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Research Article

Linear settlements: Morphological Patterns and Processes, Shaping territory, networks and urban fabrics. A case study in and around Vienna in a European perspective

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A B S T R A C T

Linear settlements represent a distinctive village typology that is prevalent across numerous regions of Europe, encompassing both rural and more urban areas. In the context in and around Vienna, historical linear settlements are a defining feature of the built landscape.

From historically grown structures to top-down planned settlements, these linear village types are defined by a range of factors, e.g. agricultural activities, geographical conditions or even internal colonisation processes by monarchs. Over the course of history, a canon of different village forms with distinct spatial qualities has developed. However, within the scope of this research on Vienna and against the background of the umbrellaing 15 mC project (emc2), the predominant types of *Straßendorf* and *Angerdorf* are the primary focus. In Vienna, these historic linear settlements are integrated into the urban fabric while still retaining varying degrees of permanence and persistence in the urban layout.

By combining different methods - local morphogenetic analysis, urban network analysis, regional typological mapping and comparative analysis to regions in France and Italy - this study provides insights and findings on how linear settlement types in and around Vienna have developed morphologically, with a particular focus on the last two centuries. The objective of this study is to explore the influence of these linear settlements on the shaping of territories, networks and urbanisation processes, and their subsequent characterisation of contemporary urban and rural environments.

1. Introduction

Linear settlements represent a prevalent type of settlement across various European contexts (Miller, 1950) manifesting particularly in eastern Austria (Dachler, 1909; Klaar, 1942). This historic village form, which in Austria dates to the Middle Ages (Klaar, 1942; Kräftner, 1987; Miller, 1950; Schickhofer et al., 1987), also occurs in areas within today's administrative borders of Vienna (Tobisch et al., 2023); with the areas outside the consolidated urban areas being particularly characterised by them (Fig. 1). This peripheral zone represents a landscape that was originally agriculturally dominated and served to supply the metropolis.

Historically, cities and their surrounding areas have undergone growth and development, resulting in the formation of interweaved systems that are in constant and dynamic interaction. In the case of Vienna, large-scale urban expansion in the second half of the 19th

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Fig. 1. Overviews of linear settlements in Vienna within today's city limits, left: today's urban landscape, right: historical geographical landscape. Linear settlements originally located within the historic fortification have mostly disappeared from the cityscape today and also fall outside the scope of this study. © Tobisch/Loeschenbrand/Psenner
Map Basis/Source: left OpenStreetMap; right: historical situation and water infrastructure according to the Franzsizeischer Kataster: https://www.data.gv.at/datasets/4030d796-0573-4305-86f2-b34e38a86a1d?locale=de.

century led to spatial displacement processes, with new urban structures replacing existing agriculturally orientated patterns and associated village structures (see: 3.1). This frequently resulted in spatial irregularities in the urban fabric: atypical plots or building configurations or historical street layouts that had been preserved and became part of later contextually diverse street grids, thereby expressing the concept of permanence or persistence (Léveillé et al., 1993).

From the perspective of an expanding and continuously transforming city, the question of the boundaries of the urban settlement area appears to be a perennial issue. It is evident that such considerations must logically encompass the spatial development of surrounding natural areas, agricultural areas and existing built-up environments. In the contemporary European context, numerous cities have developed strategies that emphasise local spatial polycentricity[1] and changing the urban outskirts. The importance of local communities otherwise referred to as 'village life', within the context of urban planning is frequently attributed to these new polycentricities. The transformation and development of the urban fringe, or more broadly the *Zwischenstadt*[2] (Sieverts, 1997), with its existing layouts and spatial structures, is a pivotal aspect regarding current and future urban challenges. More specifically, considering the *Zwischenstadt* as an ill-defined suburban nebulose with scattered fragments and incomplete, weakly central and symbolically poorly connected nuclei, begs the question of a different way of structuring emerging centralities within it.

Within this configuration, historical linear settlements, present in the metropolitan peripheries of Vienna can play an important role in structuring local centralities in their contemporary urban context. Originally, these linear village structures already functioned as local centres for their immediate surroundings and were decisive for spatial developments over centuries in the Viennese context. The following questions are thus prompted: how did the typology of linear settlements (type-specific in Vienna: 'Straβendorf' and 'Angerdorf', 1.1) become integrated into Vienna's urban fabric? What is the effect of urban growth on the functioning of the linear settlements as structuring element in the urban landscape over time? And can this case study of Vienna – where linear settlements are a characteristic feature of the built landscape – be compared with other European contexts? This study utilises a combination of methodologies - local morphogenetic analysis, urban network analysis, regional typological mapping and comparative analysis to regions in France and Italy - to elucidate the morphological evolution of linear settlement types in and around Vienna over the past two centuries. In relation to Vienna and its linear settlements, the morphogenetic and network-based analyses offer a distinctive approach to this subject that is unmatched in the context of this particular case study.

1.1. Case study Vienna

The work of Klaar (1942), who extensively researched settlement forms, including linear settlements, provides a significant foundation for the study of village types within the Austrian context. With the exception of a limited number of master's theses (e.g. Dungl, 1988; Zehetgruber, 2010; Zierhut, 1975) and dissertations (e.g. Poschacher, 1967), there is little primary literature on these linear village forms in the context of Vienna and Austria. Despite the existence of contributions on linear settlements, particularly those

[1] Many major European cities, such as Vienna (Fachkonzept 'Polyzentrales Wien – Mittelpunkte des städtischen Lebens'), Berlin ('Die Berlin-Strategie 3.0 – Solidarisch, nachhaltig, weltoffen') or Zurich ('Stadtraum und Mobilität 2040 Strategie') have incorporated approaches to polycentric urban development into their strategic planning documents.

[2] The term Zwischenstadt (in-between city), first coined by Sieverts, describes suburban areas, which today are primarily characterised by spatial phenomena that emerged in the 20th century, e.g. urban sprawl, car dominance, industrial parks etc. He and his work are highly relevant to the reception of the phenomenon of "urban sprawl".

focusing on regionally typical farmstead types (e.g. Kräftner, 1987; Schickhofer et al., 1987), these frequently address the subject from an architectural or heritage conservation standpoint. Conversely, publications from an urban or spatial planning perspective are conspicuously absent. Furthermore, Klaar's focus was on categorising and mapping village types (Klaar, 1942), as well as examining urban settlement patterns in general (Klaar, 1971). However, he did not conduct an examination of spatial genesis or an in-depth, systematic analysis of specific types within a context such as Vienna.

The geographical area encompassing the city of Vienna is primarily distinguished by two distinct types of settlement: *Straßendorf* (engl.: linear settlement or streets village) and *Angerdorf*.[3] Without delving into the intricacies of the various subtypes encompassed by these two predominant types, Klaar (1942) offers a general classification that delineates them as follows:

- "The Straβendorf is primarily determined by a fairly broad street. This street does not necessarily have to be part of a higher-level street network. The width of the street varies between 8 and 16m. The course of the street does not necessarily have to be straight, but can adapt to the terrain, offering a wide range of possible applications for this settlement-type. The development structure along both sides of the street is based on rectangular plots." (Klaar, 1942, p. 18; translation by paper authors)
- "Next to the Straβendorf, the Angerdorf can be considered the most frequently planned form of collective settlement. The various subtypes are characterised by the shape of the green area known as 'Anger', which represents the centre of the settlement and was used as common ground. The Anger is surrounded by streets to which the single building blocks were connected in a clearly defined form with rectangular plot layouts." (Klaar, 1942, p. 20; translation by paper authors)

Preliminary studies to this research have examined the significance and influence of the way in which settlements are arranged, focusing on Vienna (Tobisch et al., 2023) and adapting a transnational perspective comparing Austria, Slovakia and Hungary (Loeschenbrand et al., 2023). The aforementioned study (Tobisch et al., 2023) provides findings on the village structures and their distribution in the vicinity of Vienna's historic core. The analysis reveals that approximately two-thirds of the structures within this area, situated outside the confines of the *Linienwall* (the outer historical city fortification) but still within today's city limits can be categorised as linear settlement structures (Fig. 1). The 47 linear settlements identified in the *Franzsizeischer Kataster* (1817-1829)[4] have historically shaped the area outside the former fortifications and formed local micro-centres. As is evident on the map, a significant number of linear settlements are closely linked to water respectively blue infrastructure in terms of their location and orientation, suggesting that this might be a relevant settlement factor. The topography of Vienna's western region is defined by the foothills of the Alps. These hills extend in a linear fashion, creating a landscape of ridges and valleys that are geographically linked to streams (the majority of which have now been canalised). In this particular context, the settlements are located in valleys, while uphills are agriculturally cultivated. The topographical features of the southern and eastern peripheries of Vienna are defined by the expansive flatlands of the Vienna Basin at the transition to the Pannonian Plain. These plains are predominantly utilised for the purpose of arable farming. As posited by Tobisch et al. (2023) a significant proportion of these linear settlements, numbering over 30, persist in the present day, manifesting in diverse forms. These include villages that have retained their original character and layout, as well as those where only a few historic farmsteads remain.

1.2. View beyond the case study of Vienna

As outlined in the preliminary study comparing Austria, Slovakia and Hungary (Loeschenbrand et al., 2023), linear settlements can be identified in a broader context. As a consequence of the various internal colonisation processes that have taken place in the former territories of influence of the Habsburg monarchies, there are variations of linear settlements to be found in the northern, eastern and south-eastern neighbouring countries of Austria, as well as in certain areas of Ukraine, Romania and the northern parts of some Balkan countries.

Patterns of linear villages and settlements have been identified across the globe, both historically and in the present day. In limited cases, these correspond with the migration of German-speaking people in the 19th century, for example, to Australia (Spennemann, 2025). However, this case study must principally be analysed from a European standpoint. Despite the existence of these linear types in certain regions of England (e.g. Thorpe, 1949) and France (e.g. Trochet, 1981a, 1981b), it is primarily the Central and, to a certain extent, Eastern European context that must be taken into consideration for this study, where linear settlements have frequently been associated with strategic settlement and colonisation since the Middle Ages. In addition to the discussion of the Austrian perspective in section 1.1 ,[5] the medieval origin of *Straßendorf* and *Angerdorf* settlements is not only characteristic of parts of Germany (Miller, 1950), but also of present-day Poland (e.g. Conzen, 1945; Woede, 1980). Alongside the linear settlement patterns present in southern Poland's contemporary landscape also historically shaped by Habsburg influences, a remarkably diverse array of linear settlement patterns can be found in large parts of Poland today. These have been the subject of increasing academic scrutiny (e.g. Cepil, 2026; Legut-Pintal & Kubicka-Sowińska, 2021), particularly with regard to the persistence of linear village structures and their surrounding agricultural

[3] There is no direct English equivalent for the term 'Angerdorf'(Anger village). The 'Anger' is the German term for a green space in the centre of a village which is common land and was used collectively. There are different forms of anger; those in Vienna are mainly linear in shape.

[4] The Franciscan Cadastre (named after Emperor Francis I), compiled for the Vienna area between 1817 and 1829, initially served to determine land tax and constitutes an important early cartographic respectively cadastral record.

