Chapter 29
Urban Form of Settlements on Water: A Morphometric Comparison Between Makoko and Venice

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Abstract Recent studies highlight morphological similarities between centrally located informal settlements and historical cities, suggesting that, despite infrastructural deficiencies, the former possess valuable urban form features, e.g., human-scale design, compactness, and walkability, that are also characteristics of the latter. This research challenges the negative connotations often associated with informal settlements, advancing advocacy for the prevention of evictions and the support of legalisation. In line with these works, we compare the urban form of two aquatic settlements: Makoko, an informal settlement in Lagos, Nigeria, and the Italian city of Venice. Both are analyzed through statistical and visual comparisons of nine metrics of urban form. Since Venice is historical and Makoko was only recently established, the most consolidated part of the latter is also included in the analysis. The outcomes show similarities between Makoko and Venice in terms of building elongation, alignment to streets/canals, diversity of building footprints, and coverage area ratio. Importantly, these similarities are more pronounced in the most consolidated part of Makoko, suggesting that if the settlement continues to develop along its current patterns of change, the similarities to Venice will likely increase. Accordingly, policymakers should reconsider the current eviction approach and facilitate the adaptive development of the settlement.

Keywords Urban morphometrics · Case study comparison · Informal settlements · Makoko · Venice

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M. Hanzl et al. (eds.), *Urban Morphology versus Urban Redevelopment and Revitalisation*, The Urban Book Series, https://doi.org/10.1007/978-3-031-77752-3_29

29.1 Introduction

Most contemporary urbanization occurs in cities in the Global South (UN 2018). Much of this urban growth is accommodated through the proliferation of informal settlements, driven by inadequate resources to manage urban expansion, particularly in the context of sub-Saharan Africa (Jenkins and Mottelson 2020). Against this backdrop, approximately one billion people worldwide live in informal settlements characterized by disputed land rights and housing constructed without state authorization (Satterthwaite et al. 2020). On one side, this development is often opposed by local authorities, who present a variety of justifications for the forceful evictions of settlements (Dekel 2020; Manji 2015; Phillips 2011). On the other side, several scholars recommend distinguishing informal spatial production (Dovey et al. 2020) from poverty and social deprivation, suggesting that informal settlements are places with inherent spatial qualities (e.g., human-scale and well-connected urban fabric) comparable to historical urban centres broadly praised for their urban form characteristics (Kellett and Napier 1995; Lawrence 1990; Rapoport 1988; Stea and Turan 1990).

More recently, several quantitative studies further explored these similarities. Porta et al. (2014) indirectly addressed this when comparing the main street networks of a hundred different settlements worldwide, documenting that in cities built before the modernist period (roughly pre-WWII), the average distance between main street crossing was 400 m, whereas in mainstream cities built after WWII, this distance was consistently at least twice as long. Interestingly, the pre-modern *400 m rule* (Mehaffy et al. 2019) was observed in *spontaneously* grown informal settlements built after WWII, which lacked planning regulations. Similarly, Iovene (2018) conducted a diachronic comparison of several metrics of urban form across an informal settlement in Peru and a Venetian neighbourhood, reporting strong similarities between the two, particularly in terms of settlement growth. More recently, Venerandi et al. (2021) carried out a comparative study based on 12 metrics of urban form (block size, coverage ratio, street length, density of amenities, global and local betweenness at 400, 800, 1600 m, and local closeness at the same radii) across three informal settlements in Sub-Saharan Africa and three Italian medieval towns. Similarities were found for basic features of the urban environment, such as street length, plot coverage area ratio, and the configuration of the main street network. The study also reported significant correlations between density of amenities and betweenness centrality, which quantifies the potential through-passage in streets. The main idea underpinning this literature is that systematically demonstrating hidden similarities between seemingly different cases of contemporary informal settlements and widely praised historical towns would do justice to the former, thereby supporting their legalization, and advancing advocacy against evictions.

Interestingly, popular culture has also recognized these similarities, nicknaming Makoko, a large informal settlement in Lagos (Nigeria), the “Venice of Africa” due to its urban environment of organic street and canal patterns, buildings on stilts, and boat-based transport, reminiscent of Venice, the renown historical city

in Italy's Veneto region (Methu 2014). This paper contributes to the body of knowledge on similarities between informal settlements and historical cities with a novel emphasis on aquatic settlements. It ascertains to what extent the analogy Makoko-Venice holds, by comparing a set of nine metrics of urban form (or *morphometrics*) in the two settlements. More specifically, first, we compute such morphometrics, including dimensions, orientations, and shapes of buildings, streets, and canals. These are extracted from openly accessible geo-data sets and computed through *momepy*, a tool for urban morphometric analysis (Fleischmann 2019). Second, we compare these metrics by means of a nonparametric test assessing the similarity of distribution functions and visual summary statistics (i.e., probability density functions). Considering that Makoko developed much more recently than Venice, we also analyse the most consolidated part of the former, to provide insights into the trajectory of the development of the settlement.

Findings show that the distributions of five out of nine morphometrics (building elongation, building alignment to streets/canals, diversity of building footprints, and coverage area ratio) are similar in Makoko and Venice, with the most consolidated part of the former showing stronger similarities. This trend is consistent across all morphometrics, suggesting that, if the current urban development of Makoko is allowed to continue, similarities will likely increase. Accordingly, the study suggests that Makoko will, over time, acquire spatial and configurational properties more similar to those of the widely praised historical Italian city. On this basis, we argue that the current eviction-oriented approach in Makoko (Ajayi et al. 2019) should be abolished. Instead, we propose that authorities focus on investing in infrastructure, improving access to public services, and supporting the incremental development of the neighbourhood in dialogue with local communities.

