3	0.99
	aptsize	Apartment sizes of individual apartments	Housing unit	11	98.9	495
SOCIAL	d_popdens	Deviance in population density from surroundings	Hectare grid	-1.9	0.4	7.2
	d_kids	Deviance in share of children from surroundings	Hectare grid	-3.4	0.1	6.7
	d_students	Deviance in share of students from surroundings	Hectare grid	-2.9	-0.03	10.1
	d_elderly	Deviance in share of elderly from surroundings	Hectare grid	-3.8	-0.06	5.7
	d_hh_size	Deviance in household size from surroundings	Hectare grid	-4.4	-0.2	6.3
	d_m2person	Deviance in living space per person from surroundings	Hectare grid	-5.9	0.2	12.4
BUILT	d_layers	Deviance in building height from surroundings	Street block	-3.1	0.3	7.2
	d_fsi	Deviance in floor space index from surroundings	Street block	-2.7	0.3	7
	d_gsi	Deviance in ground space index from surroundings	Street block	-2.6	0.2	4.6
	d_aptsize	Deviance in apartment size from surroundings	Housing unit	-4	-0.01	7.3
PROCESS	patchsize	Size of densification project in m^2	Housing unit	87.7	5857	90381
	transformation type	Factor with levels: transformation of brownfields/greyfields, transformation of urban green, densification on residential areas, soft densification	Hectare grid	-	-	-

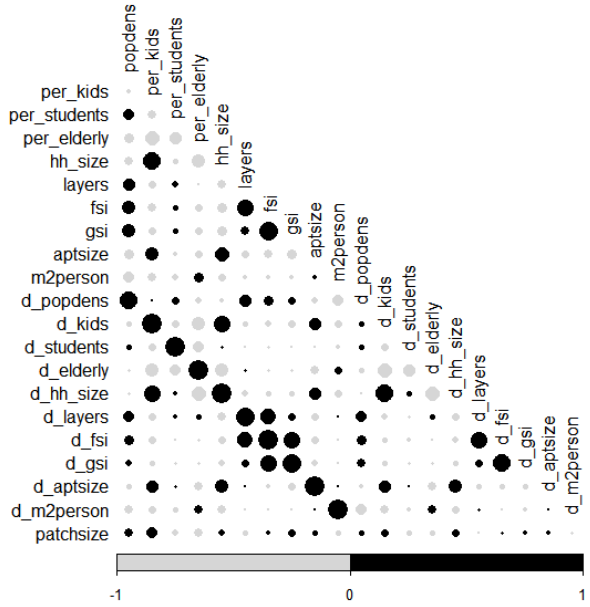


Figure S2: Correlogram of variables describing densification in Utrecht and Bern. The point size represents the strength of the correlation (larger = stronger).

Correlation analysis is conducted to validate variable selection and reduce variables for cluster analysis. The correlation analysis (see Figure S2) sustains the decision to use urban context-oriented variables (see deviation variables in Table 1), as strong correlations exist between relative and total values. Within this set of urban context-oriented variables, strong positive correlations additionally justify the reduction of morphological metrics to *d_layers* and *d_gsi* as they are relevant for discussing sensitive topics, such as high-rises and the amount of free space. Another significant, positive correlation occurs between average household sizes and the share of children in hectare grid cells

(*d_hh_size* and *d_kids* with r = 0.7). As the age range 0 to 14 does not cover all children living at home, we keep household sizes as a more precise indicator for the share of families with children. Finally, the size of a densification project (*patchsize*) shows no significant correlation with other variables and is kept as an important measure for the scale of densification.