[5] In the German-speaking context, however, there are studies from the 1930s and 1940s that must be treated with great caution. These were partly influenced by National Socialist and racist ideology and sought to portray the superiority of the 'German' linear village over 'Slavic' villages.

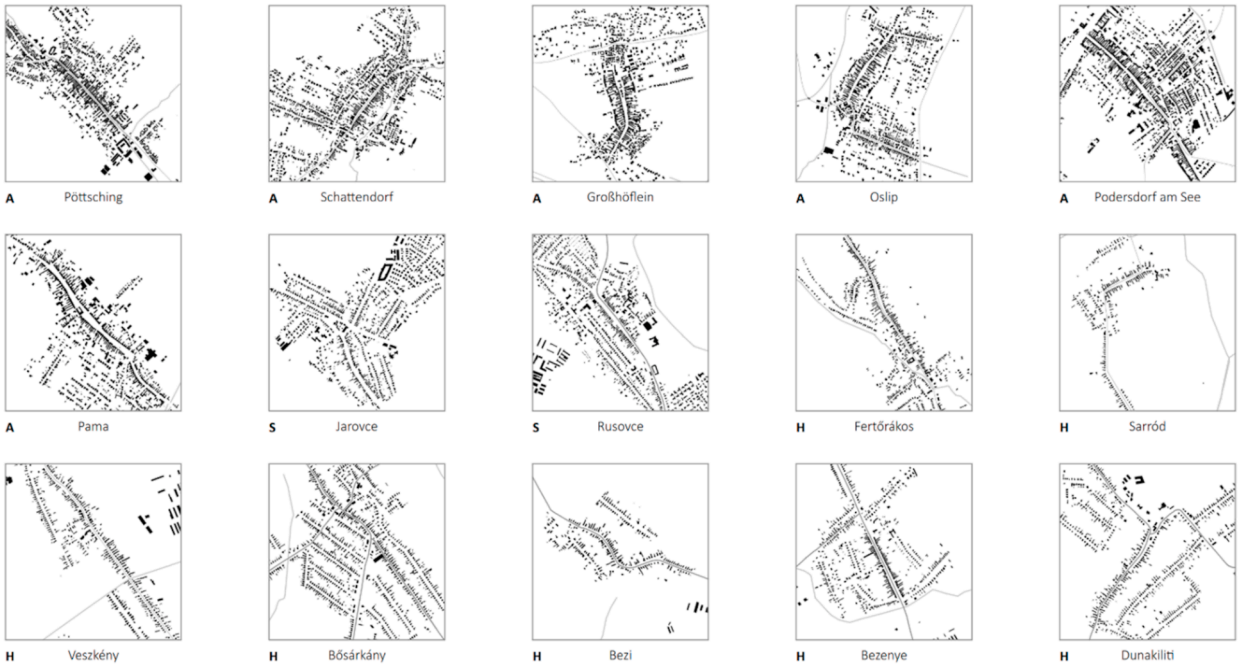


Fig. 2. Overview of selected linear settlements in Austria (A), Slovakia (S) and Hungary (H). © Loeschenbrand/Tobisch/Psenner Map Basis/Source: OpenStreetMap

land (Prus et al., 2021), and the impact of Josephine colonisation on village layouts in present-day Poland and Ukraine from the second half of the 18th century onwards (Cepil, 2021). Furthermore, Navrátilová's (1971) study focuses on the Znojmo area in the present-day Czech Republic, located approximately 75 km north of Vienna, examining the characteristics and structural developments of farmsteads within linear settlements in this region.

When comparing Austria and Hungary in the second half of the 20th century, different genesis within linear settlements can also be observed in terms of structural developments. In the Hungarian context, for instance, the collectivisation and nationalisation of agriculture resulted in the decline of individual farms, consequently diminishing the significance of preserving historical farmsteads. Concurrently, village structures underwent a process of expansion, characterised by the introduction of a new building type the Kádár cube bungalow. Within the Austrian context, the transition of agricultural activities within the village did occur under a different political system. Nevertheless, here too – as in the Austrian province of Burgenland, which borders directly on Hungary – villages underwent transformation to varying degrees during the latter half of the 20th century, with some involving alterations or new buildings both within and outside the village centre (Fig. 2). (Kleemaier-Wetl, 2023, p. 159)

1.3. Historical genesis within Vienna

The initial appearance of linear settlements in the regions surrounding Vienna in the 11th century is associated with internal colonisation processes of these areas (Klaar, 1942; Kräftner, 1987; Miller, 1947, 1950; Schickhofer et al., 1987). During the 12th and 13th century, *Straßendorf* (Klaar, 1942, p. 18) and *Angerdorf* (Klaar, 1942, p. 21; Schickhofer et al., 1987, p. 11) were established and developed as settlement types. Clearly defined planning guidelines were in place for the settlements (e.g. Miller, 1950), with military defence considerations playing a significant role in the design of a compact village form (e.g. Schmeller, 1974, p. 43). Throughout history, numerous villages in Vienna have been subject to partial or complete destruction by a variety of factors, including floods, fires and armed conflicts. These villages have subsequently been rebuilt or established anew (Hansen-Schmidt, 1995; Hinkel, 1994; Klaar, 1971). Following the Ottoman Wars of the 16th and 17th century, the *Ingenieurdorf* emerged as a particularly planned village unit and variant of the *Angerdorf* (Schickhofer et al., 1987, p. 11; Schmeller, 1974, p. 44). It is important to note that this type of linear settlement is not found directly in Vienna, but rather the best-known examples are located in the neighbouring province of Burgenland. In the 18th and 19th century, the processes of internal colonisation proceeded within the spheres of influence of the Habsburg monarchies in Eastern Europe, thus perpetuating the dissemination of principles for linear settlement structures (Miller, 1947, 1950).

The focus on Vienna reveals that linear settlement types in the 18th and 19th century were still relevant to the cultivation of the surrounding landscape and the supply of the city. In their seminal work Bobek and Lichtenberger (1978) mainly distinguished between

Weinhauerdörfer (villages with vineyards) in the west and *Ackerbaudörfer* (villages with arable fields) in the south and east.[6] Following the Revolution of 1848 and the subsequent abolition of manorial rule, there were fundamental changes to social, political and economic systems. Not only the associated changes in the agriculture sector, but also industrialisation, and Vienna's rapid growth to a population of over 2 million by the First World War (from around 550,000 in 1850) led to distinctive changes in the urban landscape. During the latter half of the 19th century, the expanding city of Vienna began to transform linear settlements depending on their geographical location or proximity to town centres. Thus, the architecture of the *Gründerzeit* period introduced new building dimensions and scales into village structures. Furthermore, examining address books from 1912 (Lehmann, 1912) in selected linear settlements reveals an increasingly differentiated pattern of land use, including manufacturing and trade. In addition to the layers pertaining to buildings and usage, consideration must also be given to infrastructure projects related to mobility (e.g. bridges, the expansion of major road links or railway constructions) in the context of Vienna's expansion and the increasing urbanisation of peripheral areas in the 19th century. Consequently, linear settlements found themselves in regularly changing new relationships with more urban constellations.

The relationship between rural linear settlements was also related to the question of affiliation within the boundaries of the administrative city. Several linear settlements located within the current urban area were incorporated into the official city limits around 1900 due to urban expansion. Vienna's present-day city boundaries were established after the Second World War. This determined which linear settlement structures were situated within the urban area and thus were subject to Vienna's sphere of influence.[7] In the latter half of the century, urban planning approaches based on classical modernism and polycentricity were initiated. This was not least due to the influence of the then Urban Planning Director, Roland Rainer (1962)[8]. The urban development plans *STEP84* (City of Vienna – MA18, 1985) and *STEP94* (City of Vienna – MA18, 1994) designated settlement corridors and multiple subcentres, some of which also incorporated selected linear settlements. Moreover, *STEP84* and *STEP94* both emphasise the preservation of selected historic villages centres and thus linear settlements within the cityscape. Prior to this, an amendment to the preservation of historic city parts (orig.: *Altstadterhaltungsnovelle*) was introduced in 1972. As a result, designated protected zones for selected linear settlements were established in the years and decades that followed. Despite the population of Vienna remaining relatively stagnant during the post-war decades, with a decline in the 1970s and 1980s, major housing projects were developed on the eastern and southern outskirts of the city, close to the existing linear settlements (see e.g. Groβjedlersdorf, Leopoldau or Siebenhirten). In accordance with the prevailing planning models of the time, several of these large housing projects featured integrated commercial facilities, providing new centres alongside to the historical linear settlements.

Recent decades have seen the City of Vienna's planning documents repeatedly emphasise the importance of villages as local centres, regardless of whether these plans were realised or whether these characteristics are evident in the current urban landscape. For instance, regarding the linear settlement of Siebenhirten, *STEP94* stated: "The village centre of Siebenhirten shall be upgraded to become an attractive local centre (…)" (City of Vienna – MA18, 1994, p. 329; translation by paper authors). Furthermore, regarding an urban area in Vienna's east, *STEP94* describes "(…) the existing old villages centres – as crystallisation points of polycentric settlement development (…)" (City of Vienna – MA18, 1994, p. 140; translation by paper authors). Two decades later, the *STEP2025* asserted: "For the compact city with short distances, the most fine-grained distribution of centres is necessary, with established village centres having just as much of a function as the city centre itself" (City of Vienna – MA18, 2014, p. 64; translation by paper authors). The role of linear settlements as centres is frequently referenced in planning documents. The official strategy document on polycentricity by the City of Vienna (orig.: *Mittelpunkte des städtischen Lebens: Polyzentrales Wien,* City of Vienna – MA18, 2020), highlights the importance of 42 historic village centres as micro-level centres for decentralised supplies. Of the 31 linear settlements identified in present-day Vienna (see 3.3), 28 are included within these 42 village centres. The recently published document (orig.: *Der Wien-Plan*, City of Vienna – MA18, 2025) identifies 21 linear settlements as local centres at the micro-level, while a further five linear settlements are currently situated within higher-level centres.

1.4. Building types within linear settlements

From a historical perspective, linear settlement structures in Vienna typically consist of single-storey farmsteads. The architectural configuration of these buildings adheres to a village layout characterised by narrow, deep plots arranged in a linear configuration adjacent to one another. As previously outlined, Klaar's work (1942) serves as a valuable basis for classification and typology, offering definitions of villages and associated farmsteads. However, subsequent authors (e.g. Bauer, 2023) have proposed divergent definitions or classifications in a few cases, possibly due to regional interpretations or the complexity of building genesis. For instance, Klaar (1942) describes the *Zwerchhof* as C-shaped, whereas Bauer (2023) defines it as L-shaped.[9] Whilst alternative classifications could be proposed, the original predominant types of farmstead footprints from the 19th-century study area in Vienna are illustrated in Fig. 3: *Streckhof, Hakenhof, Zwerchhof, Doppelhakenhof* and *Dreiseithof*.

[6] According to Bobek and Lichtenberger (1978), the dairy industry became increasingly important for selected villages starting in the 18th century.

[7] Detailed urban planning for Vienna in the 20th and 21st centuries has generally been limited to the area within the administrative boundaries.