29.2 Case Studies

Settlements on water are inhabited areas in aquatic environments where boats serve as primary mode of transportation. Such settlements are found in many parts of the world and typically emerge in cultures with economies dominated by fishing (Evers 2020; Lusterio 2008; Sutton 1974). The initial formation of aquatic settlements is typically characterized by simple houses on stilts. As the settlements evolve, more complex forms emerge, including networks of pedestrian paths and more solid building foundations. Archaeological evidence suggests that settlements on water emerged in Oceania at least 3,000 years ago and in South America at least 1,900 years ago (Felgate 2003; Navarro 2018). Tenochtitlan, the famed ancient capital of the Aztec empire, was a city built on water, upon which Mexico City was later founded (Fox 1965). Similarly, Bandar Seri Begawan, the present-day capital of Brunei, was a water-settlement more than 500 years ago (Azman et al. 2021). Although these settlements constitute important cultural heritage, their urban forms remain understudied. In this paper, two notable cases are analysed: Makoko (Lagos, Nigeria) (Fig. 29.1, left) and Venice (Italy) (Fig. 29.1, right). These were selected as (i) they are both

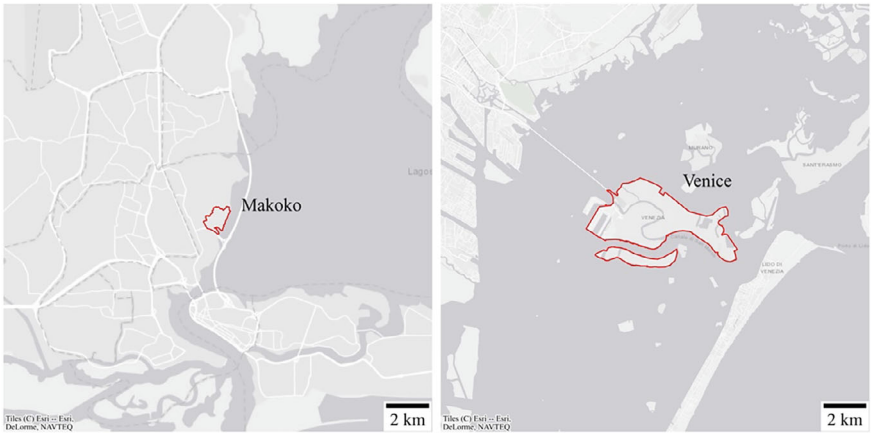

Fig. 29.1 Geographical contexts of Makoko (Lagos, Nigeria), left, and Venice (Italy), right. *Source* the authors and Esri, DeLorme, NAVTEQ (base map)

sizable settlements on water; (ii) Makoko is a recently built informal settlement and Venice is a historical city; (iii) the cases are characterized by fundamentally different contexts, including different geographic, cultural, legal, and economic settings. On this basis, this study provides insights into morphological similarities between an informal settlement and a historical city, with a novel focus on aquatic settlements.

29.2.1 Makoko (Lagos, Nigeria)

Makoko is an informal settlement with more than 200,000 residents situated in the Lagos Lagoon (Ajayi et al. 2019) (Fig. 29.1, left). It is colloquially known as the 'Venice of Africa' due to its unique architecture built on water and picturesque urban features (Methu 2014) (Figs. 29.2 and 29.3). However, the neighbourhood is characterized by poverty, inadequate basic infrastructures and limited access to public services (Ajayi et al. 2019). Makoko developed as a fishing village during the nineteenth century, on the swampy banks of the Lagos Lagoon (Oloko et al. 2022). The local geographic conditions and the fishing-based economy has led to the emergence of the unique characteristics of the neighbourhood, i.e., houses built on stilts in the water and boats as a primary mode of transportation. Following the independence of Nigeria in 1960, Lagos grew rapidly and Makoko went from a peripheral to a centrally located neighbourhood, engulfed in the metropolis (Barredo and Demicheli 2003). Lagos is the largest city in Africa and one of the fastest growing cities in the world. The high level of demand for land in the city is intensifying the pressure on the housing and land markets in Makoko due to the central location of the settlement. The authorities have adopted a hard-line eviction-oriented approach to the development of the settlement due to its extra-legal status (Ajayi et al. 2019).

Fig. 29.2 Aerial photo of Makoko. *Source* Johan Mottelson

Fig. 29.3 Kids sailing in front of a small shop (left). Elevated pathway system and water tank (right). *Source* Johan Mottelson

The urban structure of Makoko is characterized by a system of canals leading directly from the inner shore of the lagoon to the open water, with secondary smaller canals between them. Close to the inner coastline, an elaborate network of elevated pathways and small bridges connect and provide access to the individual buildings. As the distance from the coastline increases, built-up density decreases and the fabric of the settlement becomes more dispersed. This gradient broadly reflects the development of the settlement, whereby the first nucleus was built on the coastline while later expansions were added progressively towards the lagoon's open waters. Closer to the inner coastline, shallow waters were transformed into habitable land by filling simple timber frames with soil, as well as sawdust and scrap wood from the timber mills located in the southern part of the neighbourhood. Houses are built on stilts directly hammered into the bottom of the lagoon and are largely made of timber, bamboo, plywood, and corrugated iron sheets (Ilechukwu et al. 2022).

Much of the housing stock is substandard and does not provide adequate protection from the environment (Gambo et al. 2012). Some households closer to the mainland have access to water, through flexible plastic pipes. However, many families also store water in large tanks due to the unreliability of the water system. Households located further from the coastline lack direct access to fresh water and buy it closer to the mainland, transporting it by boats to their homes (Babalobi 2013). There is no functioning sewage system in the neighbourhood. Toilets and showers consist of simple timber platforms with a hole in the floor, enclosed by plastic sheets or timber walls for privacy. Consequently, the lagoon water underneath and around the settlement is highly polluted. Only a few parts of the neighbourhood are connected to the electricity grid, and the power supply in Lagos is very unstable. Consequently, many households have private gas fuelled generators causing a constant background noise in the area. In the periphery of Makoko**,** a large part of the lagoon is full of floating logs. These are transported from outside of Lagos and cut in sawmills south of the neighbourhood, supplying the city with timber for construction.[1]

The residents of Makoko lack formal legal ownership of the land they occupy, despite many families having lived there for generations. Authorities justify forced evictions by citing the illegal occupation status. These evictions occur without proper compensation for property loss and often lead to violent confrontations with the police (Ajayi et al. 2019). The authorities can only clear out small parts of the neighbourhood gradually, due to its size and the risk of political turmoil. As a result, the fate of this unique urban area and its community remains highly uncertain.

