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Urban Transformation and Associated Emerging Urban Forms: An Examination of Physical Density from Planning Interventions Perspective

Samuel Asfaw Zelelew[1]* and Zegeye Cherenet Mamo[2]

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Abstract. *Rapid urbanization frequently results in unanticipated morphological traits that could have multifaceted consequences, especially in the urban physical transformation of cities in developing countries. This study aimed to examine these spatial transformation events and identify the related emergent urban forms in the morphogenesis of Dire Dawa, Ethiopia from the perspective of plan-led and spontaneous developments. The researchers conducted a thorough on-site investigation to gather the necessary physical information and supplemented it with a desk review and focus group discussion. We utilized the Spacematrix software to examine the data and pinpoint the evolving urban structures from different time periods. Overall, the research demonstrated that point-type low-rise development dominated organically developed sites, whereas plan-driven developments were dominated by block-type low-rise and block-type midrise forms. Furthermore, except for outlying areas, there has been a rising trend in the floor space index and spatial coverage patterns over the course of the city's morphological eras. This may indicate a growing concern for space efficiency and sustainable development. The density of the street network in organically developed portions, on the other hand, was greater than that in formally planned areas. This shows the relevance of considering the concept behind organic development in planning and designing interventions besides the formal western planning philosophy.*

Keywords*: Ethiopia; formal planning; morphological transformation; physical density; spontaneous development*

[1] Urban and Regional Planning Chair, Ethiopian Institute of Architecture Building Construction and City Development (EiABC), Addis Ababa, Ethiopia (*Corresponding Author). Email: samuel.asfaw@eiabc.edu.et or samuelasfaw94@yahoo.com
[2] Architecture Chair, Ethiopian Institute of Architecture Building Construction and City Development (EiABC), Addis Ababa, Ethiopia.

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Abstrak. *Urbanisasi yang berjalan dengan cepat seringkali menghasilkan ciri-ciri morfologis yang tidak dapat diantisipasi dan memiliki konsekuensi multifaset, terutama dalam transformasi fisik kota di negara berkembang. Studi ini bertujuan untuk menguji peristiwa transformasi spasial dan mengidentifikasi bentuk perkotaan yang muncul terkait dalam morfogenesis Dire Dawa, Ethiopia dari perspektif perkembangan yang terencana dan perkembangan spontan. Peneliti melakukan penyelidikan menyeluruh di tempat untuk mengumpulkan informasi fisik yang diperlukan dan melengkapinya dengan tinjauan pustaka dan diskusi kelompok terfokus. Kami menggunakan perangkat lunak Spacematrix untuk memeriksa data dan menentukan struktur perkotaan yang berkembang dari periode waktu yang berbeda. Secara keseluruhan, penelitian menunjukkan bahwa pembangunan bertingkat rendah tipe titik mendominasi lokasi yang dikembangkan secara organik, sedangkan pembangunan yang digerakkan oleh rencana didominasi oleh bentuk bertingkat rendah dan tipe blok bertingkat menengah. Selain itu, kecuali untuk daerah terluar, telah terjadi tren peningkatan indeks ruang lantai dan pola cakupan ruang sepanjang era morfologi kota. Ini mengindikasikan meningkatnya perhatian terhadap efisiensi ruang dan pembangunan berkelanjutan. Kepadatan jaringan jalan di bagian yang dikembangkan secara organik, di sisi lain, lebih besar daripada di daerah yang direncanakan secara formal. Hal ini menunjukkan relevansi mempertimbangkan konsep di balik pembangunan organik dalam perencanaan dan perancangan intervensi selain filosofi perencanaan barat yang formal.*

***Kata kunci**: Etiopia; kepadatan fisik; perencanaan formal; perkembangan spontan; transformasi morfologis.*

Introduction

Cities are dynamic entities whose settlements change over time along with their form (Trisciuoglio et al., 2021). They have been playing a central role in political, economic, social, and intellectual developments throughout history (Mamo, 2015). In recent periods, the ever-increasing level of urbanization is posing difficulties in urban planning and design exercises (Qin & Zhang, 2014), where its effect may grow in tandem with the pace of urbanization. This rapid urbanization in sub-Saharan African countries, including Ethiopia, allows for massive spatial transformation in their cities (Agyemang et al., 2019). Such fast urbanization usually results in morphological patterns that are unanticipated and, in some cases, counterintuitive (Xie et al., 2007). These situations necessitate to conduct more investigations. The purpose of this research was thus to analyze these spatial form transformation events and related emergent urban forms across history, taking six case areas of Dire Dawa, Ethiopia. This allowed us to answer the following two questions: What characteristics did formally planned and organically produced areas of the city display in their emergent urban forms as a result of the city's morphogenesis? Does the city's morphogenetic trend represent a sustainable pattern of development from the physical density perspective? The answers to these two questions could be a representative response for the scenarios exhibited in the second tier of cities in Ethiopia as well as in sub-Saharan Africa.

The spatial form transformation of cities can be defined as the study of the effects of transformational changes in urban systems (Hölscher & Frantzeskaki, 2021). The vast majority of cities need more and more land as the process of urbanization progresses. They creep up to the outskirts of villages, engulfing them, and this is how the urban transformation is taking place laterally (Chandra & Mukherjee, 2015). In the course of such transformations of cities, there will be urban expansion, which can include morphological additions to the city as well as certain

adjustments in previously existing areas. The essence of urban transition, on the other hand, may be expressed in the form of shrinking urban areas with associated changes in urban form, as has been the case in some developed countries (Cunningham-Sabot & Fol, 2009; Pallagst, 2009). In the context of this study, 'urban morphologic transformation' refers to the changes in the urban texture of cities, both internal and external, resulting in associated urban form modifications in their morphogenesis. The primary goal of urbanism should thus be to affect urban transformation (Inam, 2013), which could bring about changes at various scales (Hölscher & Frantzeskaki, 2021). To ensure sustainable development, however, it is critical to have accurate information on the rate and patterns of this urban morphological transformation (Das & Angadi, 2021).

Several agents and agencies are accountable for and have an impact on the complicated processes of urban spatial form transformation (Oliveira, 2016). Along with this urban spatial form transformation, the components that make up urban form are constantly being transformed and replaced (Moudon, 1997). According to Bentley (2004), the process of form-production is characterized by a complex pattern of negotiation and conflict among several parties. These complex patterns of relationships can manifest themselves in both organically developed and formally planned urban development cases. For instance, an urban form study conducted in slum areas in America, Africa, and Asia pointed out that organic urban development offers various opportunities to explore sustainable urban forms (Zappulla et al., 2014). Meanwhile, urban form studies on formally developed parts of cities are not uncommon. Urban form is commonly associated with the development of formal urban patterns (Zappulla et al., 2014), while organic patterns have not received proper coverage. However, Dabbour (2021) studied the organic development of Islamic cities from the perspective of Damascus. In another context, Zappulla et al. (2014) saw the scenario of organic development from a slum area perspective. Therefore, this study highlights perspectives from either side and made a comparison of both scenarios apart from exploring the morphological trend and the associated urban forms.