[8] Roland Rainer was an architect and urban planner of great significance to Vienna, who made a theoretical and practical contribution in a variety of roles (city administration, university, architectural practice).

[9] An in-depth examination of this complex definition and typology cannot be carried out within the scope of this paper and requires separate analysis.

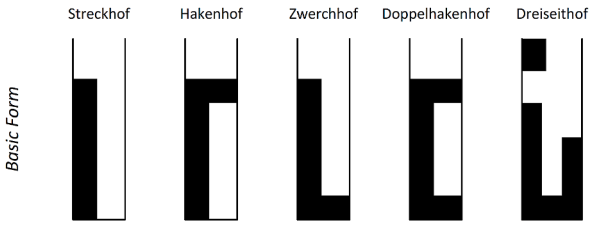


Fig. 3. Typical farmstead footprints within linear settlements. As described in the text, alternative classifications are possible. © Loeschenbrand/Tobisch/Psenner.

The *Streckhof* is a building of elongated form with the living quarters orientated towards the street. Storage rooms, stables and other utilities are located in the rear. The configuration of any transverse wings dictates the classification of buildings as either *Hakenhof, Zwerchhof* or *Doppelhakenhof*. Similarly, a U-shaped building with two utility wings can be interpreted as a *Dreiseithof*. Within these types a certain genesis can be observed. For instance, the *Zwerchhof* is frequently regarded as a subsequent extension of the original *Streckhof* (e.g. Bauer, 2023, p. 161). Furthermore, two additional related building types are represented by the *Gassenfronthaus* and the *Weinhauerhaus*. Distinguishing these typologies is not possible based on the building footprints shown above. The *Weinhauerhaus* is necessarily located in viticultural villages and does not follow a clear floor plan (Kräftner, 1987, p. 140). The *Gassenfronthaus* that is considered the latest development in farm constructions, replaced the *Streckhof*, *Hakenhof* or *Zwerchhof* in the second half of the 19th century (Kräftner, 1987, pp. 132-135).

A consideration of the current state of single-storey farmsteads in Vienna reveals that, despite the dominance of historical façade architecture (Fig. 4), historical farmsteads in the Viennese context have undergone various developments right up to the present day, including some cases of alterations or adaptations to the façade (Fig. 5). Preliminary investigations involving the review of archive materials on 20 selected farmsteads have already been carried out outside the scope of this paper.[10] These preliminary investigations revealed that within plots the building density increased, occasionally accompanied by the demolition of buildings, thus emphasising the ongoing transformation of the plots—the Burgage Cycle (Conzen, 1960). In isolated cases, farmsteads can be found where the residential wing facing the main street, for example, was rebuilt in the second half of the 20th century (Fig. 5). Protected zones, which were introduced from the 1970s onwards under the *Altstadterhaltungsnovelle*, were intended to support the preservation of historic structures. However, they have also led to alterations where the historic street frontage and façade are retained while the interior of the plot is densified to the maximum possible extent.

2. Methodology

2.1. Scope and aims

The research focuses on how linear settlements have shaped and characterised the city of Vienna and its surrounding area over the past 200 years and how they have been incorporated into the urban fabric resp. urban system. This is conducted on three scales: neighbourhood, city and regional. In the context of a morphological framework, particular attention is paid to the spatial genesis and transformation, as well as the persistence of the respective linear settlements. Furthermore, within the context of the regional analysis, comparisons are drawn with other European study areas.

2.2. Methods

The study combines three complementary analyses, resulting in a multi-step resp. multi-scale approach. The morphogenetic study focuses on the neighbourhood level, examining the built development of 10 selected linear settlements based on six time periods between ca. 1820 and 2020. At the city level, diachronic network analysis observes changes and shifts in the centrality of these 10 examples and their surrounding streets as well as how these shifts are linked to transformations of the linear settlements. At the final regional scale of the study, all linear settlements within a 30 km radius of Vienna are identified. The selection process is predicated on the presence of a discernible linear structure on historical maps from the early 19th cent. that has persisted to the present day. The resulting map of linear settlements at a regional level in Vienna is subsequently used for a comparative analysis with study areas in France and Italy.

2.2.1. Morphogenetic analysis

The morphogenetic analysis includes six time periods (1820s, 1870s, 1912, 1938, 1971, 2020s) to illustrate the development of the building structure in ten selected linear settlements in Vienna. Due to the absence of height information in historical maps and aerial photographs, this study operates within a two-dimensional framework, thus excluding three-dimensional spatial parameters, including building heights. Furthermore, the given scope of the study did not allow for the consideration of relevant topics such as plots. The

[10] This preliminary study was presented at the ISUF2024 Conference, please see Loeschenbrand et al. (2024).



Fig. 4. Selected historical present-day farmstead façades in Vienna. © Loeschenbrand.



Fig. 5. Selected, adapted façades and a new-build residential building that references historical farmsteads (middle). © Loeschenbrand.

primary objective of the initiative was to capture and to document the historical character of the villages, which are traditionally defined by single-storey farmsteads along the main street. The individual maps were therefore examined to determine whether the respective building footprints (shape, building depth etc.) corresponded to typical historical farmsteads or not.

In the field of urban morphology, such analysis would typically be termed as a morphological analysis. Barke (2025) has highlighted that the term *"morphogenetic"* is underrepresented in the existing discourse, despite being more appropriate for describing processual spatial developments. Barke also refers to the work of Conzen (1960, 1962) and Whitehand (1972) and the concept of the burgage cycle, which are important references for this kind of analysis. As demonstrated in the study by Pinho and Oliveira (2009), the genesis of urban form may be illustrated through the digital redrawing of historical maps. In contrast to the aforementioned study, which employed Geographic Information System (GIS) software and conducted a comprehensive analysis of entire cities, this study was conducted at the neighbourhood level using Computer-Aided Design (CAD) software (ArchiCAD, https://www.graphisoft.com/). Significant components of this morphogenetic analysis were developed as part of research-led teaching on three courses at the Research Unit of Urban Design at TU Wien. All the courses exhibited uniformity in terms of their content, objectives and templates, which had been predetermined. The task assigned to each student was to utilise historical map material to visualize the morphogenetic development of a single linear settlement. To achieve this objective, the students employed CAD software to manually vectorise four time periods according to the following maps: *Franzsizeischer Kataster* (1817-1829), the *Franzisco-Josephinische Landesaufnahme* (1870s), the *Generalstadtplan* 1912 and the current state. The students were tasked with the marking of the corresponding farmstead footprints. This was based on an individual qualitative assessment using templates (special historical buildings such as churches, were also marked), was checked by the supervisors and subsequently corrected.[11] To verify the present situation, the students were required to conduct on-site inspections of the designated linear settlement and to confirm their mapping results. Accordingly, the supervisors also made on-site visits. To limit the respective study area around the linear settlements for the students' work, students and teachers determined an abstract 15-min catchment area using the web-accessible demo version of the Travel Time Map.[12] Furthermore, the supervisors of TU Wien added two further time periods to this morphogenetic analysis for the selected villages, based on two aerial photographs (1938, 1971).

2.2.2. Diachronic network analysis

The diachronic network analysis for Vienna and its surrounding area was carried out, following the methodology of the GIS-based

[11] The 60 maps that had been processed for this study were examined by the supervisors, who employed a four-eyes principle. This entailed overlaying the original plan with the students' maps. Within the linear settlements, inspections were conducted at the building level (with approximately 15% correction rate), while outside the villages, in the immediate vicinity, the mapped building stock was examined at the block level (with approximately 12% correction rate). Challenges involved were the correct positioning of the non-georeferenced maps and the accurate interpretation of building outlines, even with poor or distorted map material.

[12] https://app.traveltime.com/.

historical network model of Gothenburg produced in a previous study (Stavroulaki et al., 2019). Using space syntax network analyses (Hillier, 1996; Hillier & Hanson, 1984), diachronic changes in network centrality are presented in four time periods (2024 (current), 1971, 1938 and 1817-29) using angular betweenness centrality and angular closeness centrality.

As in the morphogenetic study, the historical networks were created using a principle of backwards engineering, starting with the existing network of 2024 (Intermodales Verkehrsreferenzsystem Straβengraph Wien). The open-source GIS platform QGIS was used (LTR 3.34.11). To recreate the situation in 1971, the situation in 2024 was used as a basis, with streets that did not exist at the time being removed or replaced by those that have since disappeared. The same method was used to create the situation in 1938 based on the situation in 1971, and so on working backwards in time. The historical data serving as basis for this process was the same cadastral maps (1817-1829) and aerial images (1938, 1971) already used for the morphogenetic analysis (Table 1). All four networks were converted into line-segment maps, cleaned up and edited using the Place Syntax Tool (PST),[13] to make them suitable for ASA (Angular Segment Analysis) for the calculation of the network centrality measures. The final street networks shown (Fig. 5) include both motorised and non-motorised streets.

To measure centrality and centrality shifts, angular closeness centrality and angular betweenness centrality were calculated using PST. Both measures can be used as indicators for movement patterns, whereby high values of closeness and betweenness centrality can be linked to increased pedestrian and vehicular flows (e.g. Hillier & Iida, 2005; Serra & Hillier, 2017, July; Stavroulaki et al., 2019), which in turn correlates with the concentration of activities and attractions, such as local markets (Marcus et al., 2017*)*. While angular closeness centrality is typically associated with density and mixed use - i.e. the potential location of urban centres - angular betweenness centrality generally provides information about the main movement structure or foreground network of the city. In urban centres, main streets tend to have a high degree of both betweenness and closeness centrality, linking city-wide movements to high local connectivity and accessibility. However, in urban peripheries, main streets typically do not have a high degree of closeness centrality, meaning that they mainly serve as connectors between locations, but fail to create local urban centres due to their poor connections to the local network.

Network centrality analysis allows conclusions to be drawn about linear settlements, and the role the main street of the settlement played in the street network during a given time period. In addition, information can be derived about the network centrality of the context surrounding the linear settlement in relation to the network centrality of the settlement itself. The PST was also used to illustrate changes in centrality values between different time periods. This allows to visualize centrality shifts between time periods due to network transformations (e.g. urban expansion or densification) as well as the recontextualization of the linear settlements and their main street because of these transformations.

2.2.3. Regional analysis

The regional study consists of a cartographic analysis and typological mapping. Comparable investigations including linear settlements were conducted by the already delineated Klaar (1942) with the *Siedlungsformenkarte* as well as in the preliminary studies by Tobisch et al. (2023) and Loeschenbrand et al. (2023). Furthermore, cartographic work focusing on agriculture or rural areas was carried out by Dachler (1909) and Schwarz (1989) in an Austrian context.

