INFORMAL MORPHOLOGIES
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INTRODUCTION

Much has been made of the fact that most of the global population is now urban. It is not so often noted that most of this new urban population has been accommodated through the expansion of informal settlements or slums in the developing world. Informal architecture, urban design and planning are the primary means by which cities have absorbed most rural-to-urban migration over the past half-century. We define such settlements as ‘informal’ because they emerge outside the formal codes of the state in terms of land tenure, urban planning, design and construction. The label ‘informal’ is also used to avoid terms like ‘slum’ and ‘squatter’, with overlapping meanings. The distinctions between these three terms are important. Informal settlements can be defined as those where the design, planning and construction of buildings and street networks emerges without authorization by the state (Roy and AlSayyad 2004). A slum is defined by the UN as a dwelling that lacks basic access to light, space, air, water, sanitation, security or durability (UN-Habitat 2006: 19). Squatting is settlement that occurs without the authorization of the legal owner. Many dwellings within so-called ‘slums’ do not fit the UN definition and standards of construction can be quite high (Hernandez and Kellett 2010). Likewise, tenure is often ambiguous, irregular and contested with many forms of de-facto tenure (Durand-Lasserve and Royston 2002). Many informal settlements are established by ‘pirate’ developers on private land with quasi-legal tenure. Such ‘between’ conditions are typical: slums becoming upgraded; squatters becoming tenured; informal settlements becoming formalized; and formalized settlements becoming informalized. Our thinking, analysis and action on this nexus of issues needs to move beyond the somewhat essentialized concepts of slums, squatters and informal settlements.

Urban informality emerges on land that is interstitial and of marginal use – the smooth space (Deleuze and Guattari 1987) or terrain vague of the city (Sola-Morales 1995). Primary sites include urban waterfronts and escarpments, but also the interstitial easements lining transport infrastructure of freeways and railways. They can infiltrate ex-industrial and ex-institutional enclosures and flourish in the backstage spaces behind formal street walls (Dovey and King 2011). While informal settlements are often invisible from the formal city they are in no way marginal to the life and productivity of the city. Informal urbanism emerges in proximity to jobs and opportunities, their residents service the formal city where they can comprise up to half the workforce (Neuwirth 2006). Hence, any strategy that suggests they be moved to cheap land on the urban fringes will exacerbate poverty and reduce the productivity of the city as a whole. The wholesale demolition of informal settlements and dispossession of the urban poor without replacement housing continues in some nations but is now widely seen as a
state crime. The overwhelming majority of informal settlements are permanent and the challenge is one of incremental upgrading in situ where possible (Dovey 2014). The task of engagement with such issues requires a better understanding of the morphologies of urban informality.

Informal settlements are generally off the map of the formal city (Robinson 2002); largely ignored by the formal gaze, often missing from streetmaps and slated for demolition and replacement. The state knows very well where these settlements are; what we seek to reveal is the set of spatial relations between the formal and informal city. While there have been many maps of informal settlements and slums at metropolitan scale, most presume a simple binary between the formal city and the slum/informal settlement (Aguilar 2008; Alcazaren et al. 2011; Beardsley and Werthmann 2008; Greene 2010; Hasan and Mohib 2003; Huchzermeyer et al. 2014; Janches and Rohm 2012; Nijman 2010). More nuanced versions may distinguish between different forms of ownership or planning zones (Kipper and Fischer 2009; Urban 2012; Das 2011). Our goal here is to develop a form of comparative mapping of informal settlements with a focus on morphology and morphogenic processes. In doing this we do not presume a clear separation or border between formal and informal morphologies since informal and formal are always intertwined.