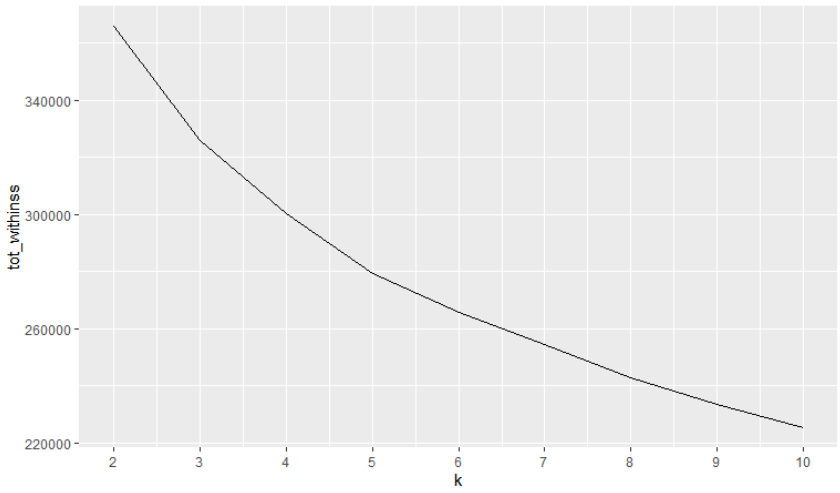


Figure S3: Scree plot showing the decrease in total within sum of squares distance per k.