Within a 30 km radius, a mapping method drawing on historical and contemporary cartographic sources is utilised to identify the current frequency and distribution of historical linear settlements. Alongside the main case study in Vienna, three other study areas were used for a comparative European study involving French and Italian case studies, within the emc2 project (Fusco et al., 2024)[14]: Context Lille, Context Nice and Context Massa-Viareggio-Pisa. In a synchronised analysis, directly comparing the historical and current states, each settlement or village structure within the four study areas was qualitatively assessed to determine whether the respective unit could be classified as a linear settlement. Three parameters were used for this purpose: a central formative main street as a backbone, a historically compact linear village structure and the presence of historical buildings in today's situation. The central main street within a village, perceived as a straight line, formed the archetype. Three additional subcategories were also recognised, based on the village layouts observed: L-shape, Y/T-shape and cross-shape. With regard to compact settlement structures, historical map material was required to depict compact building arrangements on both sides of the street. The utilisation of online map services, such as Google Maps, equipped with a three-dimensional street view function, was employed to ascertain the contemporary existence of historical edifices.

2.3. Sources

The morphogenetic and diachronic network analysis were based on OGD data sets available on the City of Vienna website (City of Vienna, Geodatenviewer) or Open Data Austria: Franzsizeischer Kataster (1817-1829), Generalstadtplan (1912) and aerial photographs (1938, 1971). Additionally, the Arcanum web portal for historical maps was used to view the *Franzisco-Josephinische Landesaufnahme* (1870s for Vienna) for the morphogenetic study. For the regional analysis in Vienna and the comparative examples in France and Italy, material according to Table 1 was surveyed.

[13] https://smog.chalmers.se/projects/pst-plugin-for-qgis/- an open-source plugin for QGIS.

[14] Further information on the DUT research project "EMC2 – The Evolutive Meshed Compact City. A pragmatic transition towards the 15-min city for European peri-urban areas" can be found at: https://urbanism-tuwien.at/en/research/project/emc2.

Table 1
Overview of the analysed cartography.

Morphogenetic Analysis		
1817-1829	Franziszeischer Kataster	City of Vienna
1869-1887	*Franzisco-Josephinische Landesaufnahme*	Arcanum Maps
1912	Generalstadtplan	City of Vienna
1938	Aerial photograph 1938	City of Vienna, Geodatenviewer
1971	Aerial photograph 1971	City of Vienna, Geodatenviewer
2020s	Map	OpenStreetMap
Diachronic Network Analysis		
1817-1829	Franziszeischer Kataster	City of Vienna
1938	Aerial photograph 1938	City of Vienna, Geodatenviewer
1971	Aerial photograph 1971	City of Vienna, Geodatenviewer
2024	Administrative boundary	City of Vienna, data.gv.at
2024	Street Graph Vienna	City of Vienna, data.gv.at
2024	Transport Network, Lower Austria	City of Vienna, data.gv.at
Regional Analysis		
1817-1829	Vienna: Franziszeischer Kataster	Arcanum Maps
1820-1866	Lille: Carte de l'état-major	Remonter le temps
1836	Lille: Topografische Karte von Frankreich	Arcanum Maps
1820-1866	Nice: Carte de l'état-major	Remonter le temps
1836	Nice: Topografische Karte von Frankreich	Arcanum Maps
1818-1829	Massa-Viareggio-Pisa Franziszeische Kataster - Lombardei, Venedig, Parma, Modena	Arcanum Maps
1841-1843	Massa-Viareggio-Pisa: Originalaufnahme vom Kirchenstaate und von Toskana	Arcanum Maps
2020s	Map	OpenStreetMap

2.4. Data limitations

The quality of the historical map data was particularly relevant for the morphogenetic and regional analysis. The *Franziszeischer Kataster* is highly detailed and provides a relatively accurate representation of the situation at that time. Similarly, the *Generalstadtplan* (1912) enables more precise assumptions to be made due to its high level of detail. Conversely, the *Franzisco-Josephinische Landesaufnahme* exhibits a lower level of detail, with even rows of buildings represented as a single assemble, making the basis less specific. Although the aerial photographs from 1971 to 1938 are available at a high resolution, they cannot always be evaluated with certainty due to shading and contrasts. The historical map bases of France and Italy were less accurate and detailed than those of Austria. Consequently, due to the quality of the data source, greater tolerance of ambiguity is required within the qualitative classification process.

The working methods for morphogenetic and regional analysis are essentially based on qualitative approaches and individual assessment and categorisation. Clear templates and parameters for identification and evaluation were provided for students and researchers engaged in the morphogenetic analysis, as well as constant feedback for students throughout the process. This was an effort to minimise the error rate of the methodology to an optimum level.

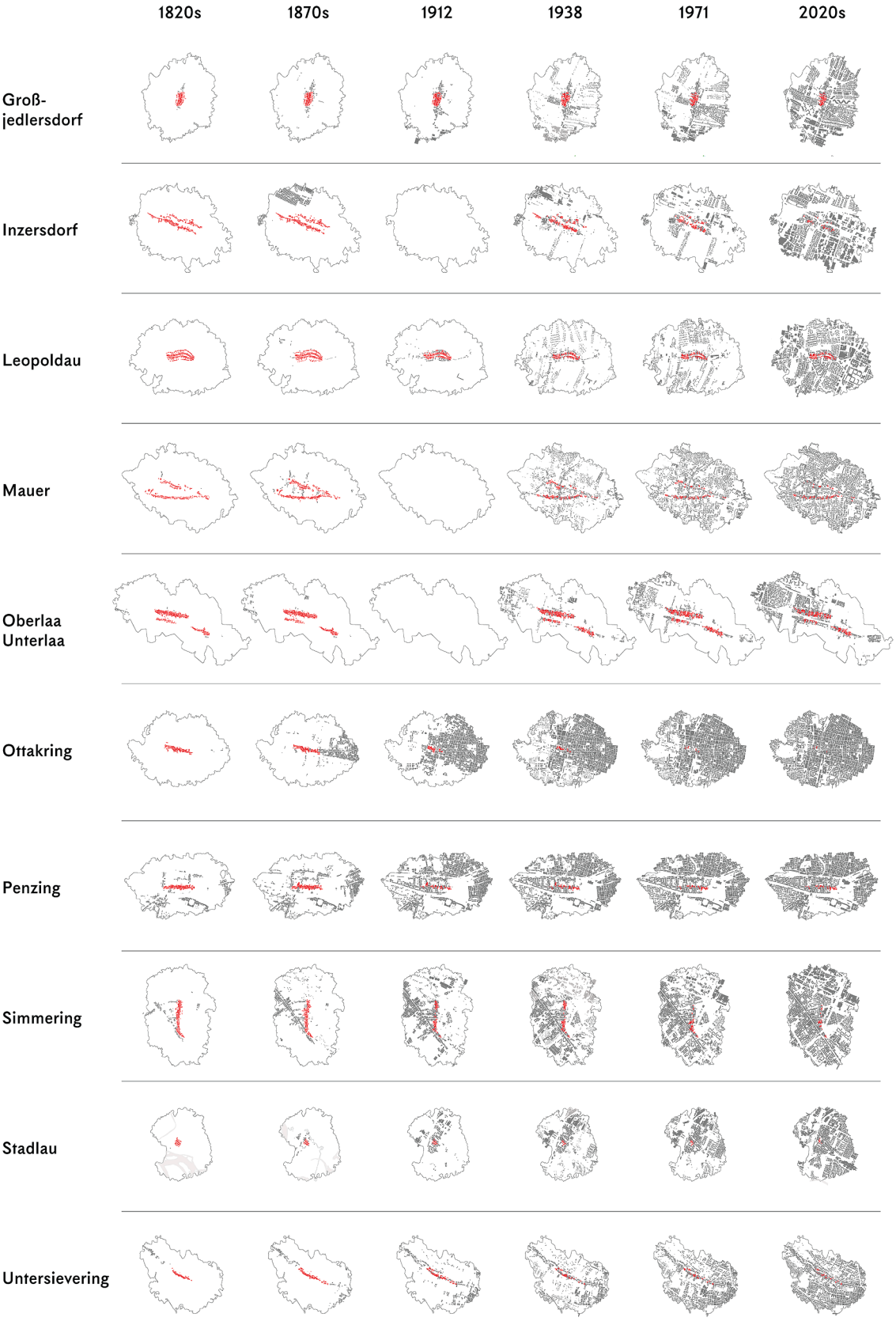
Due to the historical evolution of the city's boundaries, the *Generalstadtplan* (1912) does not encompass all linear settlement structures within the contemporary urban area of Vienna. This paucity of material has consequences for three villages (Inzersdorf, Mauer and Oberlaa) and consequently results in a missing time period for these settlements within the morphogenetic analysis. The diachronic network analysis includes the street network outside the administrative city boundaries to a certain extent. Although aerial photographs of Vienna occasionally capture areas beyond the city limits, the available data does not permit the delineation of a consistent study area beyond the administrative city limits. Moreover, the scope of the network analysis is limited in comparison to the morphogenetic study (i.e. less time periods included), due to the absence of supporting base data.

3. Results

3.1. Morphogenetic analysis

In the course of the research-led teaching activities at TU Wien, a total of 26 linear settlements were vectorised. Of these, 10 were selected for further evaluation. The selection criteria encompassed representativeness in terms of typology, geography and the extent to which the core structure had been transformed. The spatial developments of historical linear settlement over the last 200 years are illustrated by six time periods (Fig. 6). The study demonstrates how these settlements were either able to preserve their village structure or, during urban expansion processes in the context of the villages, transformed and integrated into a new urban fabric.

A range of urban developments can be observed within village structures depending on their geographical location and proximity to the city centre. The villages in the west of Vienna - Ottakring, Penzing and Untersievering - are in closer proximity to the city centre than the other settlements. In Ottakring and Penzing, the period of 1875 already demonstrates the expansion of the city during the period known as *Gründerzeit*. The context surrounding Untersievering also began to take shape when several villas belonging to wealthy Viennese residents were constructed in these locations northwest of the city centre (Bobek & Lichtenberger, 1978). Concurrently, the expansion of local public transport in the latter half of the 19th century, involving various types of tramways,



(caption on next page)

Fig. 6. Morphogenetic diagrams of the 10 selected linear settlements in Vienna within the 6 time periods. Building footprints corresponding to original historical farmsteads as well as selected historic special objects (e.g. churches) are marked in red. © Loeschenbrand/Tobisch/Psenner. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

resulted in enhanced integration of villages such as Untersievering into the urban system. This development precipitated an increase in activity within select settlements that had already gained renown as leisure and day-trip destinations, particularly those in close proximity to vineyards.

The linear settlements in present-day eastern Vienna, on the other side of the Danube, also colloquially known as *Transdanubia*, were able to maintain their village self-sufficiency for a relatively long period, as they were separated from the urban developments though the river landscape until the Danube was regulated in the 1870s (Eigner & Schneider, 2005). The following bridges facilitated the development and subsequent urbanisation of these areas, with the initial spatial developments in the context of the villages of Groβjedlersdorf, Leopoldau and Stadlau becoming apparent later, visible in the maps of 1912.

