Mapping informal/formal morphologies over time: Exploring urban transformations in Vietnam

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ABSTRACT

The emergence of informal settlements in the Global South has been at the centre of debates regarding sustainable development. While the visibility of informal settlements has been recognised as an important issue in the politics of upgrading projects, there is limited studies that systematically explore the development of informal settlements over time. This study primarily uses historical maps and satellite images as the main sources of data and adopts urban mapping as a key analytical method to conduct a study of the relations between informal and formal morphologies in the context of Hanoi and Ho Chi Minh City (HCMC) over 120 years. The research findings reveal that informal morphologies in Hanoi and HCMC have increased at different rates over the observed period. The study also finds that the development of informal/formal morphologies vary depending on the distance from the city core to peri-urban areas. By providing a better understanding of the formation and transformation of informal/formal morphologies over an extended period, the findings of this study highlight the need for a radical shift in current urban policies towards an integrated urban planning and design process that can more effectively address the relationships between informal and formal morphologies over time.

1. Introduction

Improving living conditions in informal settlements has been recognised as a key principle for sustainable development, particularly concerning safe and affordable housing (UN-Habitat, 2003, 2015, 2022). Poor-quality housing poses physical safety risks associated with natural disasters and fire, while limited accessibility for emergency vehicles exacerbates these challenges (Quesada-Román, 2022). Informal settlements have further become a critical challenge in the context of the COVID-19 pandemic as residents of these neighbourhoods endure a wide range of deprivations that negatively impact their health and well-being (Kamalipour & Peimani, 2021; Nyashanu et al., 2020; Parikh et al., 2020). Occupants without adequate sanitation and waste disposal facilities are particularly susceptible to disease, and overcrowding, inadequate ventilation, and a lack of clean water are critical risk factors for infectious and respiratory diseases (Sekhani et al., 2022; Sethi & Mittal, 2020). The insufficient living space in overcrowded informal settlements makes physical distancing and self-quarantine almost impractical, heightening the danger of rapid infection spread. There has been a growing call for immediate action to improve living conditions in informal settlements.

For the past few decades, the need to improve living conditions in informal settlements has been on the agenda of relevant organisations and/or initiatives, such as *Cities Without Slums*, the *Millennium Development Goals*, and the *Sustainable Development Goals*. While living conditions in many informal settlements have been improved, the number of dwellers in informal settlements has increased (UN-Habitat, 2010, 2022). Much of the new informal settlements emerge in Asia and Africa, where rapid urbanisation is taking place (United Nations, 2019). Various approaches have been employed to explore informal settlements, utilising observation, surveys, and/or mapping based on high-resolution satellite images to illustrate physical characteristics, such as access networks and building densities. However, the spatial development and expansion of these settlements over time remains underexplored.

To enable more nuanced approaches towards the upgrading of informal settlements, it is important to more effectively and closely explore the morphologies of these settlements in relation to their visibility (Dovey & King, 2011; Kamalipour, 2023, 2024; Kamalipour & Dovey, 2019). Various terms, such as "arrival cities", "poor urban areas", and "deprived areas", have been used to describe informal settlements (Kraff et al., 2020; Saunders, 2011; Taubenböck et al., 2018;

Thomson et al., 2020). Informal settlements are often politically referred to as "slums" to promote redevelopment projects (Gilbert, 2007; Thomson et al., 2020). These perspectives tend to be restricted to the geometry of urban spaces rather than the coherence between community needs and the configurational structure of such areas (Glaeser, 2011). To avoid the terminological imprecision of "slum" and "poor urban areas", we view informal settlements as a mode of urban development (Dovey, 2019; Roy, 2005). This approach allows for a broader perspective on urban informality as informal settlements are by no means homogeneous in terms of physical appearance and living conditions (Baud et al., 2010; Gilbert, 2007; Graesser et al., 2012; Taubenböck et al., 2018). Dovey and Kamalipour (2018) conducted a comparative study on the typologies and morphologies of informal settlements, resulting in the development of a non-binary classification approach for exploring informal/formal urban morphologies. The versatility of this approach has enabled its application across various contexts and integration into diverse databases for studying informal urbanism.

This paper aims to explore how forms of urban informality can be mapped, by undertaking a comparative exploration of historical maps and relevant databases. Using Hanoi and Ho Chi Minh City (HCMC) as case studies, this study primarily conducts a chronological mapping of the relations between informal and formal morphologies, as developed by Dovey and Kamalipour (2018), over a span of 120 years. This paper seeks to address the following research questions: (1) How do historical landscapes and urban development processes contribute to the formation and transformation of informal morphologies? And (2) How do the relations between informal and formal morphologies change during the urban development process? The outcome of this study illustrates how informal morphologies change over time. This highlights the need for a radical shift in current urban policies towards an integrated urban planning and design process that can more effectively address the relationships between informal and formal morphologies. The following sections include a review of relevant literature on informal settlements, an explanation of the research methods, including the mapping process, a detailed analysis of informal/formal morphologies across the selected case studies, and an informed discussion of the key findings in the context of related literature.

2. Research background: Mapping and classifying informal settlements

2.1. Mapping informal settlements

It is important to adopt systematic approaches to digitally explore the formation and growth of informal development (UN-Habitat, 2015). In the field of urban morphology, scholars have generally studied urban changes using maps and relevant materials, adopting a historic evolutionary perspective to understand cities, towns, and villages (Conzen, 1960). Such morphological studies explore the city as the product of the interaction between the natural environment and man-made settlements, including unplanned and planned morphologies (Burdett & Philipp, 2018; Debray et al., 2023). The study of urban forms not only helps illustrate the characteristics and changes in the built environment but also provides references for application in relevant fields, such as urban planning, architecture, and public policy, and serves as a guide for urban regeneration and sustainable development (Dovey & Ristic, 2017). The urban studies and mapping practices focusing on informal settlements can enable the improvement of living conditions and infrastructure through micro and macro interventions (Tjia & Coetzee, 2022; Abbott, 2003; Archer et al., 2012), prediction and simulation of informal development (Badwi, El_Barmelgy, & El_Din Ouf, 2022; Augustijn-Beckers et al., 2011), and determining hazard areas (Stevens et al., 2020; Taylor et al., 2020). Urban mapping can also provide a better understanding of how morphogenesis and informal codes work in informal settlements (Dovey et al., 2020; Iranmanesh & Kamalipour, 2023; Kamalipour & Dovey, 2020; Thinh et al., 2023). Urban planners

and developers also need spatial databases to track urban development, facilities, and essential services (Chakraborty et al., 2015; Bishop et al., 2000). Mapping of informal settlements can contribute to the development of databases that can be shared and used by various development agencies.

While data on informal settlements have been recognised as critical in policy and planning contexts, the challenge lies in collecting and analysing relevant data (UN-Habitat, 2015; Kamalipour & Peimani, 2023; Kamalipour, 2024; Thomson et al., 2020). Informal settlements in the Global South often remain invisible (Dovey & King, 2011; Kamalipour & Dovey, 2019). Although surveys have been widely used in recent years, they often provide numerical data. Accessing spatial data in the Global South context is difficult for non-governmental agencies and researchers (Bishop et al., 2000). Moreover, the quality of data is generally limited as formal development plans often overlook informal settlements. The methods for classifying the built environment often fall short in capturing the dynamics of informal settlements. Census data are generally insufficient to explore the spatiality and dynamics of informal settlements. Community mapping, urban surveys, and direct observation in selected case studies are considered useful for data collection (Panek & Sobotova, 2015; Archer et al., 2012; Karanja, 2010), yet such data are not frequently updated. There is still work to be done to connect these mapping efforts and spatial information to relevant databases. Using these methods also poses critical challenges when it comes to exploring the dynamics of informal settlements in challenging contexts.

With the availability of satellite images and development of image processing approaches, recent studies have examined the patterns and development of informal settlements using different sets of indicators (Cinnamon & Noth, 2023; Kraff et al., 2020; Kuffer et al., 2016; Mudau & Mhangara, 2022; Taubenböck et al., 2018). Studies using satellite images from databases such as Google Earth face limitations as high-resolution images are generally available since the early 2000s. Although Landsat images can be useful for tracking urban development since the 1970s, it is challenging to capture incremental development and informal growth due to low resolution. While the urban landscape from the late 1950s onwards can be explored using aerial photographs, the relevant databases are primarily limited to cities in the Global North. It is quite challenging to effectively and consistently map the formation and development of informal settlements throughout history in the Global South.