Urban morphology arose as a field of study concerned with the urban landscape around the end of the nineteenth century. It has its beginnings mostly in central Europe (Whitehand, 2007). From the end of the nineteenth century, substantial breakthroughs in the theoretical and analytical elements of urban morphology have been made. The contributions of Conzen's English 'school' have had an immense influence on the study of urban morphology (Gauthiez, 2004). Many researchers have conducted their research on urban form and the spatio-temporal physical transformation of urban areas based on Conzen's school of thought.

However, research on urban morphology in Africa, especially in sub-Saharan Africa, is scant. There have been some studies on their urban development characteristics, but very few have examined them from a morphological perspective. For instance, a previous research was conducted in the study area with similar cases, considering their use-mix intensity, employing the mixed-use index (MXI) developed by Van den Hoek (2008) along with an assessment of the neighborhood level open space ratio (OSR) (Asfaw & Chernet, 2023).

On the other hand, the present research approached its assessment of urban transformation from the physical density perspective, taking into account the floor space index (FSI), ground space index (GSI), network density, and open space ratio (OSR) at the plot level. From the perspective of urban physical form, this study can be considered a micro-level assessment of the urban texture based on formally planned and spontaneously developed scenarios. Thus, this study may help in understanding the spatio-temporal transformation of urban morphological phenomena from the perspective of formally planned and spontaneously developed parts of cities in the developing world. This in turn aids in recognizing modern-day changes and their impact on historic areas of cities, as well as changes in urban life as a result of the built environment. In addition, such studies,

according to Scheer (2017), contribute significantly to urban design and planning practices and policy modification.

Therefore, studying urban transformation and associated emerging urban forms have significant policy and academic implications. The use of spatial analysis tools such as Spacematrix can provide insight into the physical density of urban areas and help planners to develop effective interventions. Understanding urban transformation trends is also critical for sustainable urban development, and policymakers must understand the implications of urban change for the well-being of city dwellers. Emerging urban forms reflecting the combination of low-rise, mid-rise, or high-rise buildings and point-type or block-type developments can also have a significant impact on the sustainability of urban areas. From an academic perspective, studying emerging urban forms can provide intuitions about the drivers of urban change and the implications of these changes for urban sustainability. From these insights, it can be understood that this research may have both policy and academic significance. As a result, this study is expected to contribute to making policy modifications, reshaping building codes and planning regulations depending on the result.

Materials and Methods

The evaluation of urban forms may take several forms, depending on the study purpose. One technique for studying urban form in its three-dimensional manifestation is to evaluate the built environment's density. It is obvious that urban areas during their physical transformation reflect different scenarios in their built environment density. The density of a built environment is highly related to the sustainable development of an area. Many people believe that increasing density in urban design and planning is a good strategy to achieve socioeconomic and environmental sustainability (Bolton, 2021). There are also some negative reflections regarding increasing density and compact development, claiming its consumption of natural cover and environmental damage (Gren et al., 2019). On the other hand, these effects could be counterbalanced by the significant impact of compact development and higher density through reduced energy use and emissions (Gordon, 2008). From the standpoint of cities in developing countries, where horizontal expansion predominates over vertical development, the researchers argue that densified and compact development could be beneficial, at least until their current state of development. In this sense, evaluating density in the morphological transformation of urban areas may indicate whether or not a city's development route is sustainable.

Nevertheless, individual perceptions of density may differ from formal definitions, making it difficult to deduce information from one to the other. Thus, in keeping with the study's objective of emphasizing the morphology of cities, this research examined density via the lens of physical/spatial dimensions. This allowed for the assessment of the tactile and quantifiable aspects of the built form. Based on this aspect of density, this study attempted to examine the morphological characteristics of the study city. While doing so, it assessed the emergent urban forms exhibited through the spatial form transformation of urban areas through their development trend with the perspective of physical density, using the case study method. For this purpose, the researchers employed desk review, focus group discussions, and physical surveys of the study area.

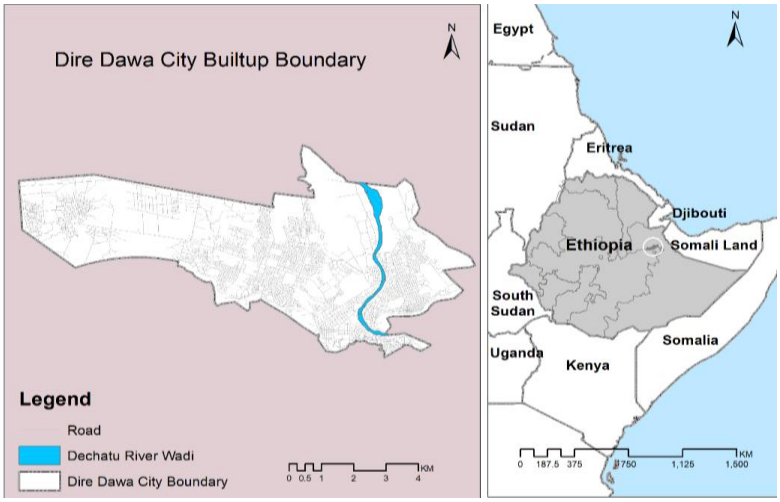
A case study is an empirical approach that explores a current occurrence (the 'case') in-depth and within its real-world environment, particularly when the boundaries between phenomena and context are unclear (Yin, 2018). It requires a thorough investigation by combining various observations (Gerring & Cojocaru, 2016). Similarly, Gillham defined a case study as one that analyzes a study case in order to answer particular research questions and seeks a variety of

different types of pieces of evidence (Gillham, 2000). Also Scheer (2017) further emphasized that case studies are commonly used in urban morphology research to compare information about individual areas and formulate theories based on observed trends.

In urban form studies, Scheer (2017) suggests that the most popular comparison approaches are to compare two locations that exist at nearly the same time (synchronic) or to compare the same location at different times (diachronic). However, different studies in urban morphological analysis are still being conducted based on more than two cases for broader comparison and understanding of circumstances depending on the intentions of the studies (Clifton et al., 2008; Conzen et al., 2012; Larkham & Conzen, 2014; Pont & Haupt, 2007). In addition, Yin (2018) describes that theoretical replication favors multiple-case research over single-case research.

Therefore, this study used multiple cases by selecting representative samples from the case study city. This allowed for a better understanding of the emerging urban forms created through the spatial form transformation of the city across its various parts. Representative cases, according to Gerring and Cojocaru (2016), are those that reflect a larger group of instances in some way. A cross-case synthesis was used in this study by reviewing the findings of each of the cases and then noting the pattern of results across the case studies. This approach has been propagated by different literature sources, from early ones to more recent ones (Bethesda, 1983; Gerring & Cojocaru, 2016; Herriott & Firestone, 1983; Yin, 2018).