Due to the partial lack of data for the situation around 1912, it is not possible to fully analyse the situation in the south of Vienna. The four linear settlements in question, namely Mauer, Inzersdorf, Oberlaa and Simmering, reflect four different characteristics. The village Mauer, located in the south-west, facilitates geographical comparisons with the linear settlements in the west of Vienna. The spatial development of the context of Inzersdorf is historically strongly linked to the growing brick industry in the 19th cent., which is located north in the context of the linear settlement. Due to its peripheral location, Oberlaa was not subject to significant surrounding influences or contextual spatial developments. The linear settlement of Simmering has been oriented slightly diagonally resp. parallel to one of Vienna's most important arterial roads. The process of intensive urbanisation and densification that has occurred in Simmering over the course of several decades has resulted in considerable spatial transformations within the linear settlement.

The degree of transformation for the respective linear settlement structures is assessed from the perspective of the main street, as this is the characteristic perspective of a linear settlement - formed by the main street and the adjacent buildings. The building replacement, i.e. whether today's building stock are historical farmstead types or can still be referenced as such despite adaptations, is described using three categories: limited transformation, medium transformation and significant transformation. The classification system is founded upon an evaluation of the morphogenetic diagram of the present state, and a qualitative assessment of whether the corresponding linear settlement structure still possesses village characteristics. In addition, an assessment is conducted to determine whether the course of the historic main street and the street profile have been preserved. To achieve this objective, the categories of unchanged, partly unchanged, or considerably changed were employed. These two assessments are supplemented and compared (Table 2) with parameters of the built context and the geographical environment.

The analysis of ten villages reveals a broad spectrum of transformations - from the preservation of the historical character, as observed in Leopoldau, Groβjedlersdorf and Oberlaa, to the almost complete dissolution of village architecture, as exemplified in Ottakring. Apart from the expected correlations between limited or medium transformation in building stock with unchanged street layout, no compelling patterns can be identified within the specified analysis parameters. Consequently, it is not possible to make overarching, generalised statements. In this particular context, it is imperative to consider each linear settlement on an individual basis, considering its spatial genesis in conjunction with all accompanying developments and parameters. It is important to note that the majority of the ten selected linear settlements are currently either partially or as an ensemble part of protection zones, within which more stringent building regulations are in force. The *Altstadterhaltungsnovelle* of 1972 led to the introduction of protection zones, which

Table 2
Analysis of transformations and corresponding parameters of the 10 selected linear settlements.

Linear settlement (LS)	Replacement Buildings (LS)	Transformation Street Layout (LS)	Urban Integration Context	Geography
Großjedlersdorf	limited transformation	unchanged original historical street layout	medium urban integration, patchwork environment	no significant topography and no waterbody
Inzersdorf	significant transformation	partly unchanged original historical street layout	medium urban integration, patchwork environment	moderate valley, parallel to a stream
Leopoldau	limited transformation	unchanged original historical street layout	high urban integration, patchwork environment	no significant topography and no waterbody
Mauer	medium transformation	unchanged original historical street layout	medium urban integration, scattered settlement environment	aligned along the slope/perpendicular to the hillside, hist. streams now channelled
Oberlaa	limited transformation	unchanged original historical street layout	limited urban integration, party still rural environment	moderate valley, parallel to a stream
Ottakring	most significant transformation	considerably changed historical street layout	high urban integration, consolidated urban environment	moderate valley, historical stream now channelled
Penzing	medium transformation	unchanged original historical street layout	high urban integration, consolidated urban environment	moderate hillside, parallel to a river
Simmering	significant transformation	unchanged historical street layout	high urban integration, consolidated urban environment	moderate hillside, historically strong relationship with the Danube
Stadlau	significant transformation	partly unchanged original historical street layout	medium urban integration, patchwork environment	no significant topography, historically strong relationship with the Danube
Untersievering	medium transformation	unchanged original historical street layout	medium urban integration, party still rural environment	in a valley alongside a stream

also included specific linear settlements. As delineated in the *STEP84* (City of Vienna – MA18, 1985), the six villages classified as limited or medium transformation in this research were designated as protected zones.

3.2. Results diachronic network analysis[15]

The network analysis maps (Fig. 7) illustrate key phases of urbanisation, such as the distinctive high-density structure of the *Gründerzeit* period around 1900 to the west and south of the city centre, as well as the continuous spatial development of eastern Vienna in the second half of the 20th century. The development of the eastern part of Vienna was predicated on the regulation of the Danube and the subsequent construction of bridges, which commenced in the 1870s. The impacts of this development are particularly evident in the angular betweenness centrality map of 1938 (Fig. 7, second from left).

By overlaying the network analysis maps from 1817 to 29 and 2024 with a map of the identified linear settlements in and around Vienna (Fig. 8), the spatial distribution of the villages in relation to the different centralities is revealed. Historically, a ring-shaped arrangement around the centre can be observed, promoted by geographical features such as the hilly landscapes in the west of Vienna and the Liesing River in the south, around which some villages are oriented (e.g. Mauer, Inzersdorf, Oberlaa). The ring is complemented by the villages in present-day eastern Vienna, which, as previously outlined, were not yet properly connected to the city centre at that time due to the unregulated Danube and the associated paucity of bridges. The comparison further demonstrates that the centrality of linear villages, as expected, has undergone a significant increase over the past two centuries, transitioning from lower medium or very low to higher levels. Ottakring and Penzing, for instance, have become firmly embedded within denser and centralised urban contexts and networks, with Ottakring serving as a prime example of the nearly complete dissolution of a linear settlement. However, a more detailed look reveals that different situations of linear settlements can be identified regarding the shifts in centrality (Fig. 9).

Especially the changes in the betweenness centrality demonstrate how villages relate to the foreground network (i.e. network of most central streets) in varying ways. Historically, linear settlements with their central main streets constituted an integral part of the foreground street network. Following two centuries of urban development and the evolution of the foreground network, it is now possible to identify four distinct situations or types: linear settlement that are still located on main street with increased centrality, linear settlement that are situated perpendicular to a street with high centrality, and linear settlements located parallel to or surrounded by main streets with high centrality (Fig. 9, bottom). The ten villages selected for the analysis can be classified in relation to the current foreground network as follows:

- On: Oberlaa, Untersievering
- Perpendicular: Leopoldau, Mauer, Ottakring, Simmering
- Parallel: Groβjedlersdorf, Inzersdorf, Penzing
- Surrounding: Stadlau

The analysis also enables the documentation of the magnitude of change between all time periods (Fig. 9, top). The centrality shift, or in this case the centrality increase, for the selected villages was classified according to three categories as low, medium and high:

- Low: Groβjedlersdorf, Leopoldau, Oberlaa
- Medium: Inzersdorf, Mauer, Penzing, Simmering, Stadlau, Untersievering
- High: Ottakring

3.3. Regional analysis

Based on the identification parameters, the study area of Vienna (within a radius of approx. 30 km) is characterised by 131 linear settlements, 31 of which are located within the city limits of Vienna (Fig. 10). These settlements are already identifiable in the *Franziszeischer Kataster* as compact linear structures, a feature which is still evident today in the form of historic farmsteads exhibiting linearity within the village layout. The topographical features of the Vienna Woods, characterised by their hilly terrain, are clearly visible on the map. With generally low settlement activity in this area, according to the definition of the types and selection parameters used, not a single linear settlement can be found there. With the exception of this western area, linear settlement types are distributed uniformly throughout the area extending beyond the city limits of Vienna. Some villages, although characterised by a certain degree of linearity in their layout, were excluded as they did not meet the selection criteria.

The other three study areas in Lille, Nice and Massa-Viareggio-Pisa present a differentiated picture in terms of the prevalence and territorial characterisation of the landscape by linear settlement types (Fig. 11). The context of Lille (northern France) also has a significant number of historical linear settlement structures, in total 59. Comparable situations to Vienna can be identified, for instance in the location in today's situation: as villages integrated into the urban fabric, as a faubourg, or as a predominantly agricultural unit in the suburbs. The study areas in Nice (southern France; 13 linear settlements identified in this study area) and Massa-Viareggio-Pisa

[15] The network centrality was also analysed in local scales (i.e. radius 2 km network distance around each street segment). The local centrality analysis revealed the same patterns as the global for the linear settlements. For the overall network analysis, please see Gandhi Romeborn et al. (2026).

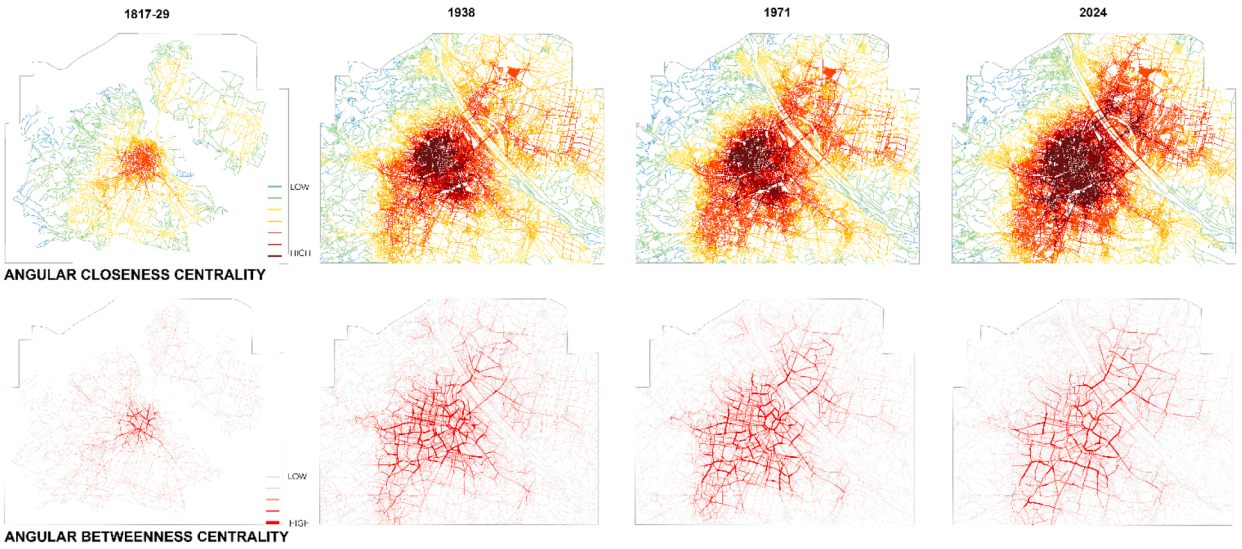


Fig. 7. Maps regarding the Diachronic Network Analysis of transformations and corresponding parameters of the 10 selected linear settlements. © Gandhi Romeborn/Stavroulaki/Berghauser Pont; Sources: see Table 1.