Image-based identification of informal settlements through remote sensing has emerged as a substantial research field over the past 20 years with the goal to develop semi-automated techniques for detecting and mapping informal morphologies from satellite imagery (Baud et al. 2010; Graesser et al. 2012; Hofmann et al. 2008; Kit et al. 2012; Kohli et al. 2012; Kuffer et al. 2014; Niebergall et al. 2008; Owen and Wong 2013). Three key criteria are often used in such studies: small grain size, high ground coverage and irregular access networks. Other factors such as proximity to hazardous areas, lack of vegetation and roofing materials are sometimes included. Such studies often conflate informality with slums. While most such studies map a binary distinction between formal and informal morphologies, some adopt more nuanced approach. Graesser et al. (2012) identify an additional type of morphology between the formal and informal city; distinguished from the informal settlement by a more identifiable yet irregular access network and mixed grain size. Baud et al. (2010) identify two categories kinds of mixed settlement using a range of criteria including access network, grain size, coverage, green space and proximity to hazardous areas. Kohli et al. (2012) develop a framework called a 'slum ontology' for detecting informal settlements based on Hofmann et al. (2008). This framework incorporates morphological indicators at three scales: buildings, settlements and the larger context. There is an emerging view that the global dynamics of such morphologies are underexplored (Kuffer et al. 2016).

Our approach is to use visual analysis of Google Earth data augmented with Streetview data where available. The key purpose of this mapping is to distinguish between different forms of informality and to generate a better understanding of how and where informal settlements emerge within the larger city. Crucially we are not mapping 'slums' nor 'squatting'; our focus is on morphological differences that can be understood as proxies for informal process.
 Streets, blocks, plots and buildings are often considered to be fundamental categories of morphological analysis (Marshall 2009). A key distinction for understanding the intersections of urban formality and informality is that between urban design (as a production of streets and blocks) and architecture (as a production of buildings). In the formal city a street layout comes first - demarcating the city into blocks that are in turn divided into plots on which buildings are then constructed in accordance with codes. Many informal settlements are the reverse: buildings are constructed first and the streets, plots and blocks emerge over time along with informal codes. However, this is never quite so simple because informal accretions also occur within formal settlements as formal streets are encroached and codes are transgressed. Just as informal settlements become formalized over time so the formal city becomes informalized. What is at stake here is a better understanding of these processes and our lens for analysing them is the multi-scale typology in Figure 13.1.

![Figure 13.1: A multi-scale typology of informal morphologies (Satellite images: Google Earth)](image)
This typology is first organized according to a distinction between the formality of the architecture and the urban design, between the buildings and the street/block layout. For each location we ask: to what degree are the buildings informal and to what degree is the street network informal? The range of morphologies then extends from those where both are informal (lower left) to those where both are formal (upper right). In every case the key criterion for informality is that the architecture or urban design shows evidence of self-organization. In the case of architecture: have the buildings been designed in accordance with a prescribed layout. An informal architecture will show evidence of bottom-up organization, micro-spatial adaptation, inconsistency and crookedness. Such a morphology may appear chaotic and random while also embodying an underlying order of single-room accretions and laneway networks. Informal architecture may be further identified by the use of construction materials that are temporary, unfinished, makeshift and irregular, compared to the more finished and regular construction of the formal city.

The key criterion for defining formal urban design is: to what degree has the street network been produced from the top-down? Has it been professionally surveyed - inscribed with straight lines, consistent curves, street widths and plots? To what degree does the morphology show evidence of order or hierarchic control, of being produced by a set of formal rules? Informal urban design by contrast will show evidence of self-organization and incremental adaptation with crooked, inconsistent and rhizomic interconnections of streets of various widths. While there is generally an underlying order, the morphology may appear random, chaotic and out of control. The informal settlement generally has a high level of coverage with minimal private open space often producing a laneway network that is invisible from an aerial photograph regardless of the resolution. Most informal settlements will not have car access, but if they do then the street surface is likely to be unsealed.