Dire Dawa, as seen in **Figure 1**, is a city on Ethiopia's eastern border, a nation situated in the Horn of Africa. It was chosen as the case study city because it is Ethiopia's second-largest city after Addis Ababa, the capital, which is a primate city with more research experience than the country's second-tier cities. It represents both western urban structures and traditional Islamic towns of the Middle East, reflecting both scenarios and allowing for comparisons. To the selection of specific sites, Berghauser Pont and Haupt (2009) identified three sample selection criteria, one of which requires representation of all historical eras of development. The other criteria are that the morphological patterns in the city should be representative, and that the samples should have a particular geographical and cultural dispersion. This will enable an examination of structural similarities and differences across the different spatio-temporal dimensions of the city under examination. With this understanding, the city's historical development eras are examined in order to draw representative samples that may reflect the city's diverse morphological patterns.



Source: Dire Dawa city administration urban planning bureau

Figure 1: Location map of Dire Dawa.

The research case areas were chosen sequentially using an approach called exploratory sequential design proposed by Creswell and Creswell (2018). Based on the three parameters identified above, in this design, qualitative data is collected and analyzed first, followed by the identification of features for further assessment using new instruments in the second phase. In the third phase, a quantitative assessment of the test features follows, and finally, the results are interpreted. Similarly, the spatial transformations exhibited in the various development periods of Dire Dawa were assessed using a qualitative database that represented its historical transformation. Representative samples were chosen for each of the development periods based on the exhibited spatial transformation scenarios throughout the city. A quantitative assessment of the city's emerging urban forms was then produced based on the selected cases.

To select representative samples from the city's many historic periods, the city's urban growth scenario was classified historically in such a manner that it demonstrated the various historic imprints on the city's-built form. Ethiopian urban reforms are linked to either the creation of a new government or changes in the organization of an existing administration. Thus, the transformation of the case city could be matched with changes in the government structure, which in most circumstances resulted in urban reforms that would leave their own imprint. For instance, Damte (1993) classified Ethiopian urbanization into three eras based on government structures, pre-Italian (1900-1935), Italian occupation (1935-1941), and post-Italian (since the 1950s), in his study conducted nearly three decades ago. This seems to have encapsulated the evolution of urban areas after the departure of the Italians in a single cup, concealing certain significant spatial forms that arose during that time period. Given that this was a study of the spatial transformation of urban forms, it would be beneficial to examine the different emerging forms throughout time. The assumption is that these changes resulted in changes in administrative philosophy and consequently in changes in the built form.

It is self-evident that urban transformation will have an influence on various parts of a city at various times. Certain urban structural features, on the other hand, are generally resistant to these temporal-based physical changes. Morphologists have discovered that settlements can be seen in terms of many essential features, the most significant of which are land usage, building structures, plot pattern, and street layout (Conzen, 1960). The least resilient features are generally buildings and the land use they accommodate. The street layout is most resistant to changes over time, followed by the plot pattern (Ahmed et al., 2014; Carmona et al., 2003; Oliveira, 2016). This study thus aimed to evaluate the urban form of the study city by using Spacematrix to assess the relationship between the more resistant elements of urban form, i.e., the street layout and the density of the respective plots.

Berghauser Pont and Haupt (2010) demonstrated that the combination of four density factors, derived from streets, plots and buildings, can be used to describe urban forms in a way that the individual variables alone cannot. The variables are well-known indicators of density. The ground space index (GSI) describing the use of the ground in two dimensions and the floor space index (FSI) describing the intensity of ground-floor use by stacking floor space in the third dimension. This brings us to the third variable: the average height (i.e., number of floors) of buildings (L). A fourth element, spaciousness (also known as the open space ratio (OSR)), indicates the intensity of utilization of natural land cover. All four variables, as can be seen in **Figure 2**, may be displayed concurrently in a scatter graph dubbed 'Spacemate,' with FSI on the y-axis and GSI on the x-axis, while OSR and L are fanning gradients.

As indicated in the subsequent sections, Berghauser Pont and Haupt (2010) have indicated the equations to examine each of the parameters to be used in the assessment of the urban forms in study cases. The present study employed the Spacematrix 2010 software produced by Meta

Berghauser Pont and Per Haupt.

The floor space index (FSI), also called floor area ratio (FAR), represents building intensity independent of thematic composition and is computed as follows:

$FSIx = Fx/Ax$ where Fx = gross floor area (m^2), Ax = area of aggregation x (m^2) and x = aggregation. This index uses the unit square meters per square meters (m^2/m^2),(1)

The ground space index (GSI), also called block area ratio (BAR), signifies the coverage of the built area or the footprint, illustrating the connection between constructed and natural land cover. It is computed as follows:

$GSIx = Bx/Ax$ where Bx = footprint area (m^2), Ax = area of aggregation x (m^2) and x = aggregation plot. This index uses the unit square meters per square meters (m^2/m^2) (2)

The open space ratio (OSR), often referred to as spaciousness, measures the amount of natural land cover at ground level per square meter of gross floor area.

$OSR = (1 - GSIx)/FSIx$ where GSI refers to the ground space index, FSI refers to the floor space index and X stands for aggregation. This graph depicts the amount of non-built space that is under pressure. OSR is measured in m^2/m^2, (3)

Network density, N, refers to the concentration of networks in a certain area, in this instance the case study areas. A network's density is defined as network length per square meter of base land area (m/m^2). It is computed as the sum of the whole internal network and half the length of the network used to demarcate the base land area. The output is measured in meters of network per square meter of the case area.

$Nf = (\Sigma li + (\Sigma le)/2)/Af$ where li = length of interior network (m), le = length of edge network (m) and Af = area of the case study (m^2) (4)

Spacemate is a design and planning tool based on a mix of density notions that may aid planners in comprehending the capacity of space and in creating adequate circumstances, mainly for unexpected growth (Berghauser Pont & Haupt, 2007). As indicated in **Figure 2** the FSI on the y-axis gives an indication of the intensity in an area and the GSI on the x-axis reflects its compactness.

In addition, Berghauser Pont and Haupt (2009) define low-rise to be lower and equal to three-story, and mid-rise as four- to seven-story, while high-rise refers to buildings with more floors than this, which require elevators. The different urban form scenarios are indicated in **Figure 2,** which represents different patterns of spatial structures. This could allow for the association of the urban forms emerging in different periods based on their respective locations in the FSI-GSI graphs of this figure. The dots represent the presence of a particular type of urban form typology, where the size signifies the intensity of the presence. The type of typology can be defined based on its position on the FSI-GSI graph.

Considering the governance periods of the city, a pre-analysis was made, which showed that the periods of early development and the Italian occupation were almost the same and were thus

together labeled as the early morphological era. Similarly, the development during the imperial era after the Italian occupation and the socialist era was similar. Thus, they were together labeled as the intermediate morphological era, while the recent period, since 1992, is referred to as the recent morphological era. The different development eras are indicated in **Figure 3**.