29.2.2 Venice (Italy)

Venice is a city located in the Venetian Lagoon, in the Veneto region, north-eastern Italy (Fig. 29.1, right and Fig. 29.4). The city is built on top of an archipelago of around 100 small islands, connected through over 400 bridges. It has a declining population currently standing at roughly 50,000 residents.[2] However, tourism raises this number considerably, especially in the high season.

There are no written records on the origins of the city; however, tradition and available evidence suggest that it was founded in the period of the Western Roman Empire (421–476) by refugees from nearby towns (e.g., Padova, Aquileia, Treviso) and rural areas of mainland Italy, who were fleeing recurrent lootings by Germanic and Hun tribes (Bosio et al. 1987). Later Roman texts reveal the presence of fishermen, referred to as *incolae lacunae* (inhabitants of the lagoon), on the islands emerging from the marshy lagoon (Fig. 29.5).

At the fall of the Western Roman Empire, only a small strip of coastline (including Venice) became part of the Eastern Roman Empire and was directly administered

[1] There exist limited academic sources on the current conditions of Makoko. The observations reported here are the result of field work carried out by one of the authors of this paper.

[2] https://www.comune.venezia.it/it/node/40751.

Fig. 29.4 Venice as seen from the top of Saint Mark's Bell Tower (left). *Source* Alessandro Venerandi. A canal of Venice (right). *Source* Johan Mottelson

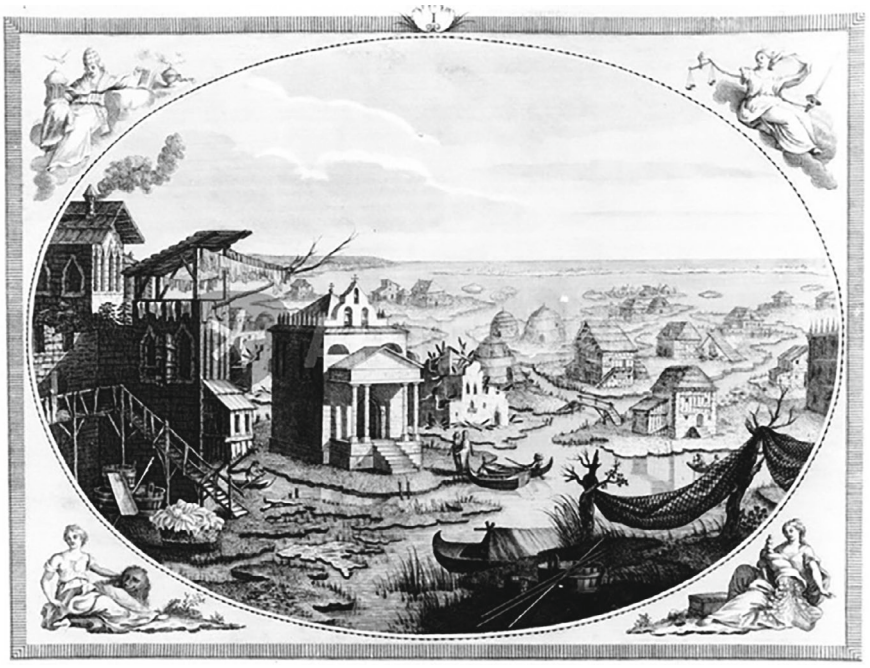

Fig. 29.5 "Stato delle isolette di Rivo-alto, prima culla della città di Venezia (State of the small islands of Rivo-alto, first cradle of the city of Venice)". *Source* https://www.iconografiacittaeuropea.unina.it/cms/stato-delle-isolette-di-rivo-alto-prima-cull

by the Exarchate of Ravenna, a nearby city on mainland Italy. In 751, the Lombards conquered most of the exarchate, leaving Venice as the last autonomous Byzantine outpost. During this period, the settlement grew further as people escaping the Lombards' invasion sought asylum in Venice. The famous Basilica of Saint Mark was founded soon after (828) to host the relics of Saint Mark the Evangelist, acquired from Alexandria (Egypt).

Between the ninth and twelfth centuries, the Republic of Venice developed into one of the most powerful financial and maritime empires of its time, becoming the main trade centre, especially of grain, silk, spice, and art, between Europe and Asia. The current configuration of the internationally renowned Saint Mark's Square dates back to this period, resulting from extensive renovation work on the nearby Ducal Palace (Ortalli and Scarabello 1990). More specifically, the square was subdivided into two spaces: a larger one in front of the main Basilica and a more secluded one located between the Ducal Palace and Saint Mark's Bell Tower. However, the most relevant changes to the urban fabric of Venice occurred in the first half of the sixteenth century, when it reached the status of global metropolis. During this period, the city had more than 150,000 inhabitants, and hundreds of new buildings, including houses, palaces, churches, and monasteries, were still being erected using traditional stilt foundations (Ortalli and Scarabello 1990).

From the seventeenth century, Venice experienced a period of decline, mainly due to the Italian plague of 1629–31, which killed a third of its population (Lindemann 2010), and the loss of its hegemonic role in favour of the rising Portuguese empire. In modern and contemporary times, Venice's urban fabric has undergone only minor changes, primarily consisting of the addition of a few representative buildings, demolitions, and road rectifications. Thus, the image of the city that we see today is largely the product of the urban development from the Medieval and Renaissance periods.