This typology is represented with examples in Figure 13.1 where the formality of the architecture increases along the vertical axis while the formality of urban design increases from left to right. The 3x3 grid generates nine possible conditions whereby the architecture and urban design may each be categorized as informal, mixed or formal. Each category is then labelled with a code showing the architecture and urban design in the format architecture/urban design - ranging from the most common conception of an informal settlement (i/i) in the lower left to the formal city (F/F) in the upper right. This is no simple continuum and the mixed conditions in between include those where the urban design involves a quasi-formal or formal streetgrid while in some the architecture is a mix of formal and informal buildings. While the two basic categories where both urban design and architecture are either formal or informal are relatively easy to detect, the mixed categories are much more problematic. We will discuss them one at a time.

i/i The lower left category is that which is most often identified as an informal settlement - generally a morphology of room-by-room accretions where the street and laneway network has emerged through an incremental process.

F/F In the upper right is the morphology of what we normally call the formal city where both buildings and street networks are formal.
The lower right category shows an informal architecture emerging incrementally within a formal streetgrid. The defining condition is that a formal urban streetplan provides the framework for informal architecture. Some examples are found in 'site and services' projects.

The lower central category is one where an informal architecture emerges within a quasi-formal streetgrid. Such developments are common where land invasions are semi-organized or where 'pirate' development takes place on private land - the land is loosely but illegally surveyed into a streetgrid prior to incremental construction that is loosely confined to blocks and plots. We label the urban design 'quasi-formal' to indicate that it is 'apparently but not really' formal - almost formal. Such street layouts are often designed to replicate some of the conditions of the formal city as a strategy to anticipate and facilitate an eventual legitimation and formalization process. While such settlements generally do not include services nor set aside land for public use, they generally ensure a level of access and streetscape uniformity. They are most easily detected on aerial photographs by distorted or slightly irregular street grids and may be based in part on pre-established boundaries of rural land use.

The between condition with regard to architecture (right centre) involves informal encroachment within an existing formal neighbourhood; new buildings and extensions are added to the formal architecture in the form of new buildings, accretions, extensions and additional storeys. This can be a difficult condition to detect from aerial photographs because it emerges incrementally from the formal city. Examples range from backyard and frontyard shacks (Lemanski 2009) to what are generally termed 'core+' programs with informal additions to a formal building core (Doshi 1988).

The central category is one where the architecture is a mix of formal and informal buildings within a quasi-formal streetgrid. This is the most ambiguous category and it often indicates informal settlements where streets have been upgraded to quasi-formal and formal buildings have become interspersed with the informal.

The upper central category is where a formal architecture is framed by a semi-formal streetgrid. Examples here are generally the result of a process where the architecture has been formalized over time while retaining a relatively informal streetgrid. There are many examples within older European cities.

The left centre category is one where some formal buildings are constructed within an informal settlement - often as part of an incremental upgrading process.

This category rarely exists within an urban context because the formalization of the architecture depends upon at least some some formalization of the street plan. It does occur in rural locations when pre-fabricated housing is informally located.
These types are variously the result of both formalization and informalization processes - the informal city becoming formalized and the formal city becoming informalized. The formalization process is often called 'upgrading'. A large part of what is at stake in this kind of mapping lies in the ways in which different parts of the city change incrementally from one category to another. Many strategies for upgrading of informal settlements can be identified within the framework established here. For instance, ‘site-and-services’ approaches such as those originally proposed by Turner (1976) involve a formal urban design with informal architecture - i/F. The strategy known as core+ (Doshi 1988) encourages informal accretions on and around a core (formal) architecture and within a formal urban framework as in type m/F. The demolition and replacement of informal settlements is generally a transformation from i/i to F/F. Incremental in-situ upgrading strategies often involve a transformation from i/i to m/i or m/m and ultimately to F/m. A better understanding of such processes is what is ultimately at stake in this research.

A few points before we proceed to the mapping. First is that urban informality is far too complex to be captured within such simple categories. While this is an empirical study with formal criteria to establish differences between morphologies, these are not essential types and the boundaries between them are fluid. Second, while these categories are entangled with social, legal and economic differences, we are not mapping social, tenure or slum conditions. We are simply mapping morphological differences that are geared to informality. Finally, while our types range from informal to formal, this is no simple continuum. It is rather two intersecting continua that work to identify mixed morphologies of seven different kinds that emerge as interstitial conditions.