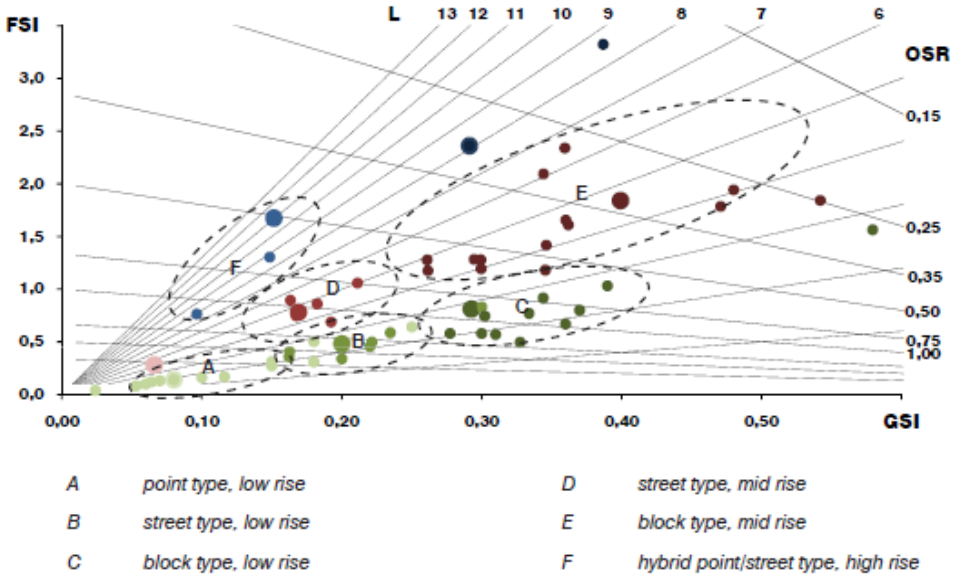


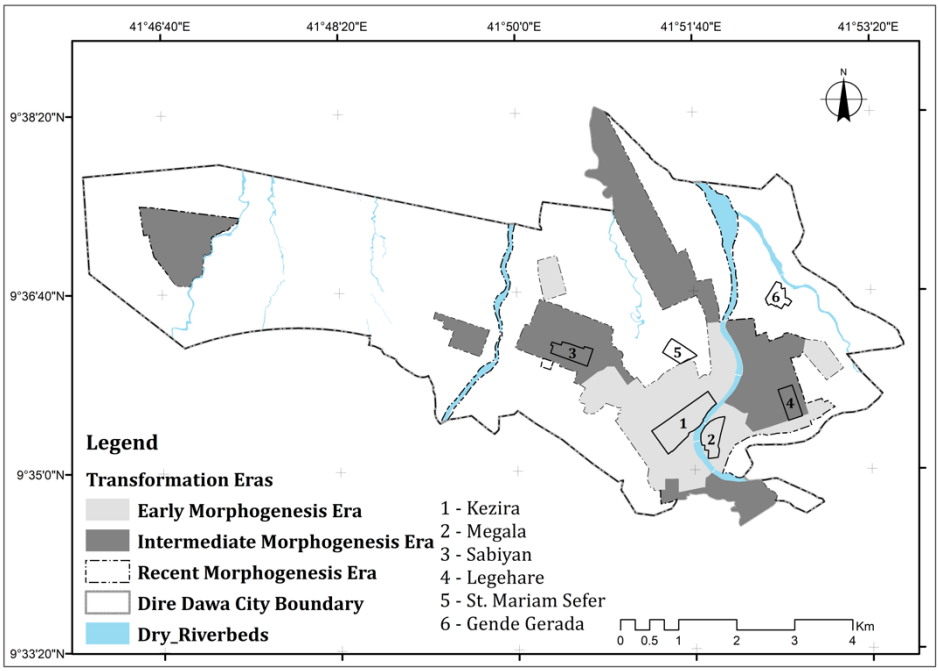
Figure 2: Spacemate plot developed by Berghauser Pont and Haupt, 2010.

The different governance periods have left their own footprints in the morphology of the city due to their influence inflicted through spatial transformations. To examine the morphological transformation of Dire Dawa over time in relation to the various governance eras, it is prudent to pick representative sample regions from each of the morphological transformation periods. As a result, sample sites from each of the three epochs were identified and then rectified across the city's evolutionary map. Following that, the sites were further refined by a rigorous debate among the participants in the focus group discussion. The case study sites were thus selected using a purposive process that recognized the representativeness of each of the sites. The six case areas as indicated in **Figure 3** and **Table 1** also describes the selected sites. The city's historic core has two distinct parts developed in the early morphogenesis of the city, reflecting a formally planned segment and an organically developed area. Correspondingly, in terms of morphology, the Italian occupation period followed a similar development pattern as an extension of the already produced patterns in those two parts of the city. Therefore, the Megala and Kezira areas represent these periods, witnessing their own morphological makeup, which was identified as the early morphogenesis era. For the intermediate morphological period, two samples were selected, which are representative for the two administrative eras (the late imperial period after the withdrawal of the Italians and the socialist period). The last one, which is the most recent morphological era of the city, two samples were selected because its transformation was much wider compared to that of its counterparts.

This study examined a total of six case study sites, each representing various types of urban development. These case studies consisted of Megala and Kezira, which respectively represent an organically developed and a formally planned area in the early morphogenesis period. The third case study, Legehare, is a formally planned area in the intermediate morphogenesis period, and the fourth, Sabiyan, is another formally planned area in the early morphogenesis period. As the informal development during the intermediate morphogenesis period was minimal, the study

took two samples of formally developed areas. The fifth case study was Gende Gerada, an organically developed area in the recent morphogenesis period, and the last case study was St. Mariam Sefer, a formally planned area in the recent morphogenesis period, as indicated in **Figure 3** and **Table 1**.

In general, as indicated in **Figure 3** and **Table 1**, there were a total of six sample cases as components in this multiple case study. The results and discussion part, based on the selected six sites representing the three morphological transformation periods, are presented in the following section.



(Source: A study made by the same authors on the case of Dire Dawa https://www.icevirtuallibrary.com/doi/epdf/10.1680/jurdp.22.00014)

Figure 3: Development extent in the morphogenesis eras of Dire Dawa and selected case study sites.

Table 1: Description of the study area

S/N	Case Study Area	Morphological Period	Planning Intervention
1	Kezira	1st morphogenesis era (1902-1941)	Formal planning
2	Megala	1st morphogenesis era (1902-1941)	Organically developed
3	Legehare	2nd morphogenesis era (1942-1991)	Formal planning
4	Sabiyan	2nd morphogenesis era (1942-1991)	Formal planning
5	Gende Gerada	3rd morphogenesis era (since 1992)	Organically developed
6	St. Mariam Sefer	3rd morphogenesis era (since 1992)	Formal planning

Figure 4 provides the analytical framework that served as a roadmap for conducting the research and brought clarity to the study process. As indicated in the figure, the research aimed to investigate the physical density of the city through both formal and spontaneous developments during its three morphogenesis periods. Within each of these periods, four factors – ground space index, floor space index, open space ratio, and network density – were evaluated to depict the

evolving urban physical structure.