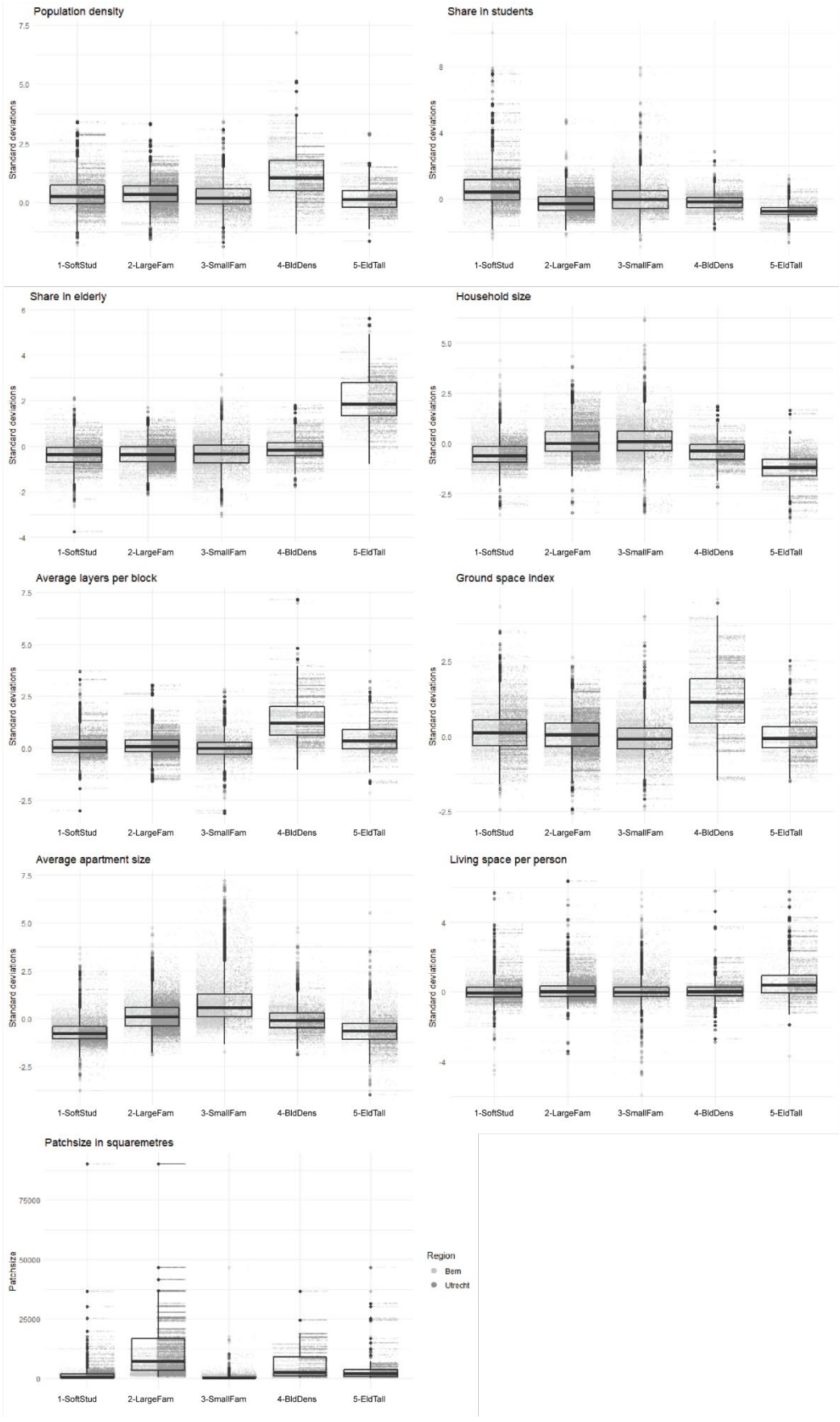


Figure S4: Distribution of observations per metric and densification type for Bern and Utrecht

Table S2: Concentration of densification types within and outside of largest municipalities

Canton of Bern (Area: 582.826 ha)					
	Total in Canton of Bern	*Units per ha in Canton*	*Total in municipalities of Thun, Biel, Bern*	*Units per ha in Thun, Biel, Bern (9.436 ha)*	*Urban to non-urban ratio*
1-SoftStud	4778	0.008	1040	0.110	13.4
2-LargeFam	4363	0.007	619	0.066	8.8
3-SmallFam	9500	0.016	1693	0.179	11.0
4-BldDens	3881	0.007	1789	0.190	28.5
5-EldTall	1383	0.002	77	0.008	3.4
Total	23006	0.039	5213	0.552	14.0
Province of Utrecht (Area: 150.000 ha)					
	Total in Province of Utrecht	*Units per ha in Province*	*Total in municipalities of Utrecht and Amersfoort*	*Units per ha in Utrecht, Amersfoort (16.307 ha)*	*Urban to non-urban ratio*
1-SoftStud	7435	0.050	3809	0.234	4.7
2-LargeFam	13908	0.093	5825	0.357	3.9
3-SmallFam	2506	0.017	905	0.055	3.3
4-BldDens	4183	0.028	2317	0.142	5.1
5-EldTall	4591	0.031	745	0.046	1.5
Total	32623	0.217	13601	0.834	3.8

Table S3: Median distance of densification types to central stations

	Median distance to nearest of the main stations of Biel, Thun or Bern	*Median distance to nearest of the main stations of Utrecht or Amersfoort*
1-SoftStud	10.4	4.4
2-LargeFam	8.8	7.3
3-SmallFam	10.1	7.8
4-BldDens	3.4	4.4
5-EldTall	10	9.6
Total	8.6	7