Despite originating and evolving in different geographical and historical contexts, Makoko and Venice share similar foundational conditions: both are settlements established in lagoons, with populations displaced by extreme poverty or military invasions, and both utilize stilts for building foundations, with fishing as the primary occupation of their residents. This paper will delve deeper into determining whether these similar initial conditions also resulted in similarities in urban form.

29.3 Investigating Similarities Between Makoko and Venice

In this section, we describe the methodology and datasets used to conduct the morphometric comparison between Makoko, its most consolidated part and Venice, as well as the results of this comparison. The methodology relies on two main parts: (i) the computation of a set of nine morphometrics from openly accessible datasets and (ii) statistical and visual comparisons of these morphometrics across the three case studies.

29.3.1 Datasets and Morphometrics

The set of nine morphometrics used in this study are computed via scripts included in *momepy*[3] (Fleischmann, 2019), a Python package for the quantitative analysis of urban form, and relies on two georeferenced datasets: (i) polygons of building footprints and (ii) centre lines of streets and canals. For Makoko, both datasets were obtained from OpenStreetMap (OSM), the first free, editable map of the world.[4] As OSM is crowd-sourced, the data can be patchy and may not cover informal settlements. However, several mapping campaigns in recent year have provided highly detailed and consistent open-source geospatial data for the neighbourhood (Adeshokan 2020). The data obtained for Makoko comprise 9,321 buildings, 449 canals, and 152 streets. As mentioned in the introduction, in addition to the urban form analysis of the entire Makoko area, we also focus on the oldest and most consolidated part of the settlement, located in the north-western section of the neighbourhood (Fig. 29.7). This part consists of 4,784 buildings, 143 canals, and 144 streets. Data for Venice were retrieved from the official data portal of the city[5] and consisted of 8,335 buildings, 384 canals, and 6,454 streets. Data for both settlements were cleaned of geometrical and topological errors, including duplicated or overlapping geometries and false intersections (i.e., street/canal segments erroneously separated where no intersections are present) to avoid introducing bias in the computation of the morphometrics.

The spatial units of analysis were generated from the building footprints, streets, and canals, through a Voronoi-based algorithm accounting for distances between these elements. The resulting *morphological cells* (Fleischmann et al. 2020) express a proxy of the "area of pertinence" of each building (Caniggia and Maffei 2001). These cells replace plots or cadastral parcels, which are ontologically ambiguous (Kropf 2018), difficult to retrieve in more challenging contexts, such as informal settlements, differently defined in traditional and modern planning (Levy 1999), and often inconsistent across different geographical or administrative boundaries. For illustrative purposes, an extract of the morphological cells generated in Makoko is presented in Fig. 29.6.

The following nine morphometrics are computed for each morphological cell of the two case studies:

- *Building footprint's area* (m^2).
- *Gini-Simpson diversity* (Jost 2006) applied to building footprint areas up to three topological steps from each morphological cell.
- *Irregularity of building corners* (measured as the difference in degrees from the 90-degree angle).
- *Alignment of buildings to streets and canals* (measured as the difference in degrees between the solar orientation of the building and that of the nearby street/canal).

[3] Http://docs.momepy.org/en/stable/

[4] Https://www.openstreetmap.org/

[5] Https://www.comune.venezia.it/it/geoportale

Fig. 29.6 Morphological cells generated in Makoko. *Source* the authors

- *Building elongation* (measured as the ratio between length and width of the minimum bounding rectangle created around the building footprint).
- *Percentage of built-up area* (measured as the proportion of morphological cell which is covered by buildings).
- *Average street/canal width* (measured as the mean value of section lines generated every 3 m alongside the street/canal segment).
- *Street/canal width deviation* (measured as the standard deviation of the above sections).
- *Street/canal edge permeability* (measured as the ratio between the number of sections hitting buildings and the sum of sections created in a street/canal).

Maps for each morphometric for all case studies are provided in Figs. 29.7 and 29.8.

A visual inspection of Fig. 29.7 highlights that the most consolidated part of Makoko has larger and more diverse building footprint areas compared to the south-eastern part of the settlement. Most buildings are overall regular, with 90-degree angle corners. Buildings are largely aligned to streets and canals, with small deviations (between 0 and 11 degrees), while more significant deviations (between 29 and 44 degrees) are found in the northern part of the settlement. In terms of building elongation, the pattern is mixed and scattered, with more elongated building footprints lying next to more square-shaped ones. In terms of percentage of built-up area on the cell, the most consolidated part of the settlement shows cells almost fully built-up (with coverage ranging from 67% to 97%). Most streets/canals tend to have overall limited widths (below 14 m, with very few cases above 21 m) and very varied sections (with differences greater than 5 m in most cases), with mostly continuous