The mapping we have undertaken here is entirely based on visual data from Google Earth and Streetview. We make no claim here to be comprehensive since the fine distinctions between categories in Figure 13.1 are not always possible with these databases. Streetview was not available in about half the cities we have analysed and it rarely penetrates into the informal settlements. Indeed, an easy way to find informal settlements is to look for those developed parts of a city where Streetview has not penetrated - they will be either highly formal enclaves such as industrial parks and gated communities, or informal settlements. While these categories can all be mapped separately our experience is that making distinctions between the six mixed categories is problematic and maps with all eight types are not easy to read. For these reasons we have collapsed the mixed categories into two - formal-mix and informal mix - as colour coded in Figure 13.1.
The sample of cities presented here are intended to cover most urban types across the global south. There is a different history of informal encroachment and upgrading to be told for each city; while these are important stories, we have scope here for only the briefest of introductions. While these cities differ in size we have mapped them (with a single exception) at a consistent scale of 30x 30 km - while informal urbanism often extends well beyond this frame, there is no stopping rule and our goal is to maintain a comparative framework at a readable scale. The four categories of 'informal', 'informal-mix', 'formal-mix' and 'formal' range from bright yellow to dark brown. Aerial photos beneath each map show examples of the particular morphologies in each city including the two most common types of mix. The maps also show relations to key centres of the formal city (red dots) and major waterways. We note that there are many aspects of urban informality that escape this lens, including the microscale settlement of sidewalk strips as well as informal encroachments within formal buildings.
Jakarta (Figure 13.3) encompasses a metropolitan region with a population of about 30 million on a flat coastal plain traversed by small rivers that are subject to flooding. The map shows a pattern of informal morphology dominated by an informal-mix - indeed Jakarta is perhaps the most difficult of cities to draw any kind of line between the formal and informal city (Simone 2014). What are generally identified as 'informal' settlements are but a small proportion of the much broader areas of mixed morphologies. These include older kampungs or villages with a semi-formal morphology that have become informalized over time.
Manila (Figure 13.4) is a harbour city on a broad and flat coastal plain with a metropolis housing about 12 million people of whom about 35% are estimated to live in informal settlements (Alcazaren et al. 2011). The informal settlements are highly mixed in type including many waterfront and railroad settlements. The informal-mix of the Tondo district near the main river mouth has an average density of 70,000 residents/sq km. Note the modern centre of the formal city known as Makati where all forms of informality have been prevented or erased. Compare with maps in Alcazaren et al. (2011).
Caracas (fig. 13.5) is a city of about 2 million people that occupies a long valley lined with steep escarpments and gullies. The informal settlements, mostly referred to as barrios, cover a significant proportion of the urban landscape and house about half the population. Most informal settlements are on escarpments – Petare to the east is one of the largest informal settlements in Latin America (Gouveneur 2015). Due to the steepness of the land almost all such settlements are of the i/i type. Caracas is notable for the very sharp distinctions between formal and informal urbanism with very few mixed areas, although there is also a high level of squatting within formal buildings that cannot be mapped here (Brillembourg and Klumpner 2013). Compare with maps in Silva (2016).
Buenos Aires (Figure 13.6) is distinctive within Latin America for its flat topography, a city that extends across a vast urban area housing about 14 million people. Informal settlements date from the 1930s and are widely referred to as villas. With few exceptions those villas within the central parts of the city were systematically demolished by the military dictatorship in the 1970s. One result was the emergence of new settlements on the urban fringe known as ascentimientos - mostly pirate developments of formal-mixed morphology. Compare with maps in Janches and Rohm (2012).
Rio de Janeiro (Figure 13.7) houses about 12 million people on an often steep coastal topography. The oldest informal settlements date from the late 19th century when returned soldiers occupied the unsettled escarpments and nicknamed them favelas. The map shows a highly distributed pattern that is strongly geared to the steep topography. There are a very large number of small favelas and a small number of large ones; the well-known Rocinha is near the coast to the south. There is generally a relatively clear boundary with the formal city (Perlman 2010) although they become more mixed with distance from the central city. Compare with maps in Beardsley and Werthmann (2008).
Lima (Figure 13.8) is a city of about 10 million people on a coastal plain lined with escarpments. Informal settlements emerged from the 1940s and were often initiated through semi-organized overnight invasions of state-owned land. The very large proportion of mixed settlements that appear on this map, reflects this high level of organization where quasi-formal streets were laid out overnight. The experiment in 'site-and-services' planning known as Villa El Salvador, inspired by the work of Turner (1976), appears as the largest patch of formal-mixed development in the southeast.
Mumbai (Bombay) (Figure 13.9) is a city of about 20 million people, mostly crowded onto a peninsula where about half the population live in informal settlements. Such settlements range from waterfronts, escarpments and railway easements to the former fishing village and marshland that is now Dharavi (immediately below the red formal centre to the north). Mumbai is the site of some of the densest and most problematic informal settlements on the planet, including mixed-use, single-room accretions of up to five storeys with almost 100% land cover. Compare with maps in Das (2011) and Nijman (2010).