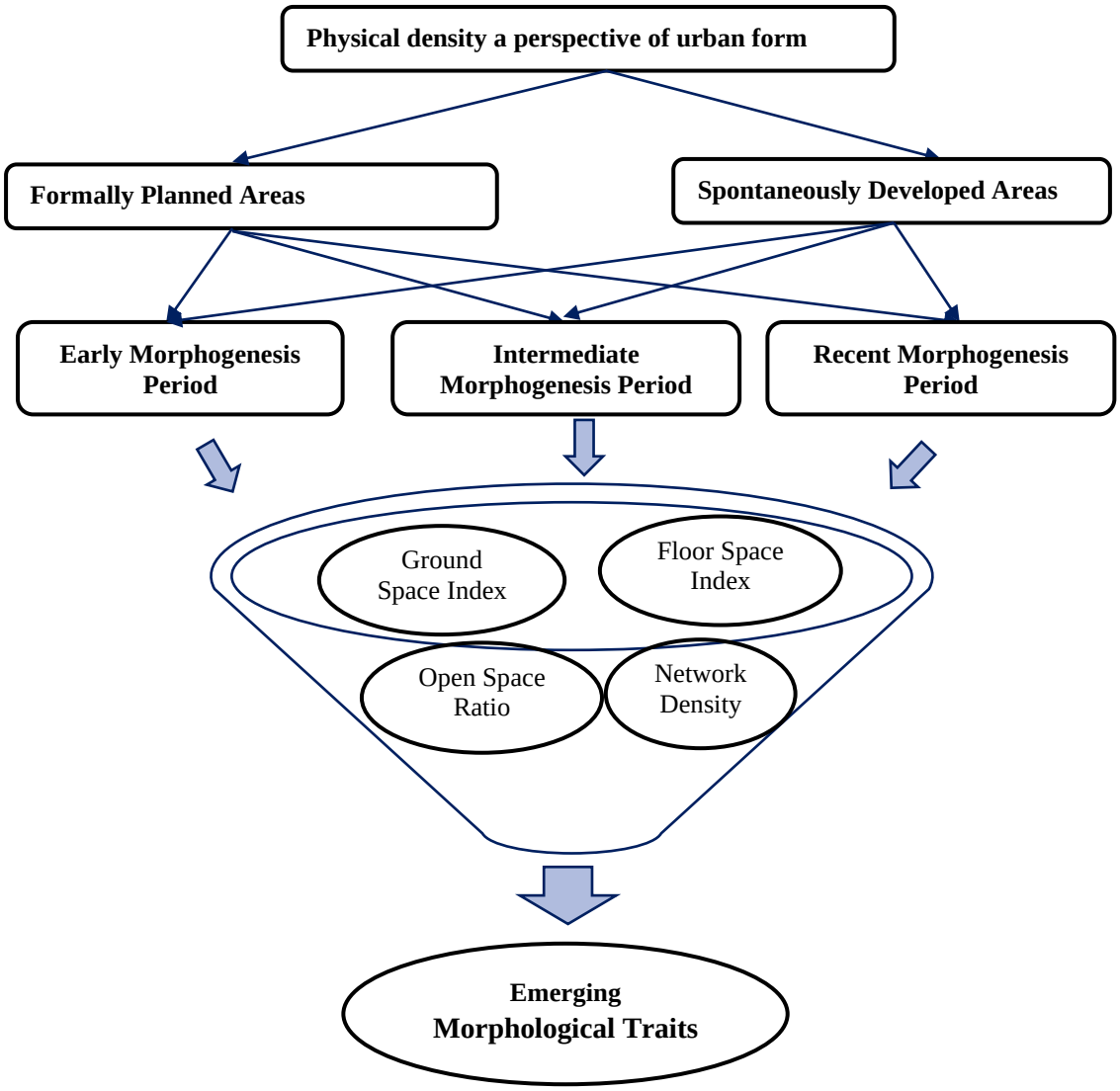


Figure 4: Analytical framework of the research.

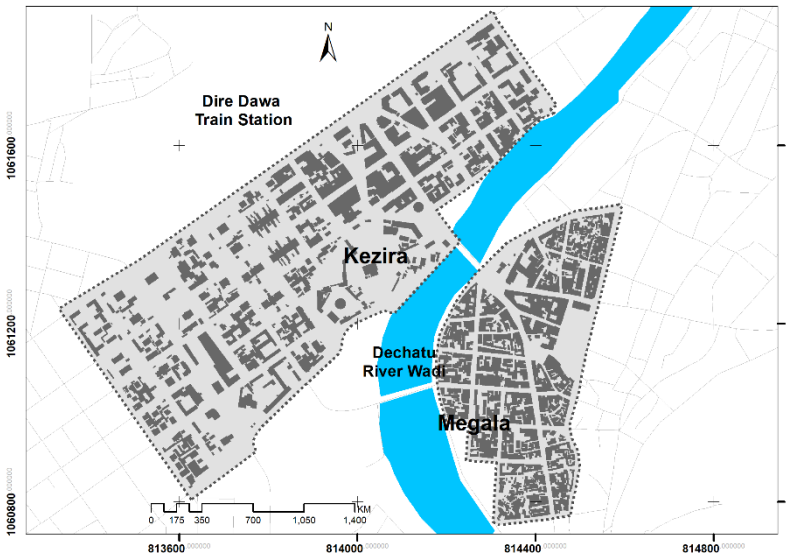
Results and Discussions

The result and discussion part of this study is stated in a comparative manner by considering two cases from the same period, assumed to represent the morphological transformation of that era. Following this, a general development period comparison is made to visualize the emerging urban forms through the urban transformation periods. It begins with the assessment of the first period development and is followed by a comparison of two cases that represent the intermediate period and finally two cases from the recent development period that represent the most recent morphological period.

Early Morphogenesis Era (1902-1941)

Kezira and Megala were the selected cases for this morphological period, where the former was

formally planned, while the latter organically developed. These two neighborhoods were constructed in the early years of the city's growth, beginning in 1902, and are now the city's historic center (Zelelew & Mamo, 2023). Both are believed to symbolize the time of early development (1902-1935) and the Italian occupation (1936-1941). These two case areas, as can be seen in **Figure 5**, are found close to each other, separated by the Dechatu River Wadi.