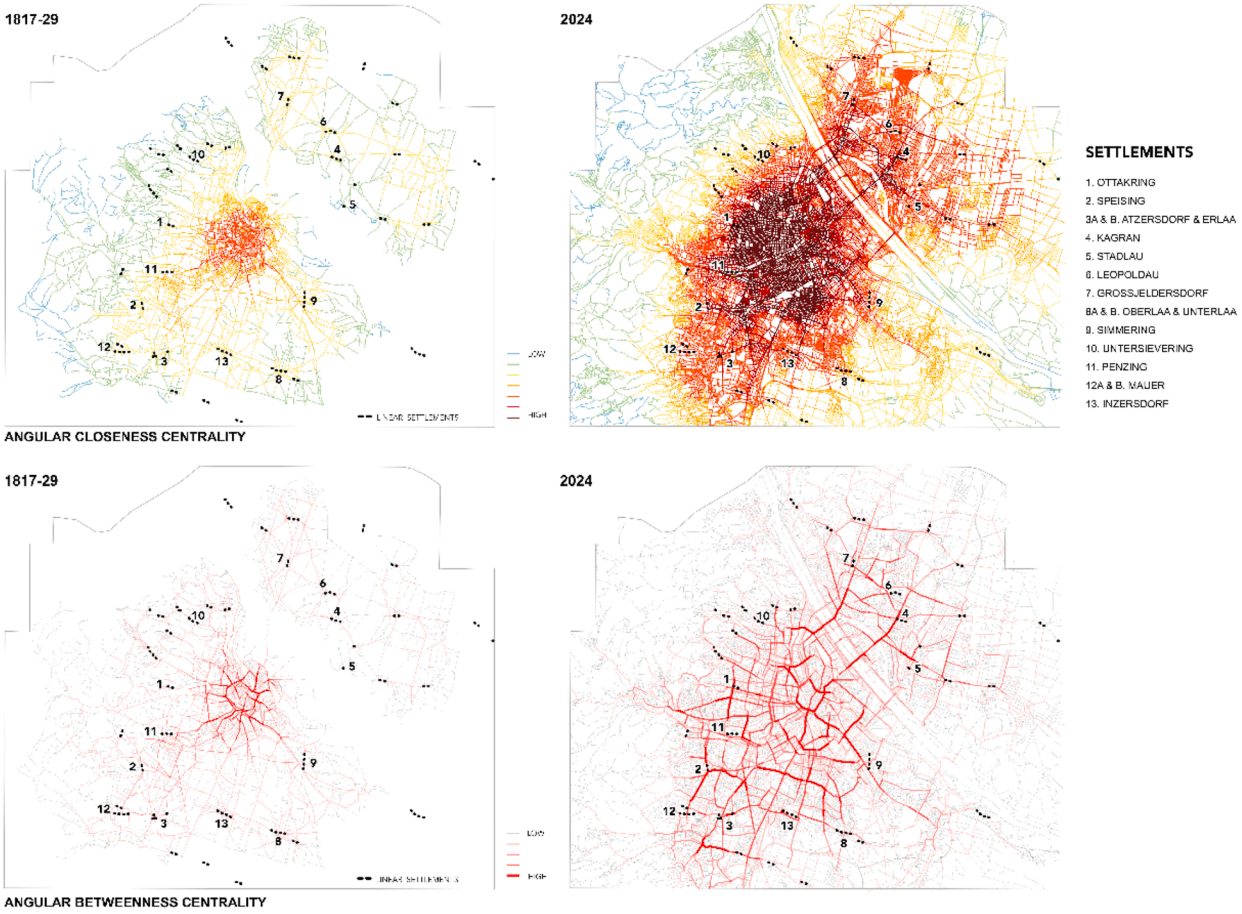


Fig. 8. Angular closeness centrality and angular betweenness centrality overlayed with selected linear settlements. © Gandhi Romeborn/Stavroulaki/Berghauser Pont.

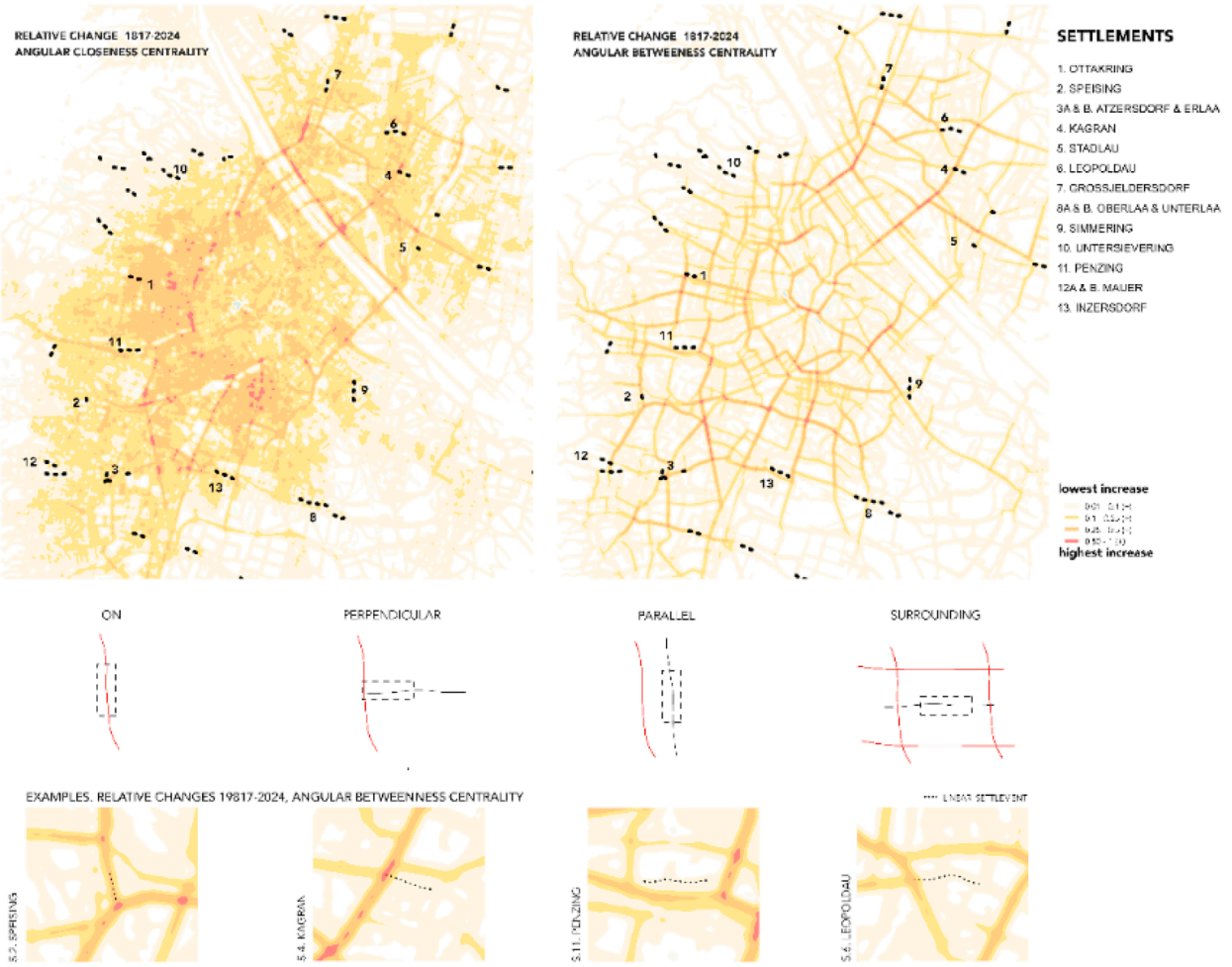


Fig. 9. Relative changes resp. increase in angular closeness (left) and angular betweenness (right) centrality (beige shows the lowest and red the highest increases) overlayed with selected linear settlements (top)
Typologies of recontextualization of the settlements in relation to the current main streets (bottom).
© Gandhi Romeborn/Stavroulaki/Berghauser Pont. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

(central Italy, 36 linear settlements identified in this study area) both reflect mountainous situations by the sea and present topographical constraints stronger than Vienna's western region. While linear settlement types are identifiable, they are not necessarily characteristic of the Nice and Massa-Viareggio-Pisa areas, with the exception of an area to the east of Pisa, in the Arno valley. The identified linear settlements demonstrate a strong correlation with the distinctive mountainous or hilly geography. The villages are situated in valley floors or on ridges, presumably due to their historical significance as defensive locations. It is interesting to note, that linear villages in Vienna are concentrated in valley floors at the foothills of the Vienna Woods. The presence of locations on ridges is uncommon in Vienna, which potentially corresponds with the significant value of land designated for viticulture.

Conducting a comparative analysis necessitated the incorporation of a consideration of regional styles into the investigative process. Even though the contexts of Vienna and Lille can be compared on a superior level, there are significant spatial differences at the village level. In comparison, the linear settlements in the context of Vienna form a more cohesive unit, characterised by a higher density of buildings in the centre. As illustrated in Fig. 12, linear settlements in the context of Lille frequently extend to a greater length compared to those in Vienna, and in specific study areas (Fig. 12, top right) they exhibit a network-like settlement pattern in their current state.

4. Discussion & conclusion

By employing the presented multi-scale approach, this research demonstrates how the ten studied historical linear settlements became part of today's Vienna and how they still characterise the metropolitan area. Additionally, within the framework of the regional analysis, comparisons are drawn with other European contexts. The morphogenetic study at neighbourhood level illustrates