Figures 13.10 and 13.11 map informal settlements in Johannesburg and Cape Town where we find a fundamentally different set of spatial patterns. While races and social classes have always been separated in colonial regimes, here separation was implemented through strategies of distance rather than walls and compounds. The apartheid regime ensured that all informal settlements were removed from the white city and new ones could only emerge on the margins and within racially segregated zones. One result is that building densities are low in the shack settlements with few buildings of more than a single storey and there is often private open space. The South African
settlements are called 'shack' settlements because they generally remain as metal shacks that are built in a day and seldom upgraded.

Figure 13.10: Johannesburg (60 x 60 km) (Satellite images: Google Earth)

Johannesburg (Figure 13.10) is a city of about 4 to 8 million people depending on where the boundary is drawn. Here we have doubled the scale to 60 x 60 km in order to show the extent to which the shack settlements have been distanced from the formal city. The map shows vast areas of mixed development on the urban fringe formed by backyard shacks as well as pirate development and quasi-formal encroachment. Soweto (southwest town) was initially planned as a formal settlement for the black population after they were evicted from the inner city in the 1930s, now highly mixed due to the encroachment of backyard shacks. The few informal settlements that exist within the 30 km frame are mostly aligned with the former gold mining areas that appear as black patches within the formal city. Since the end of apartheid many parts of formal buildings of the inner and central city have become informalized in a manner that cannot be mapped here but is well articulated by Simone (2006). Compare with maps in Huchzermeier (2014).
Cape Town (Figure 13.11) is a port city with a dramatic harbour setting but the informal settlements occupy a vast swathe from 10-25 km to the southeast of the city centre. The majority are mixed morphologies with formal street layouts and a proliferation of backyard shacks (Lemanski 2009).

Figure 13.11: Cape Town (Satellite images: Google Earth)
Nairobi (Figure 13.12) is a city of about 4 million people where large informal settlements remain close to the central city along with extensive areas of mixed informality. The large settlement of Kibera which now houses about a half million people just 5 km to the southwest of the city centre is a legacy of colonial racial segregation since the area was first allocated to Nubian soldiers in the early 20th century. Many more informal settlements developed from the 1970s with internal migration and are now estimated to house about half the total population (UN-Habitat 2003).
Figure 13.13: Cairo (Satellite images: Google Earth)