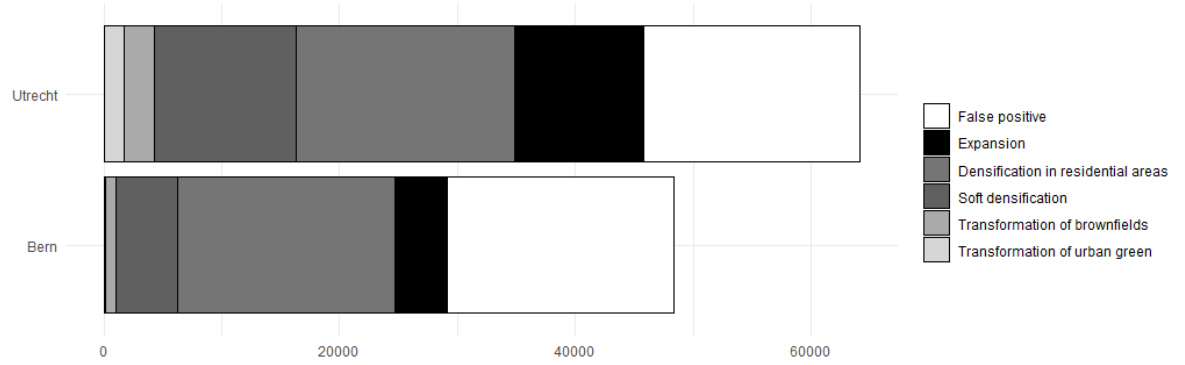
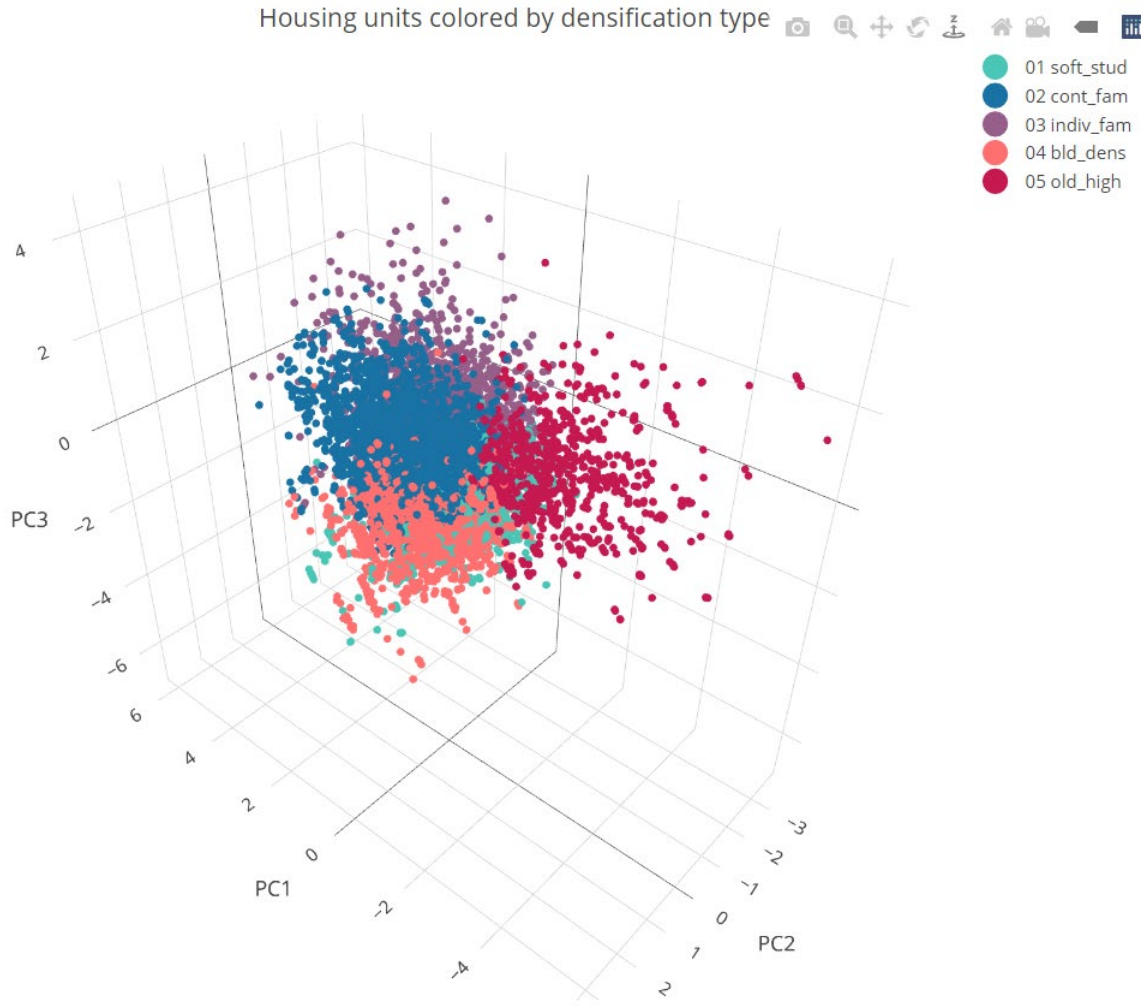


Figure S5: Total new housing units between 2011 and 2019 by transformation process, including false positives.