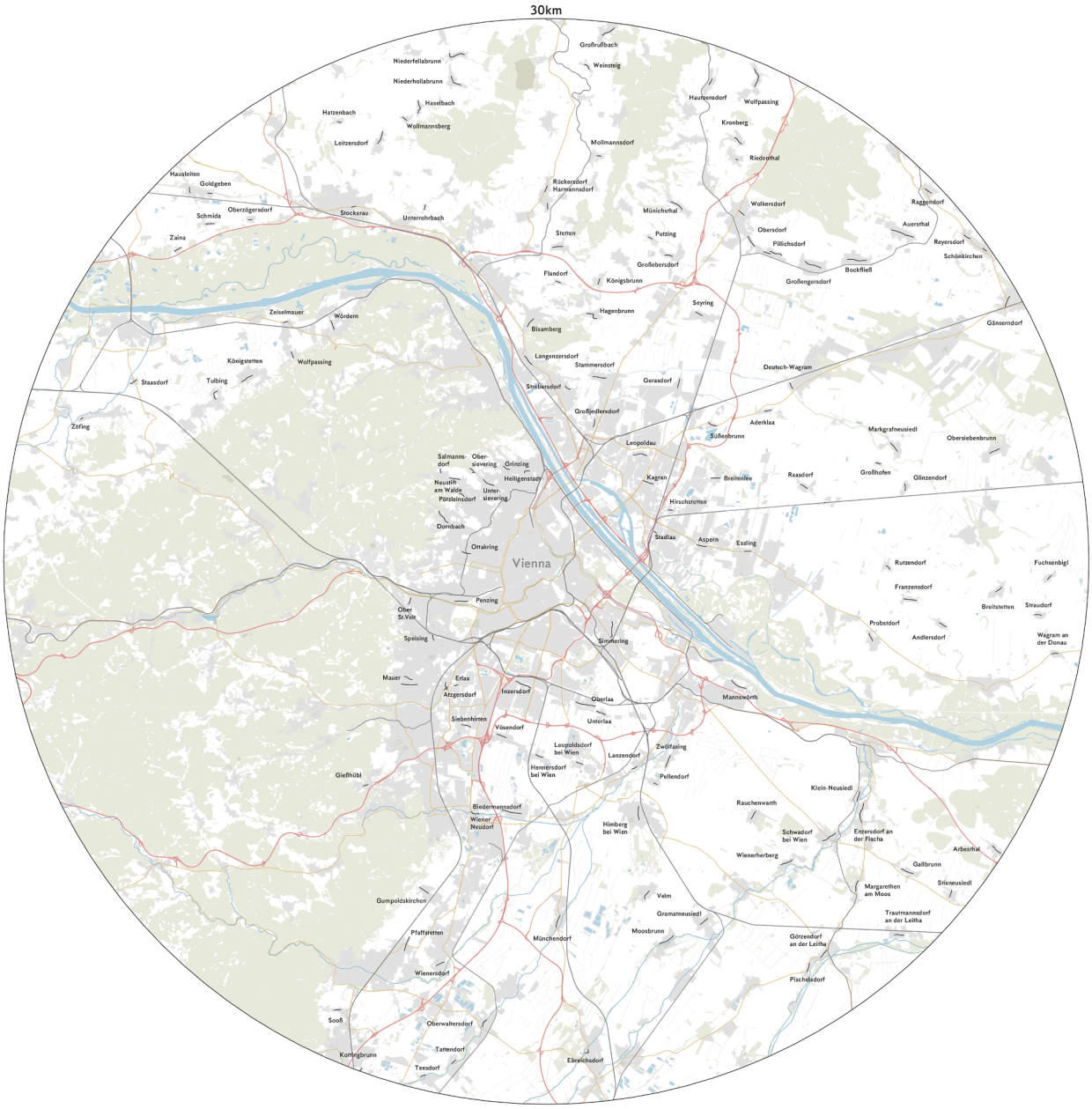


Fig. 10. Investigating and mapping linear settlements in and around Vienna, which are identifiable as a linear structure in the *Franziszeischer Kataster* and still exist today.
© Loeschenbrand/Tobisch/Psenner. Source Map Basis: OpenStreetMap.

how these historical linear villages, which have been incorporated into the urban fabric have evolved. The investigation addresses the variety of different influencing factors (Table 3) within the genesis of linear settlements in Vienna. The role and importance of the characteristic main street within the street network is of particular significance, as illustrated by the diachronic network analysis and the resulting centrality measurements.

The results of the morphogenetic analysis and diachronic network analyses are combined using a co-occurrence matrix, which illustrates how frequently combinations of parameters from both analyses occur (see Table 3). This cross-analysis reveals no clear patterns, except for the relationship between the degree of morphological transformation of the ten settlements and the extent to which their centrality increases due to broader city-scale network transformation. For instance, the linear settlement Ottakring, which underwent the greatest morphological transformation, is the settlement that exhibits the biggest increase in centrality. The three villages that were examined with limited building transformation (i.e. Leopoldau, Großjedlersdorf and Oberlaa) are characterised by a low centrality increase. The linear settlements with medium centrality increase have either medium or significant transformation.



Fig. 11. Further study areas in the contexts of Lille (FRA), Nice (FRA) and Massa-Viareggio-Pisa (ITA) for comparative analysis. © Loeschenbrand/Tobisch/Psenner. Source Map Basis: OpenStreetMap.

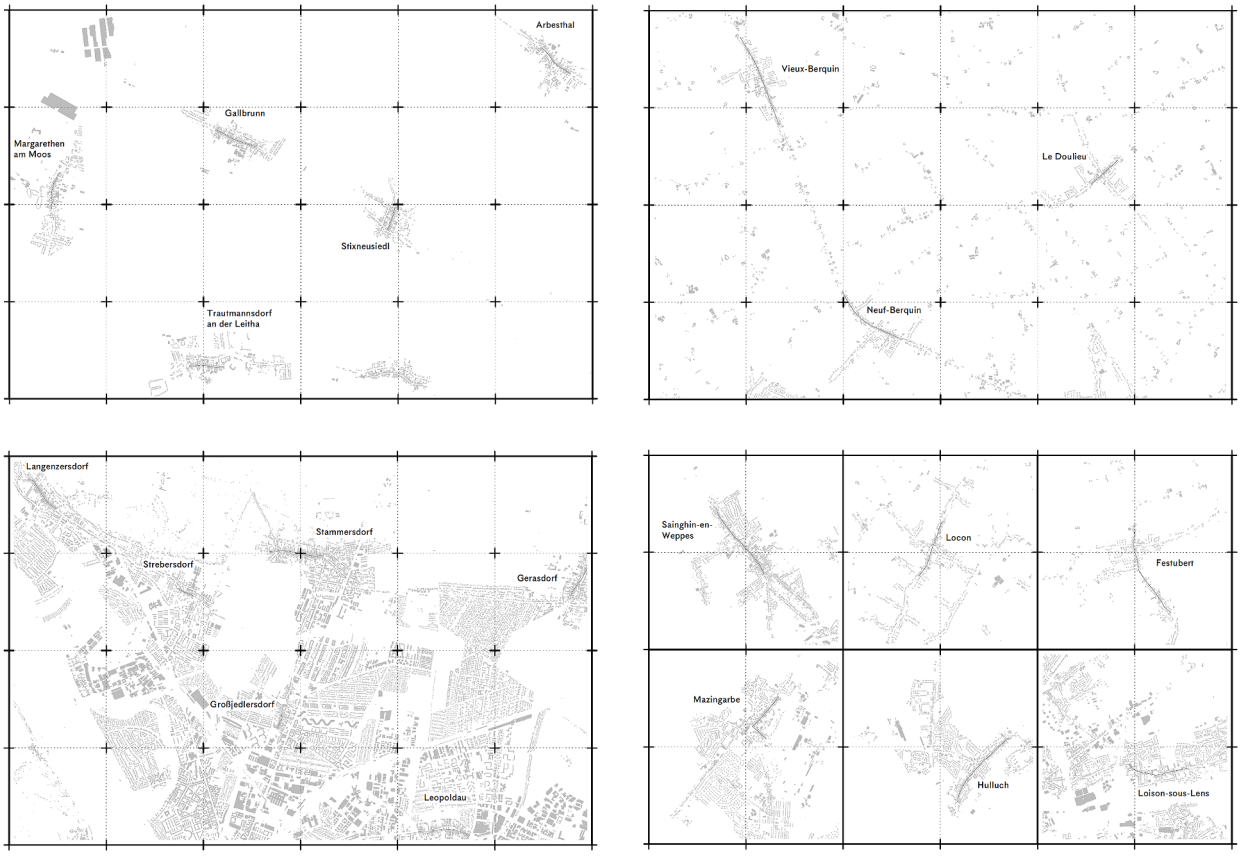


Fig. 12. Selected excerpts from the study areas in the context of Vienna (left) and Lille (right) to analyse settlement patterns. The black centre line on the maps in the individual villages approx. marks the extent of the historic centre according to historical map material. © Loeschenbrand/Tobisch/Psenner. Source Map Basis: OpenStreetMap.

Accordingly, correlations between the network centrality increase and the building resp. morphological transformation can be identified within the studied linear settlements. This is in line with the findings of the Space Syntax literature which show that increased network centrality creates the conditions for higher building densities, intense land exploitation and development of mix land uses (Van Nes et al., 2012; Berghauser Pont et al., 2019; Hillier, 1996). Another finding is that most of the historical main streets of the linear villages no longer function as the main streets of the neighbourhood and are no longer part of the foreground street network of the city, the one that combines local accessibility with city-scale connections.

Table 3
Co-occurrence matrix between morphogenetic analysis and diachronic network analysis.

Diachronic network analysis			Morpholoigcal resp. morphogenetic analysis															
			Replacement Buildings (LS)			Transformation Street Layout (LS)			Urban Integration			Context				Geography			
			limited transformation	medium transformation	significant transformation	unchanged hist. street layout	partly unchanged hist. street layout	considerably changed hist. street layout	limited urban integration	medium urban integration	high urban integration	party still rural environment	scattered settlement environment	patchwork environment	consolidated urban environment	significant topography	no significant topography	significant waterbody	no significant waterbody
	Position LS to current foreground network	On	1	1	0	2	0	0	1	1	0	2	0	0	0	2	0	2	0
		Perpendicular	1	1	2	3	0	1	0	1	3	0	1	1	2	3	1	1	3
		Parallel	1	1	1	2	1	0	0	2	1	0	0	2	1	2	1	2	1
		Surrounding	0	0	1	0	1	0	0	1	0	0	0	1	0	0	1	1	0
	Centrality increase	Low	3	0	0	3	0	0	1	1	1	1	0	2	0	1	2	1	2
		Medium	0	3	3	4	2	0	0	4	2	1	1	2	2	5	1	5	1
		High	0	0	1	0	0	1	0	0	1	0	0	0	1	1	0	0	1

Table 4
Overview of the analysed cartography for the French Riviera.

Excursus: Specific regional analysis on French Riviera
Historical cadastral maps (*Cadastre Napoléonien*), with the Var River marking a politico-historical divide in the study area: cadasters from 1809 to 1835 to the west, and from 1862 to 1875 to the east.
Recent orthophotography (2012–2023) from Google satellite imagery.
Building footprints from the IGN BD TOPO database (15/12/2023), provided as 2D polygon vector data. Attribute data include construction or appearance dates for approximately 38% of buildings.
Named road networks from the IGN BD TOPO database (15/12/2023), provided as 2D polyline vector data.

On a larger scale, the regional analysis conducted for this study highlights the characteristic prevalence of this type of settlement in Vienna and the surrounding area. The selection parameters identified more than 130 linear settlements in and around Vienna. Although the study area in Lille also exhibits a characteristic number and arrangement of historic linear settlements, and certain cross-comparisons can be made with the Viennese context, there are more than twice as many identified historical linear settlements in the study area of Vienna that are still present as such today. In general, the regional analysis and associated comparative study of research areas in Lille, Nice, and Massa-Viareggio-Pisa highlighted the influence of geographical conditions on linear settlement patterns. Based on the methodology employed, the study area in Nice yielded the fewest identified examples of linear settlements, although structural linear patterns are present within the study area.

- Excursus: Specific regional analysis on French Riviera: In a separate study, a more thorough assessment was conducted for the French Riviera area around Nice. Historical cadastral maps from the 19th century were used to identify all settlements that have persisted to the present day. Utilising a similar methodology as in the regional analysis, an evaluation of historical maps and contemporary conditions (see Table 4) was conducted to identify historically and currently relevant settlement types in the French Riviera based on the configuration of their main axes. This approach diverges from the methodology employed before, wherein classification was predominantly informed by built structures. The French Riviera is known to be characterised by the presence of many compact hilltop villages (Raybaud & Chiappello, 2020; Reclus, 1864). One of the objectives of this work was thus to understand whether linear settlements played any role in structuring early urbanization in the study area. For this, a specific typology of settlement forms was developed, distinguishing linear structures, simple-shaped surface-like structures and complex-shaped surface-like structures (Fig. 13). This typology was confronted with empirical data, namely 19th century cadastral maps of settlements in the study area. The main finding is that linear settlements constitute an important feature of traditional urbanization even in the French Riviera. They account for more than half of the traditional settlements (namely 44 out of 80), including linear villages and faubourgs. One-axis structures and three-axis Y structures are the most frequent. Coastal faubourgs (in Nice, Cannes, Cagnes-sur-Mer, Menton) are typically built around one axis, although Carras, in Nice, is Y-shaped. Many simple one-axis linear structures, and the few two-parallel-axes structures, are built on hill flanks (with or without access to a waterbody), but single-axis settlements can also be found on ridges (like Colomars). Ridge and hilltop sites favour both V and Y-shaped linear structures, ring structures, and pinecone structures. The latter are very specific to the French and Italian Rivieras and consist of a few parallel streets following the contour lines of a hilltop or promontory, without forming a closed ring, and connected by several irregularly disposed small streets. Grid-based structures are typically planned (like the bastide towns of Valbonne and Mouans-Sartoux) and situated on the plain or on gently sloped flanks.