When considering the urban landscape in the Global South since the early 20th century, historical maps are often among the only available resources. While historical maps can offer promising data, they also present a number of challenges. Some of the key challenges of using historical maps include a lack of or limited land categories available within the legend, scale issues, different coordination systems, and, to some extent, exaggeration of certain geographic features such as roads, bridges, and important constructions. There are documented examples of the use of historical maps to explore changes of the built environment and historic landscape over several decades to centuries (Connolly, 2019; Han et al., 2017; Levin et al., 2013; Shen & Dong, 2022). To overcome the challenges, satellite images and recent maps have been utilised for georeferencing (Connolly, 2019; Levin et al., 2013; Schaffer & Levin, 2015). Other sources, including thematic maps, historical documents, and relevant planning documents, can be used to cross-check and analyse the built environment (Shen & Dong, 2022). Only a few studies have explored forms of informality and their adaptations throughout history (Connolly, 2019; Han et al., 2017; Seo & Lee, 2019; Silva et al., 2015; Spolaor & Oliveira, 2022). The spatial characteristics of informal settlements and the factors impacting them over time remain overlooked in urban studies (McCartney & Krishnamurthy, 2018; Samper et al., 2020).

2.2. Dynamics and classification of informal settlements

While numerous studies have examined informal settlements,

knowledge about the growth and dynamics of informal morphologies in the Global South is still limited in the literature. It has been shown that the growth of informal settlements is associated with different factors, including rapid population growth, shortage of affordable housing, rural-to-urban migration, and/or lack of financial investments (Abebe, Derebew, & Gemeda, 2019; Alene, 2022). The formation of informal settlements is also influenced by local characteristics, including location and proximity factors, neighbourhood features, and site-specific attributes (Dubovyk et al., 2011; Kohli et al., 2012; Kuffer et al., 2016). Several methods have recently been used to explore and classify forms of informal settlement with a primary focus on their morphologies and typologies (Dovey & Kamalipour, 2018; Dovey & King, 2011; Thinh et al., 2023), morphogenesis (Alegría & Dovey, 2022; Dovey et al., 2020; Kamalipour & Iranmanesh, 2021; Thinh & Kamalipour, 2022; Zhang et al., 2020), building density, building height, and building distances (Kraff et al., 2020; Taubenböck et al., 2018; Taubenböck & Kraff, 2014), physical appearances, land tenure, and housing design (Chung, 2010; Yang et al., 2022), and stages of developments (Park et al., 2019; Samper, 2024). Much of these explorations focus on selected case studies in specific contexts. The adaptations of informal settlements over time and their relationship with surrounding urban areas remain underexplored. Little is known about how historical landscapes and urban development contribute to the formation and growth of informal settlements at a metropolitan scale.

Differences in how various institutions and researchers define informal settlements can lead to uncertainties in classification and mapping processes (Acolin & Kim, 2022; Connolly, 2019; Kohli et al., 2012; Kohli et al., 2016; Pratomo et al., 2017). The term "informal settlements" is often used interchangeably with "slums" and "deprived areas" in relation to practices of demolition and resettlement (Gilbert, 2007; Thomson et al., 2020). Informal settlements are generally situated on public or private land and do not typically comply with local planning and building regulations. However, researchers (Turner, 1976; Turner & Fichter, 1972) have shown that they are far from being unplanned. The formation of informal settlements has also been associated with the reclassification of previously rural settlements as urban areas (Thinh & Kamalipour, 2022; Van Oostrum & Dovey, 2022). Definitions of informal settlements based solely on the legality of tenure, compliance with land use regulations, and adherence to formal planning policies do not generally take into account the nuanced in-between conditions that incorporate a mix of informality and formality. During the processes of informal development and incremental adaptation, certain slum-like conditions may emerge in informal settlements (Kamalipour, 2020; Kamalipour & Dovey, 2020; Thinh & Kamalipour, 2022). Yet, these settlements can incrementally evolve over time into well-serviced neighbourhoods with varying levels of formality (Dovey & King, 2011). Informal settlements consist of a range of components and generally undergo incremental transformations that remain underexplored.

In this study, we view informal settlements as a mode of urban development (Dovey, 2019; Roy, 2005). This perspective offers a more sophisticated way of thinking about urban informality as the morphologies and growth of informal settlements vary from place to place (Kraff et al., 2020; Taubenböck et al., 2018; Taubenböck & Kraff, 2014). Previous studies often seem to focus on a binary distinction between formal and informal morphologies (e.g., Kuffer et al., 2014). Researchers have also illustrated different types of informal settlements concerning building sizes, density, patterns, or locations (e.g., Baud et al., 2010; Graesser et al., 2012). More recently, undertaking a comparative exploration of the typologies and morphologies of informal settlements in a global context, Dovey and Kamalipour (2018) developed a non-binary typology of informal/formal morphologies, with a specific focus on the development of access networks and buildings. Their typology, comprising a matrix that delineates nine morphological types, can be applied in different contexts and used in various databases to explore urban informality.

While spatial data of informal settlements at different scale are crucial for sustainable development, significant gaps exist: (1) limited understanding of how urban development is associated with the growth and dynamics of informal settlements; (2) lack of a consistent approach and database for systematically mapping informal morphologies in space and time. Using satellite images, historical maps, and relevant documents and reports, this study explores how the typology developed by Dovey and Kamalipour (2018) can be applied to analyse the adaptations of informal/formal morphologies in Hanoi and HCMC over a period of 120 years. The primary reasons for drawing on this typology are as follows. First, one of the key features of their typology is its versatility for mapping purposes across various contexts. Second, their classification method is reasonably scalable and, to some extent, more accessible for non-professionals compared to alternative typologies. Third, it has the capacity to illustrate diverse urban morphological conditions and how they are situated in relation to each other across different contexts. Fourth, their typology adopts a non-binary approach that that can uncover a range of in-between morphologies, incorporating mixed conditions.

3. Research design and methods

In this section, we introduce the research design and methods of investigation (Fig. 1). The selection of Hanoi and HCMC is based on an "information-oriented" approach (Flyvbjerg, 2004). Cadastral maps dating back to 1893 in Hanoi and 1900 in HCMC, along with satellite images from 2021, have been used for mapping (Table 1). The maps were selected based on the following criteria: (1) reflecting the built environment of Hanoi and HCMC during different historical events with a time interval of approximately 38 to 48 years; (2) incorporating detailed information about key access networks, building footprints, and/or the boundaries of settlements.

In the data pre-processing stage, maps that had been recorded on different pages, were connected based on records of latitude and longitude. It is important to check for missing aspects in historical maps. A historical map might omit features that may not appear on a similar map but at a different scale (Schaffer & Levin, 2015). Maps in Hanoi and HCMC at a scale of 1:50,000 commonly illustrate buildings in rural areas while urban areas have been generalised. For the purposes of this study, other maps from similar historical period at scale of 1:10,000 have been used to track building footprints and access networks in the city centres.

After checking, all maps needed to become aligned within a common projection system. QGIS was utilised for georeferencing the datasets. A satellite image from 2021 served as a reference for the geometric correction of historical maps. A minimum of 180 Ground Control Points (GCPs) were used to determine the correct map coordinate locations in historical maps and satellite images. The selected locations for GCPs included intersections of roads, bridges, and embankments. Important constructions such as religious complexes, landmark buildings, and industrial facilities that have remained unchanged, were also selected as reference points for GCPs to perform accurate geometric corrections. The Thin Plate Spline transformation, a rubber sheeting method, was used to align all maps and satellite images. After error checking, it became possible to make all maps comparable in terms of scale and overlay them for analysis of the built environment. Given the varying scales and sizes of the historical maps, urban morphologies were consistently mapped within a frame of 16 km × 20 km for Hanoi and 22 km × 24 km for HCMC in this study.