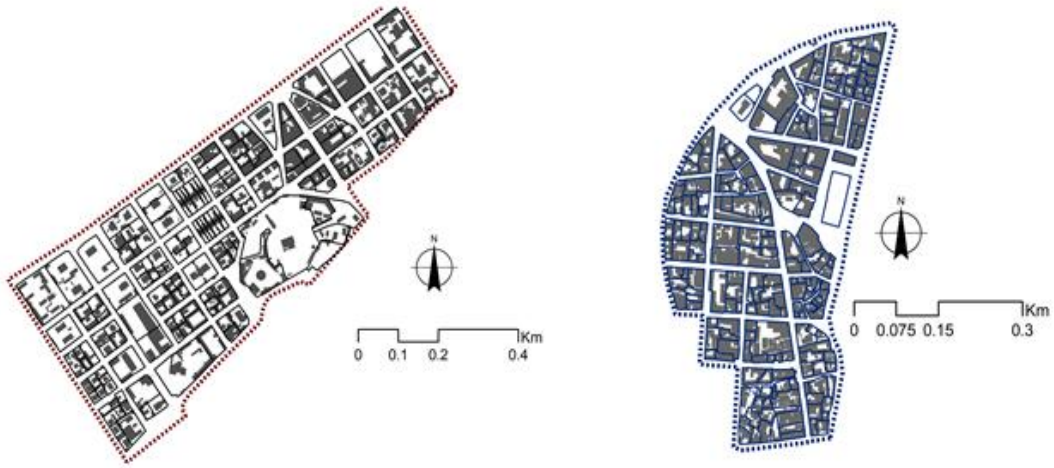


(Source: Reconstructed from data obtained from the masterplan of 1902, 1936, and Dire Dawa Culture and Tourism Bureau)

Figure 5: Kezira and Megala areas in reference to the Dechatu River Wadi and Dire Dawa train station.

As indicated in **Table 2** and additionally illustrated in **Figures 6, 7** and **8**, Kezira's floor space index (FSI) or floor area ratio (FAR) is 0.729 when the average FSI of each plot is considered, which is more than Megala's FSI of 0.671. Kezira, on the other hand, has an average street network density of 0.03 m/m^2, whereas Megala has a higher density of 0.07 m/m^2. This could be due to the relatively longer street access length for plots in Megala, which allowed for plots to be accessed from both the front and back, whereas plots in Kezira are only accessible from the front. Similarly, Kezira's coverage (ground space index – GSI) is 0.536, which is less than that of Megala's, 0.604. Although the Kezira region is dominated by ground-level structures, it does have a considerable number of two- and three-floor buildings.

In addition to the previous results, the open space ratio (OSR), which indicates the sites' spaciousness, shows that Kezira has a greater open space ratio (1.688) than Megala (1.26). However, Kezira has a disproportionate number of plots with an OSR of less than or equal to 0.25, whereas Megal has relatively few.



(Source: Reconstructed from data obtained from the masterplan of 1902, 1936, and Dire Dawa Culture and Tourism Bureau)

Figure 6: Morphologic map Kezira (left) and Megala (right) (1902-1941).

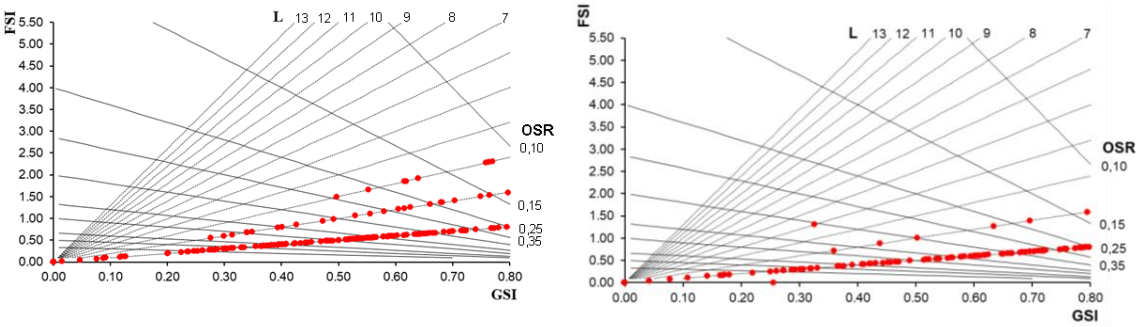


Figure 7: Kezira case study site (left) and Megala case study site (right).

Kezira's Spacemate result indicates that the site's morphology is a combination of street type low-rise and block type low-rise forms, as well as point type low-rise and block type midrise forms (see **Figure 7 and Figure 8**). The site's inclination to display high-rise structures is very uncommon. The street network reflects the grid-iron pattern form of the western urban planning philosophy. This emanates from the construction of Ethio-Djibouti railway station in Kezira, which gave raise for the first area to be developed following formal planning in the nation. Megala, on the other hand, has a street-type low-rise morphology with a predominance of block-type low-rise forms that has similarity with the context of Arab Islamic cities. The traditional Islamic Arab city, as described by Dabbour (2021), is assumed to have a series of homes turned towards the street, which were later supplemented by a back-to-back construction of closed courtyard buildings surrounding the property boundary. Megala was inhabited by locals, Arabs, and Indians, and grew organically under the administration of the Ethiopians. Kezira, on the other hand, was populated by Europeans (primarily French, Italians, Greeks, and Armenians) and built according to a formal plan (Dire-Dawa-City-Administration, 2017). As a result, the developmental distinction between the two regions may change.

The buildings in the early morphogenesis era (the early development period and the Italian occupation period), neglecting the morphological transformation that has been induced recently, is dominated by a mix of point type low-rise and block type low rise. While looking at the morphologic traits of the two cases, the organically developed part (Megala) seems to reflect less

consideration towards open space provision, while the formally planned counterpart (Kezira) emphasizes open space provision better. On the other hand, the organically developed part reveals a better level of street network density than the formally planed part (Kezira). This result will also further be seen from the other cases from the intermediate morphogenesis period and the recent morphological periods.

(Source : Dire Dawa Culture and Tourism Bureau)

Figure 8: Partial view of Kezira (left) and Megala (right).

Table 2. Average of the Spacematrix results of FSI, GSI, network density and OSR

S/N	Case Study Areas	Average Floor Space Index	Average Ground Space Index	Average Street Network Density	Average Open Space Ratio
1	Kezira	0.729	0.671	0.03 m/m^2	1.688
2	Megala	0.604	0.536	0.07 m/m^2	1.26
3	Legehare	0.602	0.560	0.03 m/m^2	1.23
4	Sabiyan	0.685	0.544	0.01 m/m^2	1.21
5	Gende Gerada	0.255	0.228	0.06 m/m^2	6.57
6	St. Mariam Sefer	1.06	0.46	0.05 m/m^2	0.69

The intermediate morphological era (post-Italian Haile-Selassie period (1942-1974) and the Dergue period (1975-1991)

Legehare is a neighborhood located east of the city that is regarded as a microcosm of the Haile Selassie era after the Italian occupation (1942-1974). It is found close to the eastern border of the city's current state, near the Megala neighborhood. The other case area, Sabiyan, on the other hand, is situated west of Kezira, though far from it, and is considered to represent the morphological makeup of the Dergu governance period (1975-1991). It is physically placed roughly halfway between the city's existing western and eastern boundaries, and hence may be considered the city's geographic center with respect to the current expanse of the city.