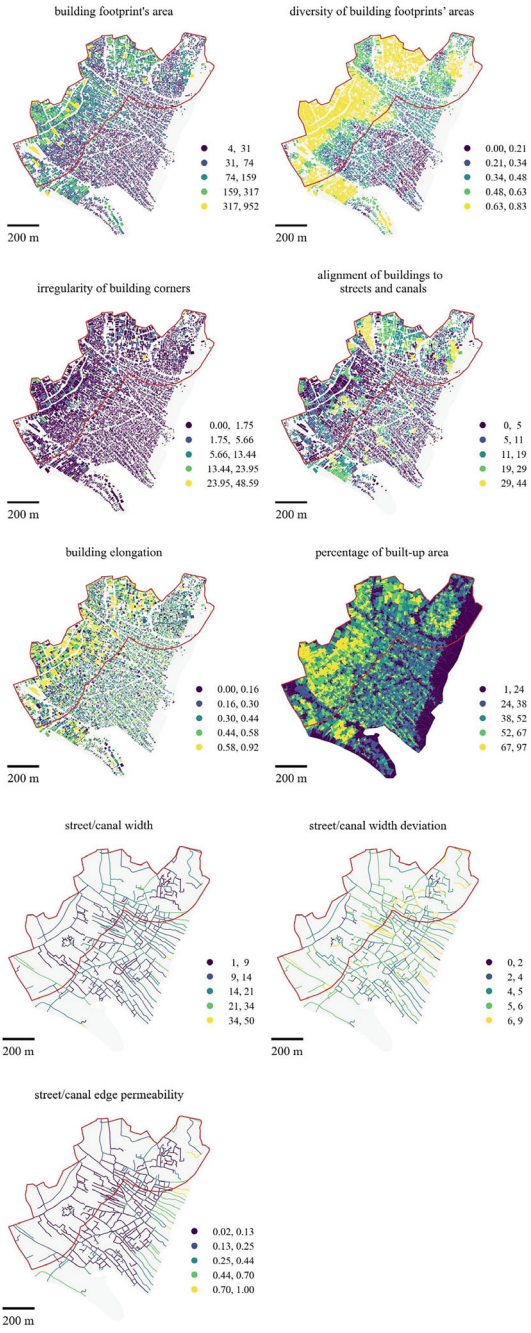

Fig. 29.7 The nine morphometrics computed in Makoko. Yellow corresponds to greater values and purple to smaller ones. The red line denotes the most consolidated part of the informal settlement (continued on next page). *Source* the authors

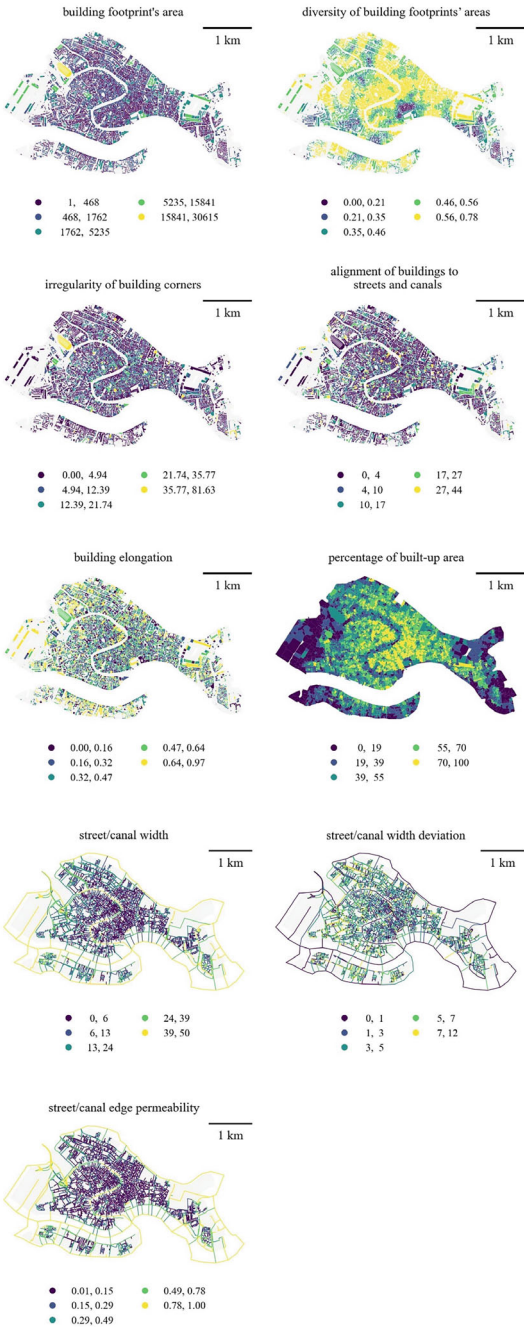

Fig. 29.8 The nine morphometrics computed in Venice. Yellow corresponds to greater values and purple to smaller ones (continued on next page). *Source* the authors

built frontages (the only exceptions being the canals at the south-east periphery of the settlement).

A visual inspection of Fig. 29.8 highlights that building footprint areas in Venice are relatively small (below 1,762 square meters), with few exceptions like the Santa Lucia station, the ferry terminal and Arsenale (the historical shipbuilding district). Building footprints are also highly diversified at the local level, with the exceptions of an area located north of Saint Mark square and the more recent neighbourhoods located south-east of Arsenale. As in Makoko, building footprints consist of a mix of mostly square-shaped and elongated forms, positioned close to one another. In terms of building corners and alignment to streets and canals, there is greater regularity, with most corners only slightly deviating from 90 degrees and buildings generally well-aligned to nearby streets and canals, with misalignments typically smaller than 10 degrees). Density concentrates in the heart of the city, especially north of Saint Mark square, in *sestiere* (i.e., the Venetian appellation for neighbourhood) San Marco and San Polo. Street and canal widths are overall small (below 13 m), with few exceptions above 39 m, such as Canal Grande (the main water artery zigzagging through Venice) and nearby waterways. In terms of street and canal width deviations, greater values (above 7 m) correspond to larger streets and canals, characterised by a more scattered urban fabric, mainly consisting of a mix of industrial/port facilities and residential units. The core of Venice has much more consistent street and canal sections, with deviations of less than 5 m. Greater values of edge permeability (above 0.49) are found in large streets and canals, such as Canal Grande and main waterways, while built-up frontages in denser parts of the city are generally much less permeable (below 0.29).

29.3.2 Kolmogorov–Smirnov Test and Summary Statistics

The values of the nine morphometrics are then compared across Makoko, its most consolidated part and Venice both statistically and visually. The statistical comparison relies on the two-sample Kolmogorov–Smirnov (KS) test, a non-parametric statistical technique that quantifies the similarity between the probability distribution functions of two variables through a null hypothesis test (Conover 1999). Operationally, the KS test measures the distance (D) between the empirical distributions of two samples, with the null hypothesis being that these samples are taken from the same distribution. When two distribution functions are very similar, D is small, corresponding to a small distance between them, and the p-value is not statistically significant (i.e., p-value >0.05). The two-sample KS test is one of the most widely used techniques for assessing similarities between two variables which is sensitive both to differences in location and shape of distribution functions (Conover 1999).