While urban informality emerges at different scales (e.g., Kuffer et al., 2016; Taubenböck et al., 2018; Thinh et al., 2023), this study focuses on buildings and access networks for analysis. We utilised the typology of "informal/formal morphologies" developed by Dovey and Kamalipour (2018) for mapping purposes. Our focus has been on determining the extent to which buildings and access networks were designed and constructed by local residents through self- organised and/ or collectively organised processes to ascertain the levels of formality/
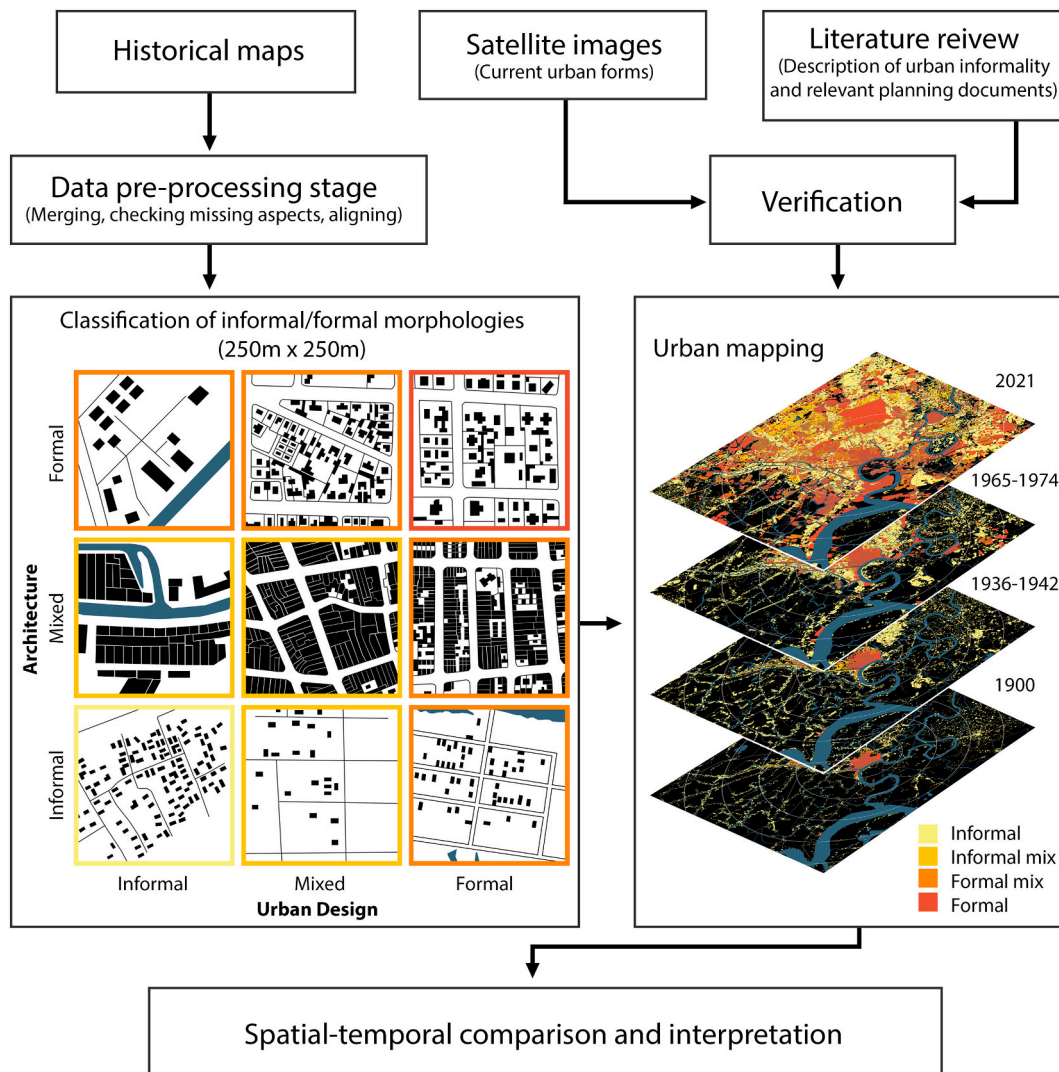
Fig. 1. The research design.

informality (Fig. 1). There are two contrasting models of housing production processes: self-governing housing and centrally administrated housing (Turner, 1976, p. 27). In the first model, the accessibility of basic resources is controlled while users have direct control over the housing design and construction process. The second model is based on a hierarchical top-down command and control paradigm. Historical maps generally depict formally planned/designed buildings in detail, using specific colours and patterns. In contrast, self-built housing areas are typically represented as unidentified boundaries, with various dots denoting housing.

In this study, settlements with no clear building patterns and housing layouts are marked as informal. Areas of self-built housing in which some building layouts might be designed by professional practitioners, such as architects, are classified as mix conditions. Access networks are considered formal if they exhibit morphological traces of professional planning, design, and construction by urban planners, surveyors, and/or engineers. In historical maps, such networks are generally highlighted using different widths and colours to distinguish them from informal networks. Mix conditions apply when informal networks have been upgraded and widened through urban development projects or regulated layouts have been applied. Informal conditions refer to networks that generally include crooked and somewhat narrow laneways. A number of key morphological conditions have been identified and used for mapping in this study (Table 2).

The scale at which the objects were digitised from the map is important as it impacts the level of detail (Schaffer & Levin, 2015). Particularly when classifying urban morphologies that display signs representing numerous buildings, the challenge lies in determining the boundaries around the studied areas. Different on-screen scales of mapping might result in different boundaries, patches, and sizes of informal/formal morphologies. To avoid generalisation, a cell grid of 2 km × 2 km has been utilised to identify informal/formal morphologies during the mapping process. A visual interpretation process was applied to detect key access networks and spatial errors that might have occurred during the mapping process.

After mapping, a range of relevant materials, including reports, planning documents, and satellite images, were used to examine and verify the informal/formal morphologies. Considering that this study explores the development of informal/formal morphologies in Hanoi and HCMC over a span of 120 years, it is important to note that various socio-economic and political changes have impacted urban morphologies. Previous studies have suggested that during the development process, buildings are often subject to frequent changes and modifications by owners, while street networks tend to remain unchanged for centuries due to their somewhat public ownership (Conzen, 1960). The current urban forms and information reported in the relevant materials also support map interpretation and provide insights into the formalisation of informal settlements and the informalisation process within

Table 1
The historical maps of Hanoi and HCMC used for mapping in this study.

Period	Map name	Map scale	Source
Hanoi			
1893	Environs de Hanoï: levé régulier. Flle n° 1	1:20,000	https://humazur.univ-cotedazur.fr/omeka-s-dev/s/humazur/item/1649#?c = &m = &s = &cv = &xywh =- −3091%2C0%2C14387%2C11194
1893	Environs de Hanoï: levé régulier. Flle n°2	1:20,000	https://humazur.univ-cotedazur.fr/omeka-s-dev/s/humazur/item/1971#?c=&m=&s=&cv=&xywh=-1455%2C0%2C11194%2C11194
1935	Hanoï	1:50,000	https://gallica.bnf.fr/ark:/12148/btv1b53066819m.r=hanoi.langEN
1942	Plan de la ville de Hanoï	1:10,000	https://gallica.bnf.fr/ark:/12148/btv1b531893703.r=hanoi?rk=171674;4
1978	Khanoï	1:10,000	https://nla.gov.au/nla.obj-2649286809/view
1984	Hanoi, Sheet 6151–2	1:50,000	https://maps.lib.utexas.edu/maps/topo/vietnam/
1984	Ha Dong, Sheet 6150–1		
1984	Luong Son, Sheet 6150–4		
1984	Son Tay, Sheet 6151–3		
HCMC			
1900	Environs de Saïgon	1:20,000	https://gallica.bnf.fr/ark:/12148/btv1b531670876/f4.planchecontact.r=hanoi
1936	Environs de Saïgon. D'après la carte au 1/25000e	1:50,000	https://gallica.bnf.fr/ark:/12148/btv1b53066853k
1942	Plan de Cholon	1:10,000	https://gallica.bnf.fr/ark:/12148/btv1b53189369q/f1.item.r=hanoi
1942	Plan de Saïgon		https://gallica.bnf.fr/ark:/12148/btv1b53197000p/f1.item.r=hanoi
1974	Saïgon i Zīađin' (C-48-46): V'etnam, provinīsīĭa̅ Zīađin' / General'nyĭ shtab	1:10,000	https://nla.gov.au/nla.obj-2649286716/view
1965	Sai Gon, Sheet 6330–4	1:50,000	https://vva.vietnam.ttu.edu/repositories/2/digital_objects/608876
1969	Bien Hoa, Sheet 6330–1		https://maps.lib.utexas.edu/maps/topo/vietnam/
1970	Can Gioc, Sheet 6330–3		
1969	Nhon Trach, Sheet 6330–2		

Table 2
Reclassification of types.

No.	Land Cover Class	Class Description in Historical Maps
1	Informal	Unplanned settlements and other unidentifiable settlements that have informal buildings and informal access networks
2	Informal mix	Informal buildings in mix access network or mix buildings in informal and mix access network
3	Formal mix	Informal and mix buildings in formal access networks
4	Formal	Residential, commercial, and industrial areas and green spaces that are formally planned/designed
5	Transportation	Key roads, parking areas
6	Water	River, stream, pool, canal, swamp, wetland
7	Unbuilt areas	Agricultural land and sand

formal urban areas.