Object S6: Visualization of the continuous variables using three principal components. The 3D Visualization can be accessed here:

S6_k_pca.html

Supplementary material for the article “For whom do we densify? Explaining income variation across densification projects in the region of Utrecht, the Netherlands”

```
Call:
lm(formula = medinc_s ~ process + OAD12 + changex + med_inc12,
    data = proj_reg)

Residuals:
     Min       1Q   Median       3Q      Max
-19123.1  -5067.1   -164.1   4958.2  26837.1

Coefficients:
                           Estimate Std. Error t value Pr(>|t|)
(Intercept)                1.165e+04  2.442e+03   4.770 2.45e-06 ***
processResidential (dem)  -1.850e+03  9.004e+02  -2.054  0.04048 *
processResidential (soft) -3.758e+03  1.154e+03  -3.258  0.00120 **
processTransformation      2.771e+03  1.139e+03   2.433  0.01534 *
processUrb Green           2.766e+03  1.363e+03   2.030  0.04292 *
OAD12                      1.985e+00  3.199e-01   6.205 1.18e-09 ***
changex                    6.209e-01  1.964e-01   3.161  0.00167 **
med_inc12                  6.756e-01  8.809e-02   7.670 9.67e-14 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 7793 on 480 degrees of freedom
  (133 observations deleted due to missingness)
Multiple R-squared:  0.2328,    Adjusted R-squared:  0.2216
F-statistic: 20.81 on 7 and 480 DF,  p-value: < 2.2e-16
```

Figure S01 Regression model with median incomes excluding households that are led by a student

```
Call:
lm(formula = medinc_srse ~ process + OAD12 + changex + med_inc12,
    data = proj_reg)

Residuals:
     Min       1Q   Median       3Q      Max
-20425.0  -4712.8    148.4   4444.5  22875.5

Coefficients:
                           Estimate Std. Error t value Pr(>|t|)
(Intercept)                1.613e+04  2.733e+03   5.900 8.99e-09 ***
processResidential (dem)  -1.787e+03  1.111e+03  -1.609 0.108589
processResidential (soft) -4.720e+03  1.457e+03  -3.239 0.001319 **
processTransformation      1.073e+03  1.282e+03   0.837 0.403135
processUrb Green           1.633e+03  1.653e+03   0.988 0.324027
OAD12                      1.349e+00  3.677e-01   3.669 0.000284 ***
changex                    4.868e-01  2.262e-01   2.152 0.032101 *
med_inc12                  6.153e-01  9.868e-02   6.235 1.38e-09 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 7851 on 330 degrees of freedom
  (283 observations deleted due to missingness)
Multiple R-squared:  0.1993,    Adjusted R-squared:  0.1823
F-statistic: 11.73 on 7 and 330 DF,  p-value: 2.427e-13
```

Figure S02 Regression model with median incomes excluding households that are led by a student, a retired person or a self-employed worker.

Table S01: Summary statistics for variables that enter regression analysis

Variable	**Min**	**1st Qu.**	**Mean**	**3rd Qu.**	**Max**
OAD12 – Density of addresses in a circle of 1km^2 around each address in the neighbourhood (dutch: omgevingsadressendichte)	74	1034	1979	2493	5908
Changex: change in median income between 2011 and 2019 (corrected for inflation)	-4030	1798	2779	3602	11994
Med_inc12: median standardised household income in neighbourhood in 2012	7102	19172	22929	26118	29209
Medinc: median standardised household income in densification project of 10 and more households in 2019	1.604	23.610	30.395	36.298	69.460