Legehare and Sabiyan are both accessible through the city's major roads, which connect it to Djibouti and Addis Ababa, respectively. As can be seen in **Table 2** and illustrated in **Figures 9, 10** and **11**, when the average FSI of each plot is evaluated, Sabiyan's FSI is 0.685, which is more than Legehare's FSI of 0.602. On the other hand, Sabiyan has an average street network density of 0.01 m/m^2, whereas Legehare has a somewhat greater density (0.03 m/m^2). Additionally, Sabiyan's Ground Space Index (GSI) is 0.544, somewhat lower than that of Legehare, which is 0.560. Though the majority of buildings in Legehare are one-story, there are a few mid-rise

structures scattered around. While the Sabiyan neighborhood is dominated by one-story structures, it also has a substantial number of mid-rise structures as well.

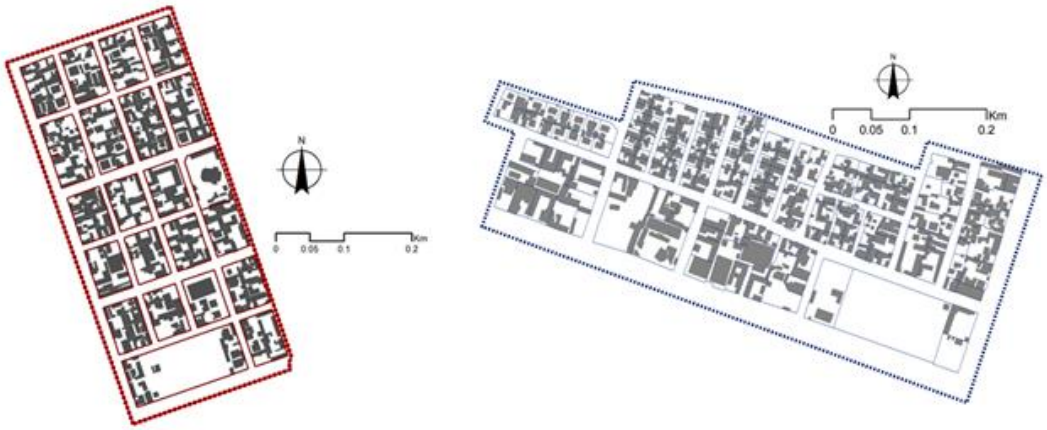


Figure 9: Morphologic maps of Legehar (left) and Sabiyan (right) (1942-1991).

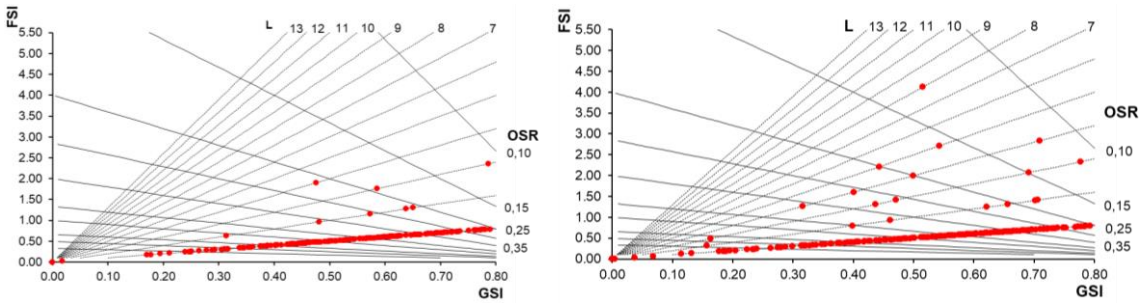


Figure 10: Legehar case study site (left) and Sabiyan case study site (right).

(Source: Mr. Gizaw Haile, a senior culture and tourism expert in Dire Dawa)

Figure 11: Partial view of Legehare (left) and Sabiyan (right).

Furthermore, the open space ratio (OSR), which measures the spaciousness of a site, suggests that Sabiyan has somehow a lower open space ratio (1.21) than Legehare (1.23). There are a disproportionately enormous number of plots in Sabiyan with an OSR of less than or equal to 0.25, while Legehare has a small amount.

The urban structure of the city is governed by a formal plan-led development during this period,

with minimal informal development; thus, both cases representing this period are formally developed parts of the city. This would not allow for a comparison between the formal and organic development scenarios. However, because it is a part of the city's intermediate morphogenesis period, it must be investigated in order to evaluate the urban form of this era. As a result, Legehare's Spacemate analysis suggests that the site's morphology is mostly block-type low-rise with some street-type low-rise forms. Sbayan's situation confirms that the urban form of this case area is dominated by block-type low-rise structures and block-type mid-rise structures. As has been evidenced from the focus group discussion, the form of Dire Dawa during the Haile Selassie regime was influenced by the available construction technology in the area and the site's location with respect to the historic core. In terms of the situation in Sabiyan, this is a region that is geographically central to recent Dire Dawa. In this scenario, the percentage of open space is decreasing while the FSI somewhat increased, indicating that awareness of space efficiency has increased from past periods, coupled with some other extra factors.

The recent morphological era (since 1992)

The areas of St. Mariam Sefer and Gende Gerada are used to illustrate the urban transformation that has occurred in the recent period after the end of the Dergue era (since 1992). The development of this era had significant spatial coverage. The city was expanding to the west due to the development of an industrial park and a new train terminal at its western edge. These areas are still not yet well developed, but it can be seen that they are attracting the city's development to the west. To examine the evolving urban forms throughout this time of spatial transformation, two case study areas were purposefully chosen: one near the geographic center and another one close to the periphery.

Participants in the focus group discussion showed that the evolution of Dire Dawa had two faces in this morphological era. The first scenario was for the city's core and intermediate areas, while the second scenario was for the city's outskirts. Formal planning enforcement was frequent in the center and intermediate areas. In contrast, the periphery was heavily impacted by informal development, which spans a similar area to the formal development. This situation along with the cases of Kezira's and Megala's case could be a clear indication that different planning practices will end up with different results. According to their assessment, this is due to the administration's reluctance to control the issue.

As indicated in **Table 2** and illustrated in **Figures 12, 13 and 14**, the sample in the geographic center, St. Mariam Sefer, has an average FSI of 1.06, which is greater than not only Gende Gerada's (0.255) but also of all case locations studied in this research. On the other hand, St. Mariam Sefer has an average street network density of 0.05 m/m^2, while Gende Gerada has a slightly higher density (0.06 m/m^2). Furthermore, St. Mariam Sefer's GSI is 0.46, which is higher than Gende Gerada's 0.228. While the bulk of buildings in the St. Mariam Sefer are two-story, there are a substantial number of four- and five-story structures. In contrast, the bulk of buildings in the Gende Gerada neighborhood are single-story, with just a handful having two stories.