To investigate the spatial development pattern of informal settlements over time at the metropolitan scale, a circular band analysis was conducted, starting from the city centre and extending to the peripheral areas in both Hanoi and HCMC (Fig. 2). Previous studies have classified city types regarding historical development, including traditional market town, suburban city, post-suburban city, and global city (Dick & Rimmer, 1998; Knox & Pinch, 2013). Each type is associated with new urban expansions, community developments, and ring roads around the city core. The band analyses help visualise and understand the growth of urban morphologies in response to economic, social, and political forces. A total of five and six 3 km-wide circular bands were consistently defined, starting from the city centres and extending outward towards the peripheral areas in Hanoi and HCMC, respectively. The number of bands was identified based on the radius of circles and the growth of urban areas. The informal/formal morphologies within each band were monitored over time.

Several limitations have been identified in this study. There is no claim that the urban mapping in this study is entirely accurate since visual interpretation depends on the experience of the interpreter and map quality (Edwards & Lowell, 1996; Kraff et al., 2020; Pratomo et al., 2017). The representation of informal settlements in historical maps is varied depending on the surveyors' perspectives, resulting in uncertainties of settlement boundaries (Molenaar, 2000). Furthermore, capturing mixed morphologies is particularly challenging due to the limited details available about building conditions. Although all maps have been aligned, various spatial errors still exist. Since distances and angles in various historical hand-drawn maps were generally estimated rather than precisely calculated, the actual shapes and forms of informal morphologies might be imprecise although the relative locations of the pertinent areas were usually presented correctly. It is beyond the scope of this study to analyse micro-scale increments, such as changes in functions and domestic spaces, additional storeys and structures over balconies and roofs. While socio-economic conditions can be explored through a literature review, discerning certain important features such as building patterns, the number of buildings, and differences between religious, public, and residential buildings in informal areas is particularly challenging in historical maps. Access networks may undergo upgrading and widening over time, while buildings might be rebuilt, upgraded, or extended through micro-scale and self-built practices. These transformations can result in unclear boundaries between informal, mixed, and formal conditions, introducing potential errors into the mapping process.

4. Study sites and results

4.1. Study sites

4.1.1. Hanoi

Hanoi was established in the 1010 in the South of the Red River, and it quickly became one of the key commercial and political centres in Vietnam. The built environment in Hanoi in the late 19th century was based on a relationship between a citadel and a historical trading quarter (Logan, 2000). The citadel was built on high ground surrounded by lakes, ponds, and rivers, which served as natural barriers. As the city was located on ancient maritime trade routes in the Southeast Asia, the trading quarter was incrementally developed along the bank of the Red River. Outside the historical quarter and citadel, there was a dense network of villages that provided materials and craft products for the trading quarter. Fig. 3 (top left) illustrates the informal/formal morphologies of Hanoi in 1893. The formal, informal, and informal mix were the dominant morphological types in the city core (band 1), which was surrounding by lakes, ponds, and the Red River. The formal areas included newly built constructions in the south of the historical town and the citadel. While the access networks in the historical town had a seemingly self-organised pattern, they were upgraded and widened during the late 20th century. One of the noteworthy characteristics of traditional houses in Hanoi was the tube house typology (Phe & Nishimura, 1991). Traditional urban houses built during the late 19th century
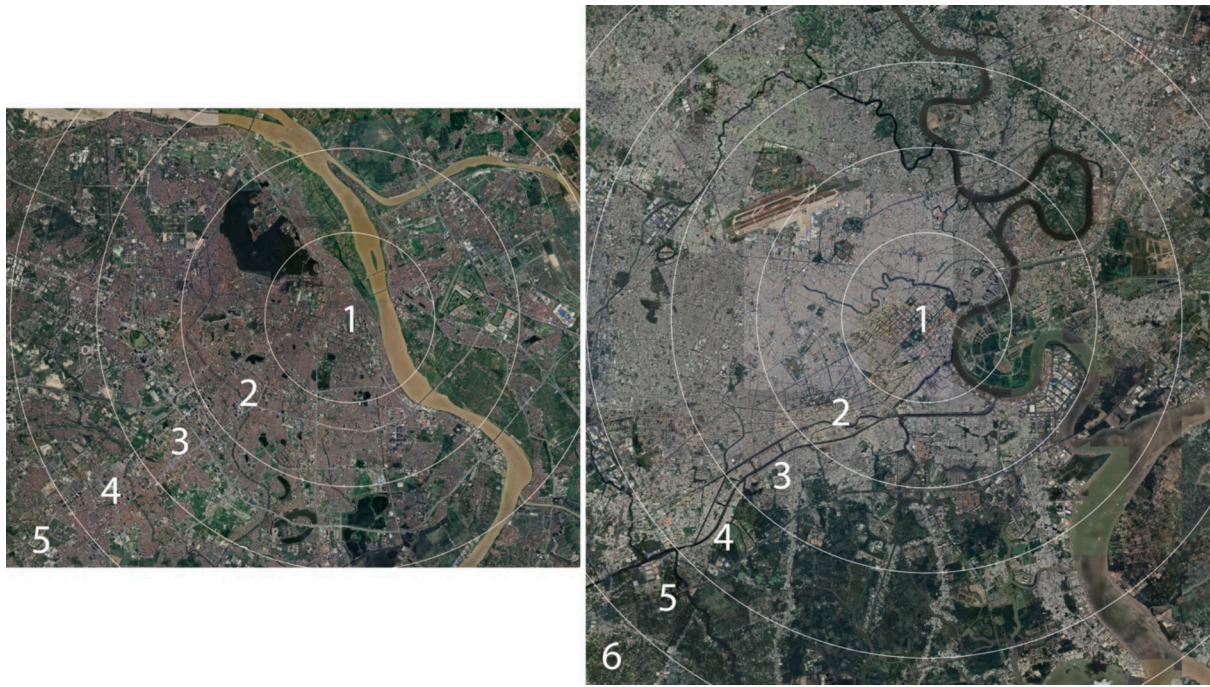
Fig. 2. Circular band analyses starting from the city centre and extending to the peripheral areas in Hanoi (Left) and HCMC (Right). Satellite images: Google Earth.
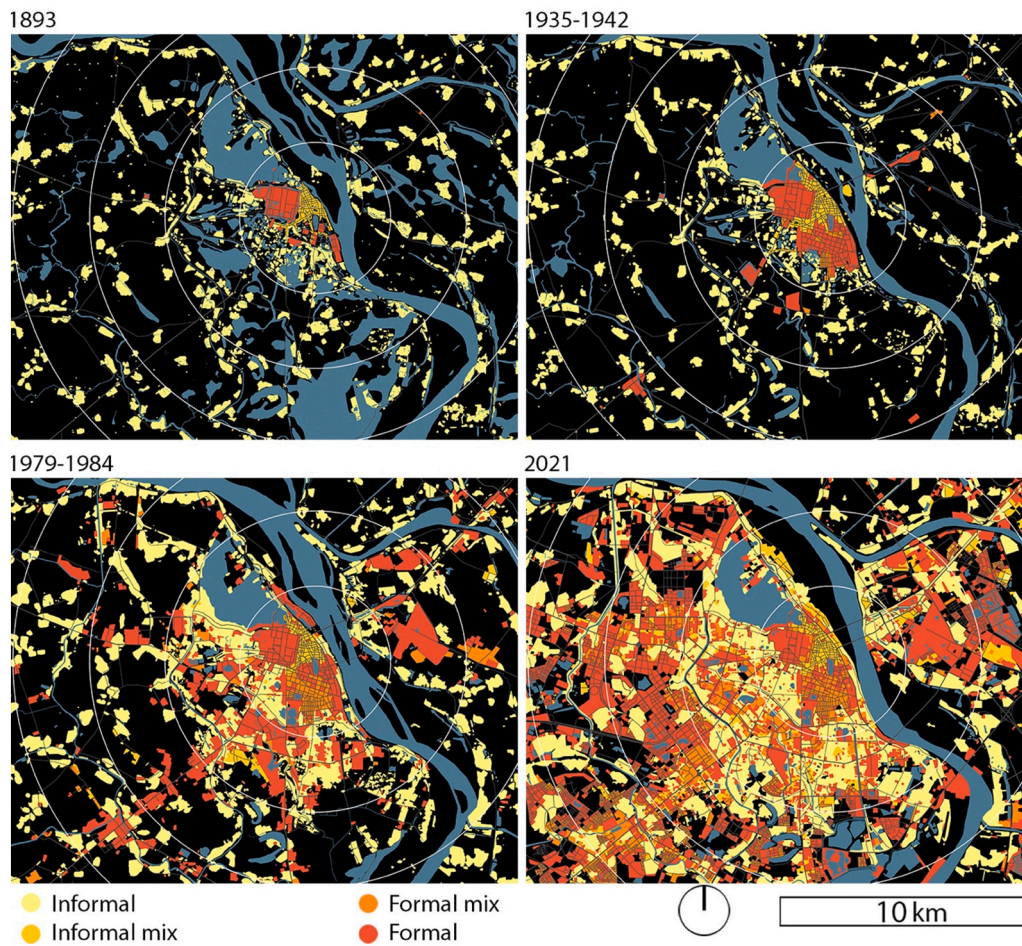