The two-sample KS test is applied to quantify similarities across the distribution functions of the nine morphometrics for the couples Makoko (entire settlement)-Venice and Makoko (most consolidated part)-Venice (Fig. 29.9). P-values are statistically significant (<0.05) in all tested combinations, meaning that the null hypothesis

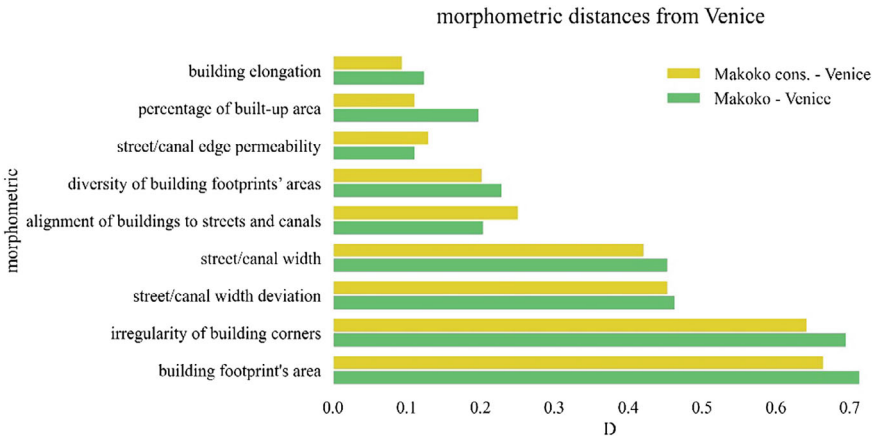

Fig. 29.9 Distances (D), computed via two sample KS test, between distribution functions of morphometrics, for the couples Makoko and Venice (green) and consolidated part of Makoko and Venice (yellow). *Source* the authors

of statistical similarity can be rejected (i.e., distribution functions are not identical across the case studies). Nevertheless, distances (D) in Fig. 29.9 highlight that the distribution functions of five morphometrics out of nine (i.e., building elongation, percentage of built-up area, street/canal edge permeability, diversity of building footprints' areas, alignment of buildings to streets and canals), are relatively close to the ones observed in Venice (D <= 0.25) for both Makoko and its most consolidated part. Interestingly, for all morphometrics except two (street/canal edge permeability and alignment of buildings to streets and canals), the distributions in the latter are more similar to those of Venice than to those computed for the entire settlement.

Since the KS test only provides statistical information on the similarities of distribution functions rather than comparing the actual values of the morphometrics, Probability Density Functions (PDFs) are computed and plotted to offer both visual representations and numerical insights into these similarities. A PDF is a function whose values, at any given point in the range of possible values that a variable can take, correspond to the relative likelihood that the variable's value will be close to that point (Grinstead and Snell 2009). In practice, the PDF is a smoothing function that estimates probability density per unit length, making it extremely useful for visually comparing the same variable across different case studies.

PDFs for each of the nine examined morphometrics in each case study are calculated and presented in Fig. 29.10. Visual assessment confirms the results of the KS test: the distribution functions are relatively dissimilar across the tested case studies. However, the distributions of the five morphometrics previously mentioned are very similar in Makoko and Venice. Again, the same patterns are even stronger for the most consolidated part of Makoko and Venice. More specifically:

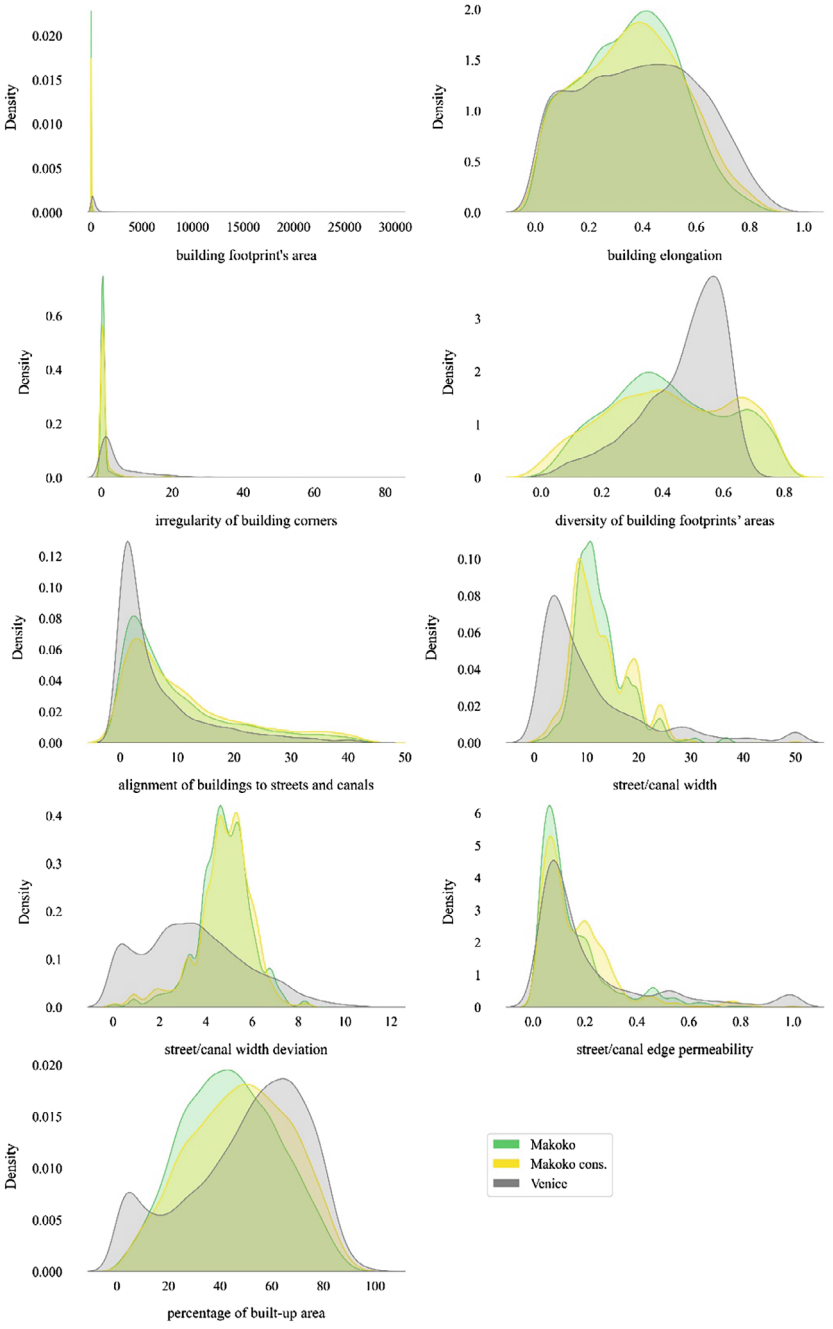

Fig. 29.10 Probability density functions (PDFs) of the nine morphometrics for Makoko (green), the consolidated part of Makoko (yellow) and Venice (grey). *Source* the authors

- In terms of building elongation, Venice has a larger proportion of very elongated building footprints, with values between 0.6 and 0.9, compared to the other case studies. However, the distribution of values in the consolidated part of Makoko tends to be more similar to Venice than to the entire informal settlement, showing a small peak at 0.4 and a growing curve with values between 0.6 and 0.8.
- The distributions of percentage of built-up area show a similar behaviour, with the whole Makoko peaking at around 40%, its most consolidated part at around 50% and Venice at around 60%. Interestingly, the first peak in Venice (corresponding to several cells having built-up areas close to 0%) may be attributed to the targeted demolitions and addition of new public spaces (e.g., square, wider streets) during the eighteenth and nineteenth centuries, which reshaped the extremely compact and dense urban fabric of the medieval city.
- The gradient Makoko (whole settlement), Makoko (most consolidated part), Venice is also visible in the distribution functions of street/canal edge permeability, where the trend indicates more streets and canals with fully built-up frontages (see peaks at 0.1).
- In terms of diversity of building footprints' areas, the previously observed trend is less apparent. However, the most consolidated part of Makoko shows a higher diversity in footprint sizes compared to the entire settlement (see the second peak of the distribution function). It may, therefore, be that over time, the distribution of this metric will become more similar to that of Venice.
- In terms of alignment of buildings to streets and canals, the distribution functions for the three case studies show clear similarities, with most buildings closely aligned to nearby streets and canals (see peaks just above 0 degree, indicating near-perfect alignments).

Further observations can be made from the morphometrics, whose distribution functions, although statistically less similar across the three case studies, still provide a common overall picture. The peaks and very long tail distributions of building footprint's area and irregularity of building corners, which correspond to many small and regularly shaped buildings and very few large and irregularly shaped ones, refer to more spontaneous and adaptable forms of urban development. These forms are typical of bottom-up, plot-based (Porta and Romice 2014) processes of urbanization. The same types of distributions also characterise natural systems, in contrast to the normal distribution that consistently emerges in top-down processes of urban planning, which results in less adaptable forms, such as most modernist developments (Jiang 2019; Salingaros and van Bilsen 2005). In terms of street/canal width and street/canal width deviation, the distributions of values in Makoko (both the entire settlement and the most consolidated part) suggest an earlier formative stage compared to Venice. This is evidenced by slightly larger streets and canals in Makoko and its most consolidated part (peaks around 10 m) compared to Venice (peak around 5 m), as well as larger deviations in section sizes, with peaks of 5 m for the former two and 2.5 m for the latter. Nonetheless, both findings highlight an underlying similarity between the settlements under examination and support the hypothesis of a

longer-term evolutionary trajectory that is bringing Makoko increasingly close to Venice.

To make the results of the analysis more tangible, map extracts of the most and least statistically similar morphometrics (building elongation and building footprint's area) are presented in Fig. 29.11. In terms of the former (first row, Makoko on the left and Venice on the right), elongation values are more evenly distributed across the intervals, indicating that both case studies have a similar number of buildings with comparable elongation values. In terms of building footprint's area (second row, Makoko on the left and Venice on the right), the first two value intervals (10 to 22 square meters and 22 to 41 square meters) are almost entirely absent in Venice. This suggests that, unlike Makoko, Venice does not exhibit a fine-grained fabric of very small buildings due to its higher degree of consolidation.