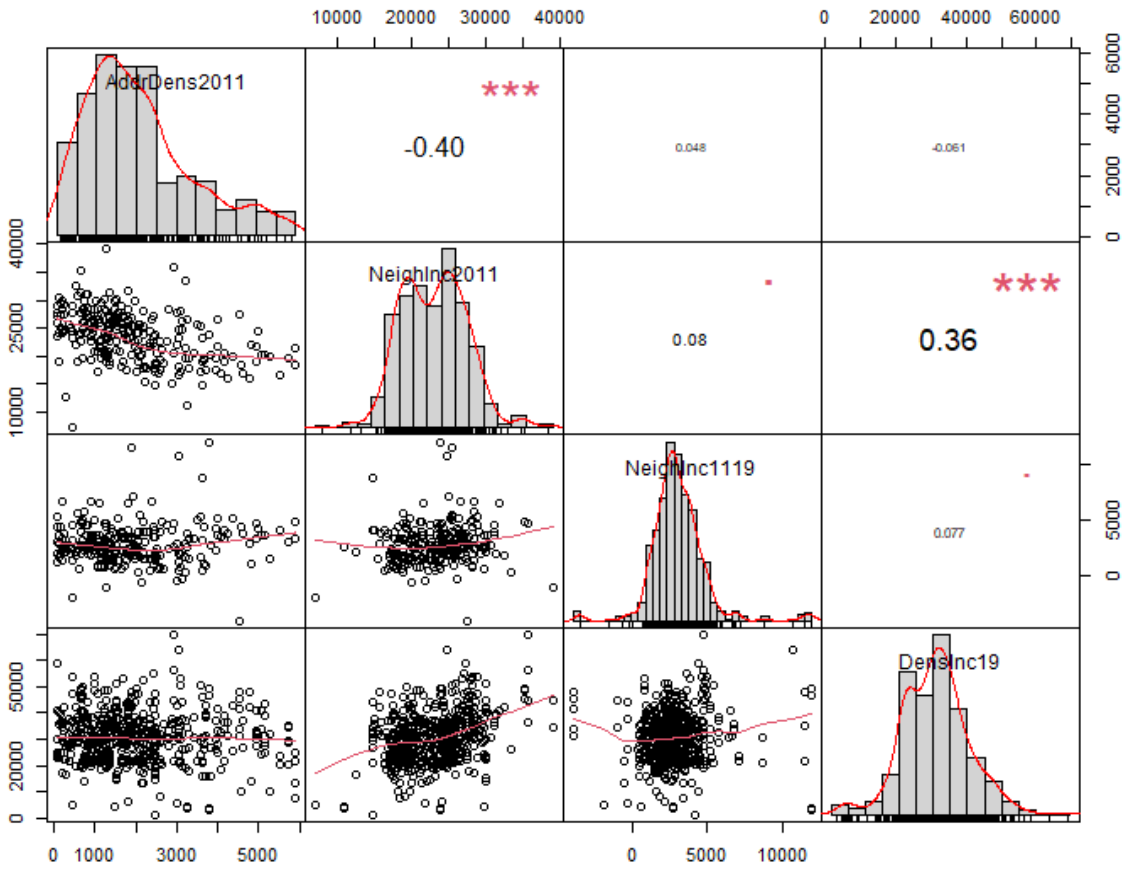


Figure S03: Correlation matrix for variables that enter regression analysis using the following abbreviations: AddrDens2011 = Address density 2011, NeighInc2011 = Median neighborhood income 2011, NeighInc1119 = Change in median neighborhood income 2011-2019, DensInc19 = Median household income in densification project 2019 (dependent variable for illustration, does not enter regression analysis)

Table S02 living space per person

	Added households as share of total densification	*Average median neighbourhood income 2011*
Transformation of brownfields	*26*	€25,000
Transformation of urban green	*9*	€24,400
Residential densification	*24*	€23,500
Residential densification through redevelopment	*27*	€22,400
Soft densification	*14*	€21,800

Table S03 living space per person

	Median living space per person in 2019
01 Province	*-*
02 Expansion	*50*
03 Densification	*51*
03.1 on brownfields	*47*
03.2 on urban green	*55*
03.3 Residential	*55*
03.4 through redevelopment	*53*
03.5 Soft densification	*54*
04 No soft densification	*51*
05 Projects with 10+ households	*50*