Fig. 3. The spatial distribution of informal/formal morphologies in Hanoi city.

and the early 20th century typically had one to two floors constructed by bricks and timbers. The buildings were quite narrow in width, but their length could be up to 100 m. Outside the city core, only a few key roads to the southwest and west were developed to connect Hanoi with other provinces. Most village settlements exhibited informal morphology, characterised by a self-organised access network and building patterns. The access networks in rural areas were generally controlled and managed by villagers. The physical structure of villages was designed to protect residents from external aggressions (Labbé, 2011; Ngo, 1998; Nguyen, 1994). There were no formal rules for village structures; however, the physical forms of villages were influenced by surrounding rivers, lakes, and agricultural land. A village could consist of several clusters, all located around the communal houses, temples, pagodas, and wells. There were village gates and multiple layers of bamboo trees surrounding village settlements to control access. In terms of building architecture, most village houses were courtyard houses, with the main living spaces and supporting constructions separately built around the courtyard (Ngo, 1998; Nguyen, 1994). Buildings in the village were mostly single-storey structures made of bamboo, thatch, timber, and bricks, constructed based on the traditional knowledge and experience of local builders and households through self-built practices.

In 1902, Hanoi was chosen to become the capital city of Indochina (Logan, 2000). There were two master plans for Hanoi, one proposed by Hebrard and the other planned by Cerutt. Given the changing political circumstances and the termination of the French colonial system in Vietnam in the mid-twentieth century, only the former plan was actually executed while the latter plan was not fully implemented (Geertman, 2007). Following the Hebrard's plan, the traditional trading quarter was kept, and its infrastructure was redeveloped under the strict French regulations. A new French quarter, featuring formal and formal mix morphologies, was built over about 450 ha in the south of the traditional trading quarter. Several village settlements were demolished to make way for the construction of the French quarter. Outside the city core, several formal constructions, including Ha Dong town, the train station and depot, residences of elite officers, and a hospital were developed along key routes. As there were no other major urban developments, the urban morphologies of Hanoi remained almost unchanged until the 1960s. Fig. 3 (top right) illustrates the informal/formal morphologies in Hanoi in 1935–1942. As the infrastructure and buildings in the trading quarter were upgraded over time, the boundary between the French quarter and historical town was not clearly defined. The citadel had been demolished and replaced by new administrative buildings and offices. In the South of the trading quarter, the French quarter was planned with square and rectangle grids, filled with villas. Outside the French quarter, several areas featured small grid or were developed over existing networks for the Vietnamese elite class who worked for the French government (Labbé et al., 2013). The housing typologies in those areas shared various similarities with tube houses in the trading quarter. Outside the city core and French quarter (band 1), there were no policies to develop village settlements; thus, villagers constructed their houses based on traditional techniques and norms using locally available materials.

During the period from 1954 to 1986, the Vietnamese government adopted a socialist system of public ownership within a planned economy. During this period, the housing policy aimed to produce housing on a large scale using the model of collective quarters or *Khu Tập Thể* (KTT). KTTs, which consisted of several apartment blocks, were planned in close proximity to manufacturing zones to provide shelters for workers and local officials. After the reunification in 1975, residents came back to cities, resulting in overcrowded living conditions. It was estimated that the total number of the newly constructed buildings could only supply 20 % of the housing needs, not including buildings that needed upgrading and redevelopment (Logan, 2000). While building a private house was prohibited through a number of licences, rising demand and poor living conditions led to a boom in informal constructions. It was estimated that in 1986, 91 % of households in Hanoi had

bought or sold housing and modified their living spaces without registering with the state (Koh, 2004). Fig. 3 (bottom left) shows the informal/formal morphologies of Hanoi during the early 1980s. The formal morphologies, including KTTs, institutions, and industrial areas, were generally built in peripheral areas (bands 2, 3, and 4) along the key network routes in the Southwest and Northeast. Meanwhile, there was a significant expansion of informal morphologies around village settlements and over farmland (Kunihiro, Daisuke, & Huan, 2004).

Since the economic reform in the late 1980s, the provision of welfare social housing has been removed, and individuals, households, and developers have become the main contributors to housing production. Changes in housing policies since the economic reform have resulted in the rapid development of informal housing in different types of neighbourhoods, including the historical quarter, French quarter, and village settlements, where existing houses have been modified or rebuilt using concrete (Koh, 2004; Geertman, 2007; Thinh and Gao, 2021; Thinh & Kamalipour, 2022). Informal practices can also be seen in the former KTTs (Hong & Kim, 2021; Koh, 2004; Tran & Yip, 2008). Due to economic changes, residents in the KTTs have started to modify their apartments. On the ground, parts of public spaces have been appropriated for new rooms while new structures have been added to upper apartments. Many areas that were initially planned as KTTs and developable land on the rural-urban interface have also been transformed into self-built housing areas. These areas have generally been developed by work units and state institutions, such as army units, mass organisations, ministries, and universities. The serviced plots were then directly sold to employees (Geertman, 2007). Households could design and built their houses according to their needs and savings. It was estimated that such self-built practices contributed to around 70 % to 80 % of the housing stock in Hanoi in the late 1990s and early 2000s (Nguyen & Kammeier, 2002; Koh, 2004; UN-Habitat, 2014). Since the late 1990s and early 2000s, to avoid informal practices and further boost the production of housing, a series of directives encouraging investment by large developers have been applied (Tran & Yip, 2008). Large-scale housing projects, known as New Urban Areas (NUAs) and built by developers, have had to follow strict regulations and planning controls. Fig. 3 (bottom right) illustrates the informal/formal morphologies of Hanoi in 2021. The newly built formal areas, including new central business district and NUAs, which were generally associated with grid network, were constructed in the East and West, far away from the city core. Very often, NUAs were built over farmland rather than village settlements to avoid costly compensation and resettlement. As a result, the village settlements, which generally had informal morphologies, have been kept during development process (Thinh & Kamalipour, 2022).