Despite having similar objectives – specifically, identifying historical linear settlement patterns that have been preserved – the two studies of the French Riviera diverge in terms of their methods and results. The results of the evaluation whether the villages in their historic, compact form can be classified as linear, does not reveal any characteristic distribution of linear settlements around Nice. However, the study based on the configuration of the primary axes reveals that many historical villages and settlements exhibit linearity. The specific regional analysis of the French Riviera, which was conducted as a subsequent element of the general regional analysis, underlines the significance of the methodology and objectives employed. Shifting the primary indicator from built structures to street axes enables a substantially different evaluation of the linear character of historical village settlement types on the French Riviera. Despite the existing typological and morphological characterisation of the methods employed in the regional analysis and the morphogenetic analyses, further scope for in-depth typo-morphological analysis remains, particularly at the building level. (see

10 MORPHOTYPES		Valley / Plain	Flank to Waterbody	Flank	Ridge Hill-Top
1 Axe I		Saint-André-de-la-Roche	Cap d'Ail	Touët-de-l'Escarène	Castagniers
2-parallel Axes //		La Trinité	Villeneuve-Loubet	Le Tignet	La Roquette-sur-Var
2-convergent Axes V			Théoule-sur-Mer	Le Bar-sur-Loup	Contes
3 Axes Y		La Colle-sur-Loup	Roquebrune-Cap-Martin	La Roquette-sur-Siagne	Cagnes-sur-Mer
4 Axes Y		Le Rouret		Spéracèdes	

10 MORPHOTYPES		Valley / Plain	Flank to Waterbody	Flank	Ridge Hill-Top
Ring				Vence*	Aspremont
Pinecone			Villefranche-sur-Mer	Peille	Berre-les-Alpes
Grid		Mouans-Sartoux	Saint-Laurent-du-Var	Valbonne	Castellar
Large Complex Surface (LCS)		Sospel	Antibes	Grasse*	Menton*
Assemblage*		Vallauris	Nice Centre	Saint-Jeannet	Tourrettes-sur-Loup

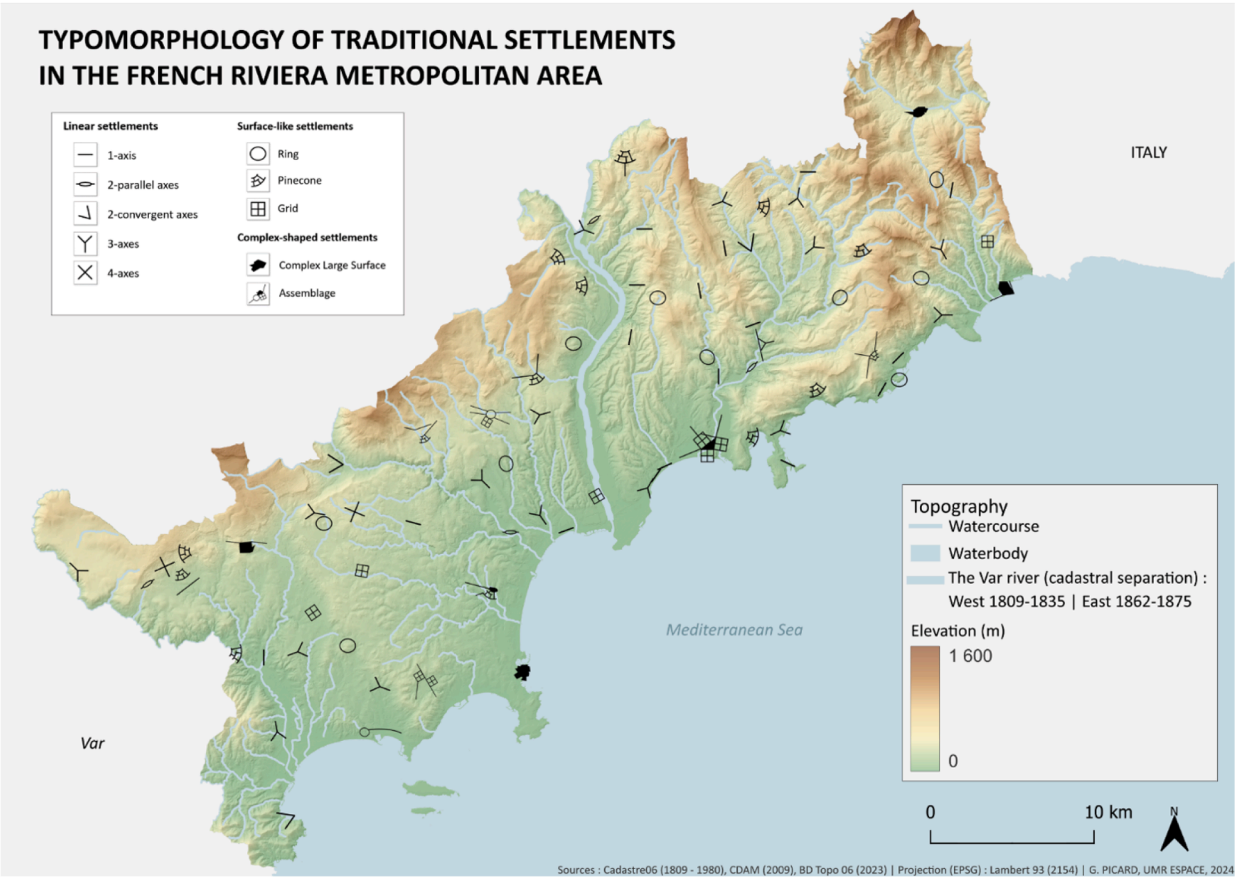


Fig. 13. Overview of the 10 defined morphotypes in the French metropolitan area (top). Map of the French metropolitan area with identified traditional settlements (bottom). © Fusco/Picard.

Caniggia, 1963; Caniggia & Maffei, 2001; Conzen, 1960, 1962; Muratori, 1959, 1963).

In addition to spatial or morphological perspectives, the linear settlements also form distinctive socio-spatial points of identification in the urban fabric of Vienna: linear settlements as part of leisure activities offered in the city of Vienna and as excursion

destinations[16], as typology linked to the identity-forming viticulture.[17] More research is required to explore this characteristic in relation to spatial points of identification (Lynch, 1960) or place identity. Furthermore, there is the potential for additional insights to be gleaned from this research, or for it to be contextualised in other debates:

1) As delineated, the current state of the art on the typology of linear settlements from an urban and spatial planning perspective in an Austrian context is limited and has room for further contributions. The presented paper has been composed principally from a German-speaking perspective. It is evident that transnational studies which engage researchers e.g. from the former spheres of influence of the Habsburg monarchies hold considerable potential. The preliminary study by Loeschenbrand et al. (2023) and the work by Judith Leitner, (2024) on the topic of *Angerdörfer,* conducted in collaboration with universities in Vienna and Brno, could serve as a basis for further research.
2) This study of *Straßendörfer* and *Angerdörfer* is the first to provide an extensive analysis of these settlement types in the context of Vienna. However, the scope of this study did not allow for the full exploration of all relevant aspects, necessitating further research to fully understand the distinctiveness and representativeness of linear settlements in Vienna. For instance, investigating the different functional roles of individual linear settlements within today's urban area could reveal additional shaping effects and provide valuable insights. This could include the potential further development of these village structures within the context of the 'city of short distances'. As stated in the introduction, the specific locations of the linear settlements in Vienna and their associated spatial qualities exhibit potential for enhanced integration into future polycentric urban developments. The distribution of the villages is of particular interest in relation to chrono-urbanism concepts, given that many are within a 30-min walking distance of each other.

3) In future research, this correlation could be extended by also including historical and contemporary points of interest (POIs). In the context of the emc2 research project, Mara et al. (2025) produced a diachronic network analysis of Versilia, with additional consideration of current commercial establishments, specifically an evaluation of bars, clothing stores, supermarkets and gas stations in the current network. Research and mapping of historical uses are usually time-consuming and based on the availability of the relevant historical data sets. Nevertheless, Psenner (2023) has demonstrated the added value and detailed insights into the urban fabric that can be gained through integrated archival research with historical uses, as outlined in her methodology 'Urban Parterre Modelling' (Psenner, 2023). Accordingly, a combination of the three aspects - the built environment, the network as well as historical and current uses - within a diachronic analysis would be highly promising.

The typological and settlement related patterns concerning linear settlements have been formative for large parts of today's Vienna. In addition to the spatial patterns, the presented studies furthermore aimed to investigate the genesis and attributes of historical linear settlements in the context of the Austrian capital city. In comparison with Vienna's more prominent building typologies, such as *Gemeindebau* or *Gründerzeit*, linear settlements are comparatively marginalised. Despite their rural origins and location outside the consolidated urban area of Vienna, these linear villages can exert influence on highly relevant urban planning issues. The spatial attributes of this typology, including the specific settlement layout and geographical distribution, address contemporary human-scale topics in urban design (e.g. 15min City) and have the potential to emerge as a point of interest for future urban polycentric developments in peripheral areas in Vienna. However, this study, which is based on the Vienna case study, is also intended to provide valuable insights for other cities with comparable spatial and geographical configurations. A thorough understanding of the typological and morphological characteristics of the selected settlement patterns, particularly the processes of urban incorporation and transformation, is essential for (their) future development.

CRediT authorship contribution statement

Daniel Loeschenbrand: Writing – review & editing, Writing – original draft, Visualization, Methodology, Investigation, Data curation, Conceptualization. **Ioanna Stavroulaki:** Writing – review & editing, Visualization, Methodology, Investigation, Data curation. **Susanne Tobisch:** Writing – review & editing, Visualization, Methodology, Investigation, Data curation, Conceptualization. **Giovanni Fusco:** Writing – review & editing, Writing – original draft, Visualization, Supervision, Methodology, Data curation, Conceptualization. **Tanja Gandhi Romeborn:** Writing – review & editing, Visualization, Methodology, Investigation, Data curation. **Grégoire Picard:** Methodology, Investigation. **Meta Berghauser Pont:** Writing – review & editing, Supervision. **Angelika Psenner:** Writing – review & editing, Supervision.

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work the authors used DeepL in order to improve the grammar and readability of text. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

[16] https://www.wien.gv.at/freizeit/stadtwanderwege.
[17] https://www.wien.gv.at/stadtplanung/weinbau-in-zahlen.

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Declaration of competing interest

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