Cairo (Figure 13.13) is a city of about 20 million with the majority housed in vast areas of informal-mixed settlements across the Nile valley (Kipper and Fischer 2009). Informal urbanization dates from the 1950s and settlements are mostly large pirate developments on private agricultural land that extend south, west and north of the old city where they have swallowed many former rural villages. The density of these settlements is generally very high. The informal morphology is often geared to the spatial framework of agricultural fields in long narrow strips that have become the increments of informal planning with streets emerging along the boundaries. Compare with maps in Kipper and Fischer (2009).
Karachi (Figure 13.14) is Pakistan’s largest city, seaport and financial centre; centre of a conurbation of about 24 million people. The topography is relatively flat and the informal settlements line waterfronts and spread across vast areas - most notably the informal-mix of Orangi Town in the north west which houses about 2.5 million people. Compare with maps in Hasan and Mohib (2003).

Discussion
Our primary goal in this chapter has been to develop a typology of informal urban morphologies and test it as a tool for comparative mapping of cities across the global south. We have argued that the morphologies of urban informality can be usefully understood through the lens of the typology introduced in Figure 13.1 where the intersecting axes of architecture and urban design are each divided into three categories of informal/mixed/formal. This mapping of the city according to informal and formal morphologies is neither binary nor a simple continuum it rather maps a field of differences.
A first finding is to identify some limits to this mapping exercise. While urban informality emerges at multiple scales, we have chosen two scales - buildings and street networks - as the framework for analysis. Urban informality extends to the interiors of buildings and to micro-scale encroachments that cannot be mapped with this method. Even at the scale of buildings and street networks there are often questions of reliability - the degree to which morphogenic processes can be accurately read in terms of their irregularity and incremental change.

A second finding of this study is that while the most formal (F/F) and informal (i/i) morphologies are relatively easily identified, mixed morphologies are far more problematic to differentiate. While an accurate and readable mapping of each mixed type proved impractical at this metropolitan scale, we have shown typical examples under each of the city maps. It is notable that the highly informalized settlements (i/i), have a relatively consistent morphology across these cities as shown in the lower left samples from each city. The mixed categories, by contrast, involve a multiplicity of forms and increment sizes - the mix is a mix of mixes (see also chapter 10). The mix is produced by the morphogenic processes of both formalization and informalization at the scales of both architecture and urban design. On the one hand both pirate developments and incremental upgrading processes produce a mixed or quasi-formal morphology. On the other hand, informal encroachments within the formal city also produce various kinds of mix. The difficulty in mapping this mix is much more than a problem with the typology or a lack of data. This blurring of informality with formality is part of the opportunistic way that informal encroachment operates - both to camouflage itself within the urban fabric and to produce quasi-formal morphologies in anticipation of formal legitimation.

A third finding here lies in the extent of mixed informality that we have identified across these cities. While some maps, like those of Caracas and Mumbai might be seen to largely reinforce the binary principle that has guided previous research, most of the other cities show that the settlements that can be easily identified as informal (i/i) are a small percentage of the areas that are mixed. In cities such as Cairo, Karachi, Cape Town, Johannesburg, Nairobi, Jakarta, Manila and Lima these mixed areas are vast. In some cases these are informal settlements becoming formalized, in others it is the reverse and in many it is both. Given that slum conditions comprise some parts of each of these mixed categories, this underlines the difficulty of mapping slums.

Given the limitations on mapping so many ambiguous categories, it could be suggested that the framework informal/formal is a flawed lens through which to view such cities. However, this is the framework for analysis that offers the best prospect for an effective upgrading process. Many of the most effective upgrading or unslumming strategies involve a formalization from one of these categories to another. The formalization process can be understood as a transformation from the lower left towards the upper right categories of Figure 13.1. The highly ambiguous categories in-between are crucially important to this process precisely because of their ambiguity. It is often the very blurring of such categories that enables both formalization and informalization to take place outside the gaze of the state. Informality camouflages itself within the urban morphology. While there is no scope to pursue these arguments within this chapter, this is ultimately what is at stake in the mapping of urban informality.
REFERENCES

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