4.1.2. HCMC

While the history of HCMC goes back to ancient times, the Nguyen Dynasty marked the beginning of urban development in the late 17th century when two towns, Saigon and Cholon, were established over seaports for trading and tax collection. In 1790, the Bat Quai citadel was built to protect the Saigon town. In 1836, the citadel was dismantled, and a smaller citadel was constructed on the same site. During the late nineteenth century, there were two remarkable urban areas: Saigon city, planned by French architects and planners with a network of square grids over the citadel area, and a Cholon city, which was developed over the self-organised layout of the historical trading town. Fig. 4 (top left) illustrates the informal/formal morphologies of HCMC in 1900. The formal and formal mix were the main morphological types in the city cores located in bands 1, 2, and 3. As the waterways were important mode of transportation, rural settlements were built along the roads, river, and canals outside the historical towns. Unlike rural villages in the North, which were built around clan halls and communal buildings, rural settlements in the South of Vietnam were commonly identified with a dispersed pattern in which buildings were surrounded by open spaces, and building density was relatively low. Most of the buildings were constructed using timber and thatch.
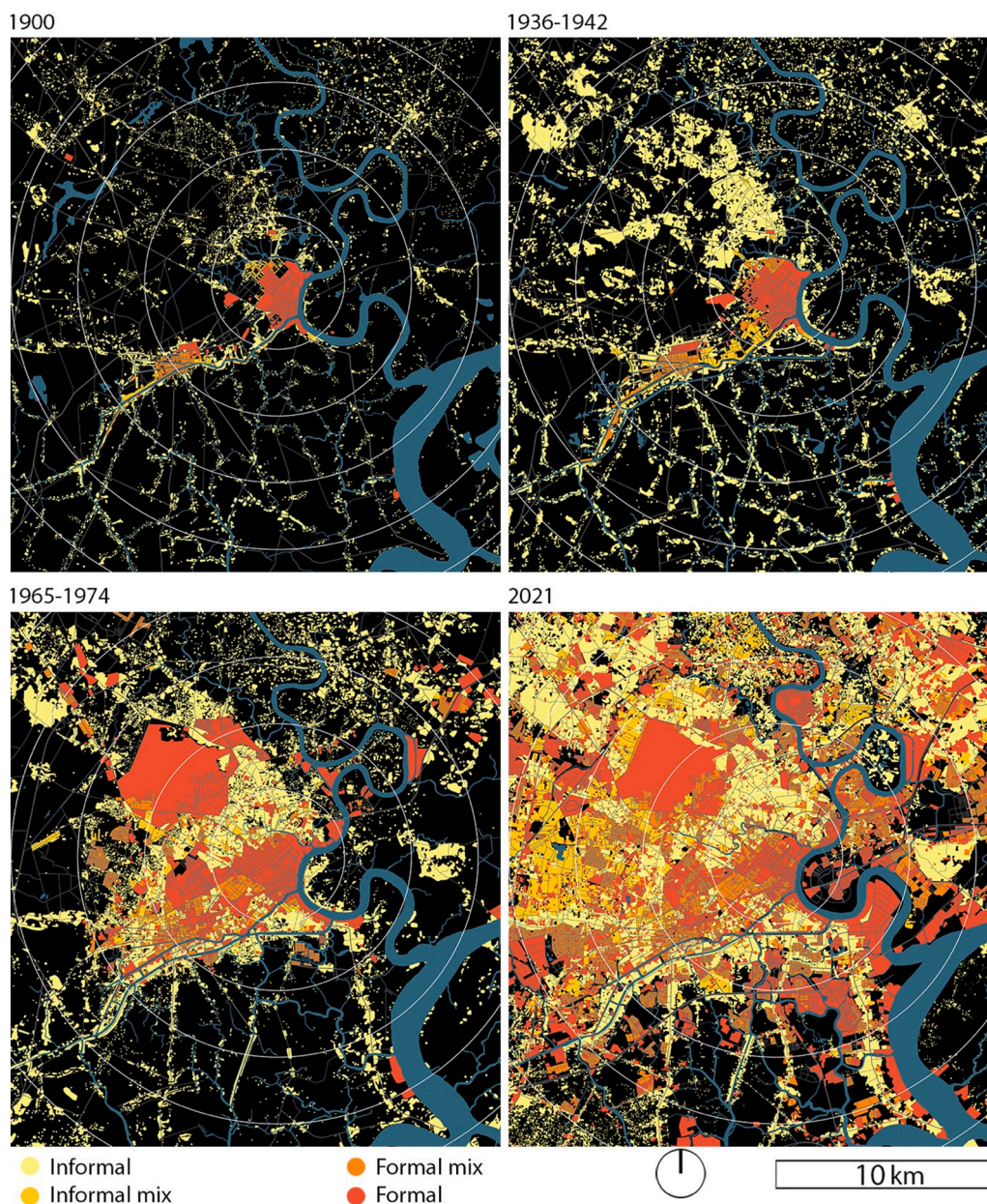
Fig. 4. The spatial distribution of informal/formal morphologies in HCMC.

In 1931, the two towns were merged by the French administration into a single municipality and became known as Saigon-Cholon. Despite the change in administrative status, the morphologies of the city experienced few changes. Fig. 4 (top right) illustrates the informal/formal morphologies of the city in 1936–1942. The access network and built-up area in the Saigon area slightly expanded to the northwest direction while the access network between the two towns remained unchanged. As various new buildings were constructed around existing rural settlements, informal mix morphologies dominated the spaces between the two towns. Meanwhile, as a network of new canals (*Kênh Tẻ* and *Kênh Đôi*) were created to connect the Saigon River and existing canals, various storages and buildings that were identified with formal mix morphologies were found along the canals.

After the Geneva Agreements in 1954, the United States replaced the French military presence, and Vietnam was divided into two parts: the Democratic Republic of Vietnam in the North and the Republic of Vietnam in the South. As the war broke out between the North and the South from 1954 to 1975, the urban development of HCMC was influenced by the United States, with Saigon as the capital of the Republic of Vietnam. During the war, about one million immigrants from rural area moved to the city, particularly after the implement of the Strategic Hamlet Program in 1963. In 1975, the urban population reached 4.5 million, nearly triple the projected population in 1968 plan (Huynh, 2015), and the majority of immigrants lived in informal settlements around the city cores. Due to rapidly increasing population, urban development plans were considered an urgent task, and several master plans, including Hoang Hung plan, Ngo Viet Thu plan, the Doxiadis plan, and the WBE plan, had been created. Nevertheless, no master plans had been fully implemented due to the wartime (Thai, 2011). Fig. 4 (bottom left) illustrates the informal/formal morphologies of HCMC during 1965 to 1974. The major formal development was located in the North, around the Tan Son Nhat airport, and the existing city core while some small-scale urban projects and industrial zones had been developed in peripheral areas (bands 2, 3, and 4). Numerous informal settlements had emerged along the canals in the south of city core and around existing rural settlements.

After the reunification of Vietnam in 1975 to the late 1980s, collective programs were introduced in HCMC, and the government took responsibility for providing housing for those working for the state. Unoccupied houses were nationalised. Due to housing shortages, people often had to share houses. Since the late 1980s, economic reforms have been introduced to boost local and foreign investments in Vietnam. As a regional economic hub, HCMC has attracted a large number of migrants from different regions, and the planning process has not kept pace with the urbanisation process. The planned population up to 2010 in the urban planning in 1993 was about 5 million. Nevertheless, the official population in 1998 already surpassed 5 million and reached 6.2 million in 2005, not counting about 1.9 million migrants lacking legal residential status (Waibel et al., 2007; Huynh, 2015). The actual urban population in 2010 might have been twice as high as the 1993 plan (Huynh, 2015). Due to limited capacity and finances to provide affordable housing, the area of informal morphologies has rapidly increased the peri-urban areas to accommodate migrants. Fig. 4 (bottom right) illustrates the informal/formal morphologies of HCMC in 2021. Large-scale projects and NUAs have been built mainly over farmland, swamps, and wetlands while informal practices over farmland, unused areas, and rural settlements have escalated (Kontgis et al., 2014; Thinh et al., 2023; Vinh & Leaf, 1996; Downes et al., 2024).

4.2. Results

Our findings illustrate how informal/formal morphologies have emerged and developed in Hanoi and HCMC over time. Tables 3 and 4 outline the changes in informal/formal morphologies in Hanoi and HCMC. Over a span of 120 years, the informal area has nearly doubled in Hanoi and increased about 3.8 times in HCMC. Also, for every square kilometre increase in formal morphologies, informal morphologies increased by 0.62 and 0.86 km^2 in Hanoi and HCMC, respectively. During the late nineteenth century, the informal area accounted for approximately 92 % and 81 % of the total built-up areas in Hanoi and HCMC, respectively. The informal area in Hanoi slightly decreased from 31.4 km^2 in 1893 to 28.7 km^2 in 1935–1942, primarily due to the development of French quarter. In HCMC, the informal area increased by nearly 2.5 times, from 27 km^2 in 1900 to 68 km^2 in 1936–1942. The informal area in HCMC was slightly reduced to 60.1 km^2 in 1965–1974 due to the development of a new airport, formal areas, and infrastructure over rural settlements in the North. Recently, the areas of informal and informal mix in Hanoi and HCMC have continued to experience an upward trend. However, their contribution to the total built-up areas has decreased from 60 % during the 1970s and 1980s to approximately 51 % in 2021.

Unlike informal settlements in Latin America, which are often located in peripheral areas and associated with escarpments (Alegría & Dovey, 2022; Dovey & King, 2011), informal morphologies in Asian countries, and Vietnam in particular, can be found in various parts of cities (Dovey & Kamalipour, 2018; Thinh et al., 2023). It has been shown that informal morphologies in Vietnamese cities are primarily associated with informal development and subdivision over rural settlements and farmland (Thinh et al., 2023; Thinh & Kamalipour, 2022). Figs. 5 and 6 provide details about the proportion of informal/formal morphologies

within the identified bands in Hanoi and HCMC over time, respectively. In general, the size of informal areas in 2021 was considerably larger than those in 1893 and 1900. The band-based analyses illustrate that the rate of change in informal/formal morphologies varies significantly depending on the distance from the urban core to peripheral areas and the socio-economic conditions of each city.