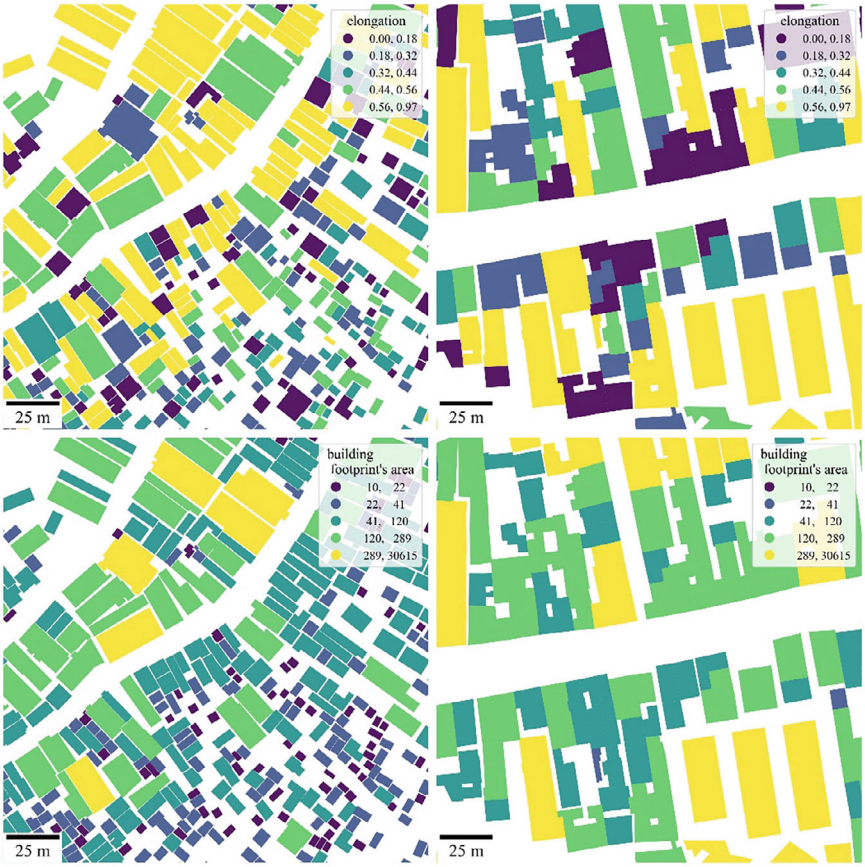

Fig. 29.11 Most (top row, Makoko left, Venice right) and least (bottom row, Makoko left, Venice right) statistically similar morphometrics across the case studies. *Source* the authors

29.4 Discussion

Is Makoko the "Venice of Africa"? The short answer is partially, or not yet. The results highlight that the distributions of the nine morphometrics under examination are not statically identical across Makoko, its most consolidated part and Venice. However, distances between distribution functions are relatively small for five morphometrics out of nine. Moreover, the distinct characterisation of Makoko's oldest part suggests an ongoing pattern of consolidation, eventually leading to spatial configurations more akin to those of Venice. In a nutshell, Makoko seems to be on an evolutionary trajectory towards Venice. This finding suggests that if Makoko's growth continues along the same spatial principles we have observed so far, rather than being jeopardized by widespread evictions and housing demolitions, it is likely to bring urban qualities to the settlement similar to those acknowledged and celebrated in Venice (Gehl 2013).

This study contributes to the body of knowledge built by previous qualitative studies of 'bottom-up' urban growth (Kellett and Napier 1995; Lawrence 1990; Rapoport 1988; Stea and Turan 1990) and quantitative studies examining the similarities between historical cities and informal settlements (Iovene 2018; Porta et al. 2014; Venerandi et al. 2021). It also provides further legitimacy to the inherent spatial qualities of informal settlements. While we acknowledge the significant issues linked to inadequate infrastructure provision and the lack of state recognition (e.g., insecure land tenure, substandard housing, overcrowding, and limited access to water and sanitation), we argue that informal settlements often exhibit favourable morphological preconditions (as evidenced in this study on Makoko and in the previous studies mentioned above), which should be considered assets to preserve and enhance in any slum upgrade policy. More sensitive, community-oriented and fine-grained design policies that recognise and value the spatial assets built over generations by local inhabitants while addressing deficits in sanitation, infrastructure, and services, could, in the long run, lead tounexpected benefits in terms of both diversity and adaptability, similar to those that have contributed to the development of Venice and continue to shape its character. As Andres Duany, founder of the Congress of New Urbanism, repeatedly said in various contexts: *"even Florence was once a shanty town. But its technology allowed it to evolve into what it became. Suburban technology is not able to do that. Over time it is able only to decay"* (A. Duany, personal communication, December 18, 2019).

Finally, informal urban development often results from the failure of formal housing markets to provide affordable accommodation. Eviction-based approaches to informal urban development do not address the underlying issue of housing affordability and may, in fact, increase the cost of informal housing by limiting its supply (Goytia et al. 2023; Mottelson 2020). Based on this, and in line with the findings of this study, we argue that authorities in Lagos should recognize the cultural heritage of Makoko, abandon eviction-focused policies, and promote community-driven in situ upgrades, infrastructure provision, and access to services.

29.5 Conclusion

In line with previous works focusing on morphometric similarities between informal settlements and historical cities, we compared the urban fabrics of Makoko, a large informal settlement located in Lagos, Nigeria, and the renown Italian city of Venice. The comparison was carried out by (i) extracting data on buildings, streets, and canals from openly accessible datasets (i.e., OSM and the official geodata portal of Venice); (ii) computing nine morphometrics descriptive of the urban fabrics of the two case studies; and (iii) using the two-sample KS test to compare distribution functions of the nine morphometrics across case studies. The results showed that distributions were not identical across Makoko (the entire settlement and the most consolidated part) and Venice. However, the distances between distribution functions were very small for five morphometrics out of nine (i.e., building elongation, percentage of built-up area, street/canal edge permeability, diversity of building footprints' areas, alignment of buildings to streets and canals), highlighting similarities across the settlements. These similarities were even more pronounced when comparing Venice to the oldest and most consolidated part of Makoko, suggesting that, over time, the informal settlement may develop morphological qualities increasingly similar to those of Venice. By extension, we suggested that this may apply to informal settlements in general, provided that the underlining principles of their largely bottom-up and locally managed evolutionary patterns of urbanisation are not disrupted by extensive clearances or top-down redevelopment. A shift towards alternative approaches, based on minor interventions generated and supported through a participatory environment, is urgently needed. These approaches should prioritize addressing infrastructural, service, and sanitation gaps while recognizing the value embedded in the settlement's existing morphology, shaped by generations of dwellers. Finally, given the existence of many informal water settlements across the Global South (e.g., Cambodia, Vietnam, Benin, the Philippines, Indonesia, Guatemala, and Papua New Guinea), this study's relevance extends beyond Lagos and Africa. A deeper understanding of these settlements' spatial qualities may challenge their extra-legal status and strengthen advocacy for their legalization and preservation.

Acknowledgements This work was supported by the Axel and Margaret Ax:son Johnson Foundation as part of "The Urban Form Resilience Project" at the University of Strathclyde.

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