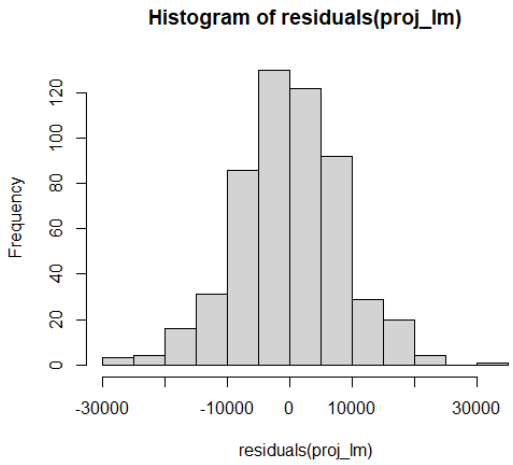


Figure S04: Distribution of Residuals in regression model

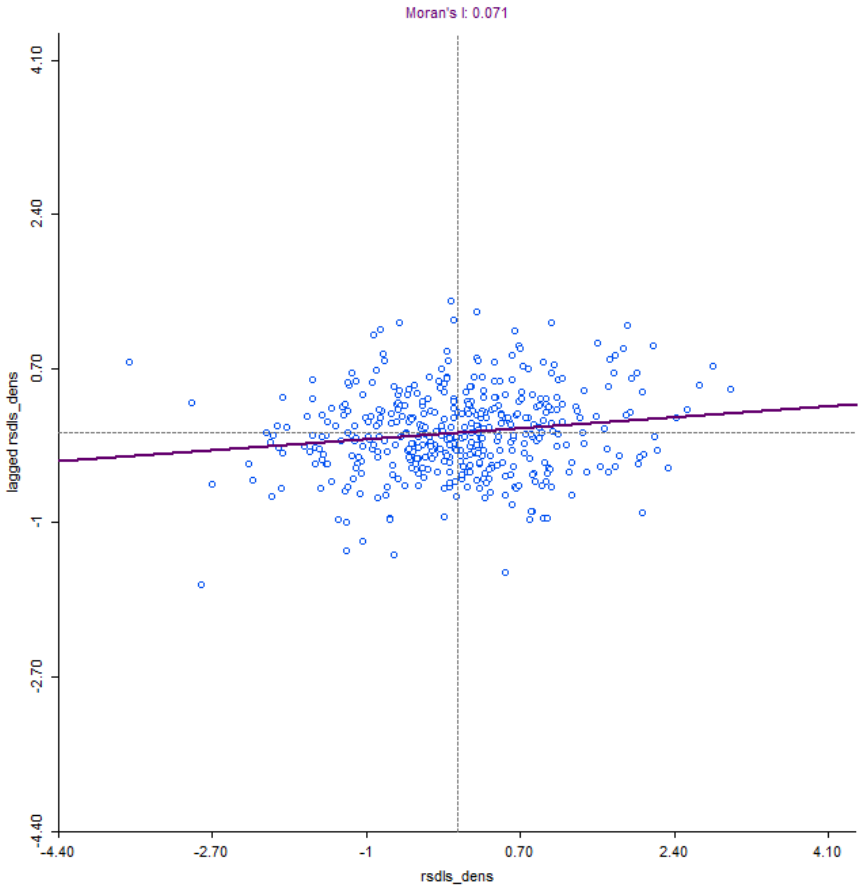


Figure S05: Moran's I matrix of global spatial autocorrelation. Calculated on a contiguity-based weight matrix and the residuals of the regression model. At 999 permutations, the pseudo p-value is 0.006

A5: Declaration

I declare herewith that this thesis is my own work and that I have not used any sources other than those stated. I have indicated the adoption of quotations as well as thoughts taken from other authors as such in the thesis. I am aware that the Senate pursuant to Article 36 para-graph 1 litera r of the University Act of September 5th, 1996 and Article 69 of the University Statute of June 7th, 2011 is authorized to revoke the doctoral degree awarded on the basis of this thesis.

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Signature and date