In Hanoi, informal morphologies in 1893 dominated the landscape across the city core and peripheral areas. In 1935–1942, informal morphologies in band 1 slightly decreased mainly due to resettlements and the development of the French quarter while informal mix slightly increased. The proportion of informal morphologies increased significantly in bands 1 and 2 in the 1980s primarily due to informal practices over farmland and existing village settlements. Studies suggest that since the economic reform in 1986, self-built housing has quickly dominated the urban landscape around the city core (Geertman, 2007; Kunihiro, Daisuke, & Huan, 2004; Thinh & Gao, 2021). As such, informal patches in bands 1 and 2 might have joined each other as they expanded during the urbanisation process. While informal morphologies in other bands also experienced spatial growth, the extent of change was mostly limited to the sub-division of residential areas and small-scale development around village settlements with nucleated layout. In 2021, large pockets of informal morphology were generally concentrated around the city core.

In HCMC, informal morphologies dominated the urban landscape in peripheral areas, from band 2 to band 6 during 1900 and 1936–1942. During the period of urban development from 1936-1942 to the period 1965–1974, informal morphologies in bands 1 and 6 considerably increased. A key distinction of urban morphologies in HCMC is that the areas of informal and informal mix, generally developed by farmers and informal developers over farmland, rapidly increased from the period 1965–1974 to 2021 (Fig. 6). Previous studies have suggested that due to a large flow of rural-to-urban migrants to HCMC, unplanned urban development tends to take place around dispersed settlements in peri-urban areas (Kontgis et al., 2014; Thinh et al., 2023). In 2021, the proportion of informal morphologies located in bands 3, 4 and 6 slightly outweighed the proportion of informal morphologies in bands 1 and 2.

5. Discussion

In the context of cities in the Global South, which are experiencing significant socio-economic changes and rapid urbanisation, improving living conditions in informal settlement is critical for moving towards the achievement of the Sustainable Development Goals. Informal settlements are increasingly being used to shape urban policies and redevelopment agendas for different purposes (Dovey & King, 2011). While emerging forms of informal settlements share some similarities, they often differ in terms of their historical development and the complex nature of informality. It can be quite challenging, if not impossible, to fully account for all these differences through mapping alone. In this study, we applied a non-binary typology of informal/formal morphologies developed by Dovey and Kamalipour (2018) to analyse urban morphologies using historical maps in Hanoi and HCMC. In this section, we discuss key findings in the context of the relevant literature.

Table 3
Areas of informal/formal morphologies in Hanoi.

	1893		1935–1942		1979–1984		2021	
	Land area (km2)	% of total built-up area	Land area (km2)	% of total built-up area	Land area (km2)	% of total built-up area	Land area (km2)	% of total built-up area
Formal	1.92	5.3	5.02	14.1	27.18	32.8	59.71	41.5
Formal mix	0	0	0.41	1.1	3.72	4.5	9.77	6.8
Informal mix	0.81	2.2	1.32	3.7	1.86	2.2	9.81	6.8
Informal	31.44	92.5	28.74	81.1	50.01	60.5	64.53	44.9

Table 4

Areas of informal/formal morphologies in HCMC.

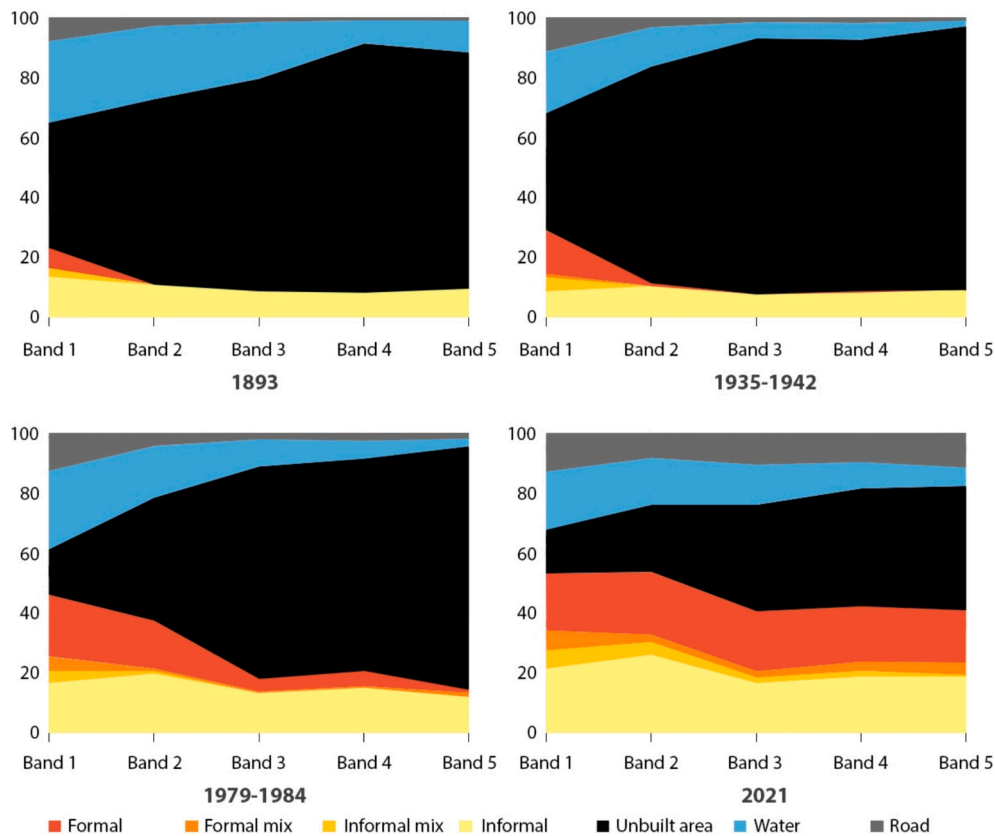|	1900		1936–1942		1965–1974		2021	
	Land area (km2)	% of total built-up area	Land area (km2)	% of total built-up area	Land area (km2)	% of total built-up area	Land area (km2)	% of total built-up area
Formal	4.09	12.2	5.03	6.3	38.36	30.4	98.42	37.2
Formal mix	0.98	2.9	2.17	2.7	7.29	5.8	31.27	11.8
Informal mix	0.99	2.9	4.50	5.6	3.85	3.1	29.37	11.1
Informal	27.58	81	68.24	85.4	60.1	60.7	105.42	39.9

Fig. 5. The proportion of informal/formal morphologies within the identified bands in Hanoi.

5.1. Capacities for mapping informal development over time

Informal settlements have grown considerably in recent decades in relation to ongoing socio-economic changes and rapid urbanisation (Davis, 2006; Shatkin, 2004). A key challenge lies in understanding the relationships between urban development and the growth of informal settlements over time (Liu et al., 2019). Previous studies have often focused on the growth of informal settlements at different scales (e.g., Dovey et al., 2020; Han et al., 2017; Thinh & Kamalipour, 2022; Zhang et al., 2020). Our understanding of the dynamics of informal settlements remains limited, partly due to the lack of a reliable database (Kuffer et al., 2016). This study demonstrates that historical maps can be used to produce useful information on the growth of informal settlements in the Global South. While high-resolution satellite images are limited since the 2000s, historical maps can serve as a significant data source to track urban development overtime. Such a database has the capacity to spatially capture forms of informal urbanism.

We recognise that measuring the spatial characteristics of informal settlements is particularly challenging. This study mainly focuses on access networks and building footprints to capture the morphological types. There are challenges in verifying the built environment within informal settlements. While buildings may appear random and somewhat chaotic on maps, they might have followed certain local rules and/ or norms. Housing in the early twentieth century was primarily constructed with timber, brick, and thatch, rather than the concrete and corrugated sheets commonly found in contemporary informal settlements. Representations of building types and sizes in historical maps are often abstract. As the "informal/formal morphologies" thinking (Dovey & Kamalipour, 2018) adopted in this study is part of a broader understanding of urban areas, further studies using different mapping approaches are needed to explore the characteristics of informal/formal urban morphologies.

Several approaches, including the following two, can be useful here. The first approach can primarily focus on study of morphogenesis (e.g., Augustijn-Beckers et al., 2011; Dovey et al., 2020; Kamalipour & Iranmanesh, 2021; Iranmanesh & Kamalipour, 2023). Such studies can examine the relations and growth of buildings and access networks at neighbourhood scales. The number of buildings and types of access networks can be counted and modelled to explore and predict parallels and differences between informal morphologies across different locations and geographic conditions. The second approach can examine how various socio-economic models, wars, and historical planning impact
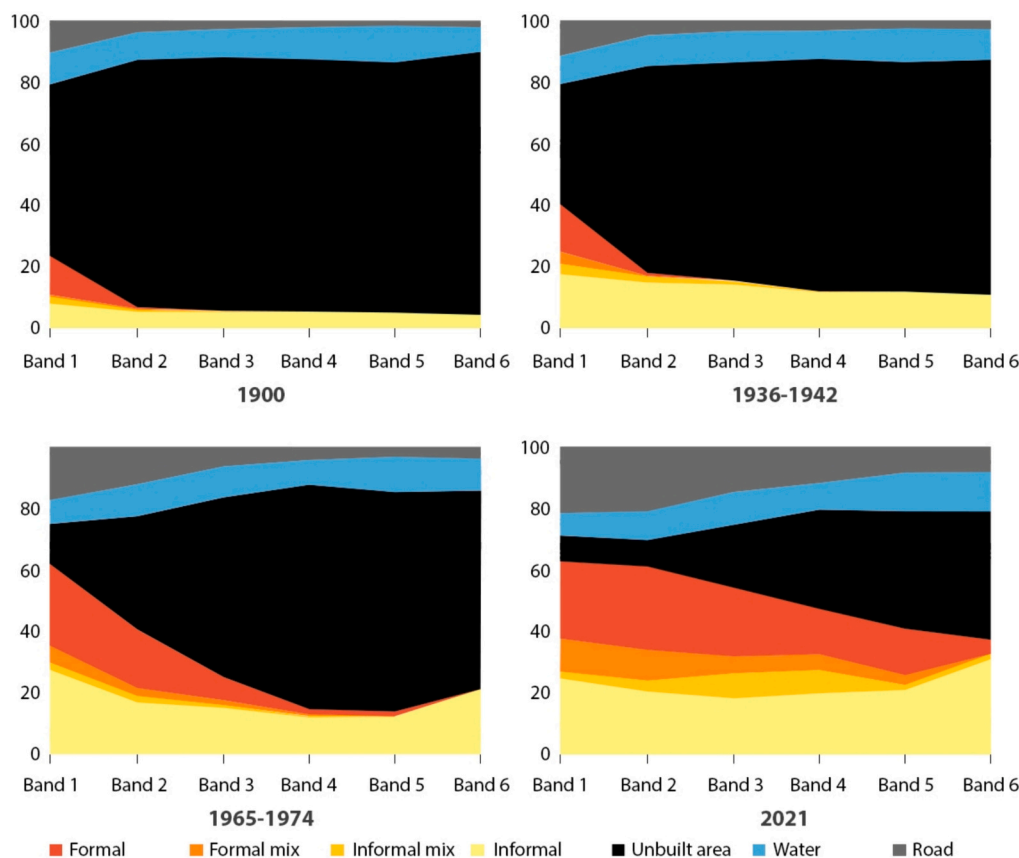
Fig. 6. The proportion of informal/formal morphologies within the identified bands in HCMC.

the development and distribution of informal settlements. This approach, linked with socio-spatial urban assemblages, can address multiple scales of analysis. The task here is to explore how urban transformations throughout history enable or constrain the dynamics of informal urbanism.

5.2. Urban transformation and growth of informal settlements

This study primarily contributes to the related literature by providing a better understanding of the spatial development of informal/formal urban morphologies. Various studies illustrated that informal settlements have largely emerged in recent years, and the development of informal settlements is mainly associated with urbanisation and rapid population growth (e.g., Saunders, 2011; Abebe, Derebew, & Gemeda, 2019; Alene, 2022; Dubovyk et al., 2011; Kohli et al., 2012; Kuffer et al., 2016). However, our knowledge about the relationships between informal and formal morphologies at different scales is still limited. While urban growth is generally well-studied, such studies have mainly focused on land-use zones, including central business centres, residential and industrial areas, and the provision of supporting facilities (Dick & Rimmer, 1998; Knox & Pinch, 2013). Informal settlements are considered forgotten places and invisible in the planning process (Kamalipour & Dovey, 2019; Shatkin, 2004). As shown in this research, various forms of urban informality existed in the studied areas during the late nineteenth century. The informal morphologies used to be rural settlements or farmland, where buildings and access networks co-evolved over time in response to local needs. While this study illustrates the dynamics of informal/formal urban morphologies in Vietnam, somewhat similar dynamics also appear to take place in some other countries in the Global South, particularly within the Southeast Asian context (Dovey & Kamalipour, 2018; Thinh et al., 2024). During urban transformations, it is critical for urban planners and designers to

broaden their focus beyond merely developing new urban areas that often tend to primarily focus on urban aesthetics and image. Attention must also be given to the integration and improvement of existing informal settlements, enabling more equitable and inclusive urban growth.

While informal morphologies dominated the landscape the in the early twentieth century, the distribution and development of informal/ formal morphologies in both Hanoi and HCMC vary depending on their distance from the urban core. In the late nineteenth century, the primary access network was not very extensive as it was limited to a network of small paths connecting villagers and farms. Over time, new access networks and formally planned settlements developed over the farmlands. The planned settlements in the early twentieth century were generally situated around historical quarters and/or former administrative areas. During the city expansion process until the 1980s, several rural settlements were demolished to make way for new urban areas. Since the economic reform in 1986, new urban areas and central business districts have primarily been built in bands 3, 4, and 5 in both Hanoi and HCMC. This development trend is associated with the limited availability of unbuilt areas within bands 1 and 2, as well as various patches of informal morphologies around the historical cores, which could increase the costs of compensation and relocation programmes. As such, the majority of informal morphologies, in which buildings have used for different retail functions, have been retained during the urban expansion process. These informal morphologies share fairly similar characteristics with what Dovey and King (2011) refer to as the "districts" type.

Over the course of 120 years, water flow has also been associated with the dynamics of informal settlement and urban development. The flow of water may vary considerably depending on the season when the surveys were conducted to produce the maps. Nonetheless, several emerging patterns of relationships between informal growth, urban development, and the waterscape in Hanoi and HCMC can be identified.

Generally, there are two types of waterscapes. The first type comprises ponds, wetlands, and swamps, within and around rural settlements. It has been observed that due to the urban development process, these ponds have been filled in for village extensions and new urban constructions by villagers and developers (Fanchette, 2016; Thinh and Gao, 2021; Thinh & Kamalipour, 2022). Only a few large ponds significant for geomancy and flooding control have been retained. A similar development process can be found across rural settlements in both Hanoi and HCMC. The second type encompasses lakes, rivers, and canals. During the early 20th century, the key mode of transport was waterway. Thus, key towns and villages tended to emerge around lakes, rivers, and canals (Figs. 3 and 4). Due to the development of infrastructure around riverbanks since the late 1980s, new informal settlements have emerged around key roads, highways, and over farmland while informal settlements along lakes, rivers, and canals have experienced limited growth.

6. Conclusion and outlook

This study has primarily focused on the contexts of Hanoi and HCMC. As such, there is no claim that the outcomes of this study can be directly applied in other cities and regions as each city has its own distinct historical, social, political, economic contexts, as well as development processes. Understanding the dynamics of informal/formal morphologies over time is critical for developing more tailored urban planning approaches and design strategies that suit each city. Mapping, in this regard, is not simply about documenting data; it serves as a means of producing spatial knowledge that can provide a better understanding of how cities work and a more nuanced ways of thinking about them (Dovey & Ristic, 2017). Considering the diversity of urban growth trajectories, future research could particularly focus on undertaking more comparative studies across different contexts to further investigate the processes underlying the formation and transformation of informal settlements. Future research could also explore the following questions, among others: To what extent do the unique historical landscapes and locations of different cities influence the emergence and dynamics of informal settlements? How do informal settlements with rural origins impact the overall quality of urban environments and contribute to the vitality of cities? How can urban planning, policy, and design interventions harness the capacities of informal settlements to enhance urban sustainability and resilience?

CRediT authorship contribution statement

Ngo Kien Thinh: Conceptualization, Methodology, Visualization, Writing – original draft, Writing – review & editing. **Hesam Kamalipour:** Conceptualization, Writing – review & editing.

Declaration of competing interest

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

Data availability

Data will be made available on request.

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