Aside from that, the open space ratio (OSR), which reflects the spaciousness of the sites, reveals that St. Mariam Sefer has a lower open space ratio (0.69) than Gende Gerada (which has the highest open space ratio of all the case study sites), indicating that it is spacious (6.57). Because land is less expensive in the periphery than it is in the center, the coverage (GSI) and floor space index are low, even though the plot sizes and open space ratios are larger. In contrast, in locations near to the center, both the ground space index and the floor space index are fairly large in order to optimize the utilization of available space in an efficient manner.

According to the Spacemate data, Gende Gerada's morphology is largely point type low rise, with some street type low-rise forms thrown in for good measure (See **Figure 13 left**). St. Mariam Sefer's case, on the other hand, reveals that this area's form is dominated by block type low-rise buildings, with block type mid-rise structures serving as a secondary characteristic (See **Figure 13 right**). In terms of the planning characteristics of these two case regions, St. Mariam Sefer is a formally planned area, while Gende Gerada is not. The land utilization intensity of an organically built site may differ from that of a formally planned and constructed area. Furthermore, the focus group participants affirmed that there are concerns about legality, which may lead to the destruction of structures via legal enforcement procedures, discouraging builders from erecting buildings with greater GSI and FSI. This may also be related to the location of the area, which is positioned near the periphery.

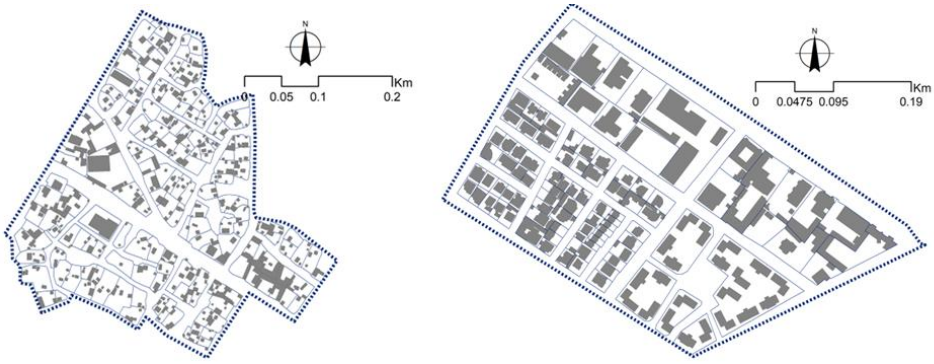


Figure 12: Morphologic maps of Gende Gerada (left) and St. Mariam Sefer (right).

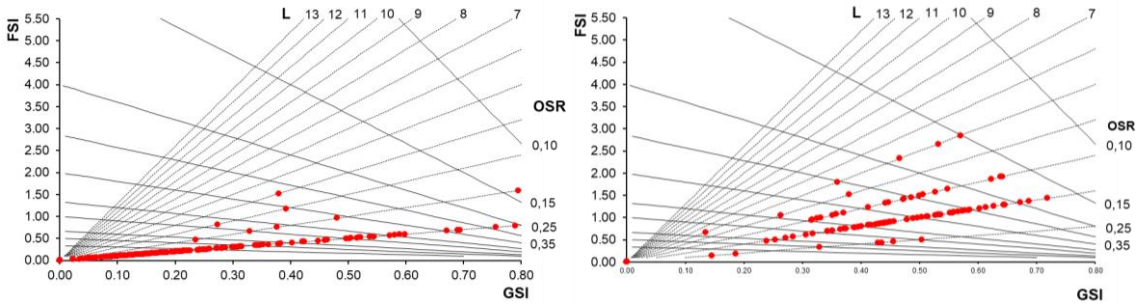


Figure 13: Gende Gerada case study site (left) and St. Mariam Sefer case study site (right).

(Source: Authors, 2021)

Figure 14: Partial view of Gende Gerada (left) and St. Mariam Sefer (right).

A city's history plays a basic role in its future and provides a good platform to learn from (Agirbas & Ardaman, 2015). This study helped to identify the changes in the urban form of Dire Dawa through its different eras of governance, along with the associated urban habituation patterns. This can be considered a representative case for the second-tier cities in sub-Saharan Africa. Different urban patterns, for example, planned versus organic, treelike versus grid-like, are claimed to perform differently in terms of flow intensity and distribution, building density, and land uses (Berghauser Pont et al., 2017). As can be seen in **Figure 15**, the cases in this study revealed that the organically developed and the formally planned areas do have different patterns of urban form. The morphological transformation trend was identified, as it deviates from the form in its portions from its foundation, similar to what Dabbour (2021) has identified. It has also been reported that the majority of Ethiopian cities and towns have horizontal physical growth with low urban density (Jenberu & Admasu, 2020). This was confirmed by this study's output, though improvements were exhibited by following the chronological time frame.

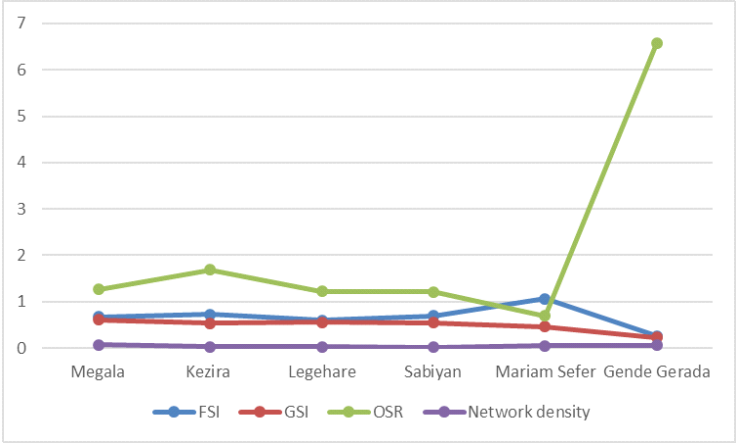


Figure 15: Average GSI, FSI, OSR and street network density of all case study sites.

The current urban planning scenario indicates that increasing the density or compactness of cities is the path to sustainable growth (Nielsen, 2019). There is a gradual decline in the open space ratio from the earliest historic evolution period of cities to the most recent one. As a result of the morphogenesis trend, it seems that second-tier cities, as in the case of Dire Dawa, have given emphasis to compact and dense development, especially in their formally planned sections. This shows that they are on a good path towards sustainable development, though the level of density in their compact development requires additional assessment.

Conclusion

The primary objective of this study was to identify the emerging morphology of urban transformation and assess its impact on urban sustainability, with a particular focus on physical density and emerging urban forms. To achieve this, the study utilized the Spacemate method to investigate the variations in density and urban forms across different development scenarios. The research delved into the morphological features that influenced the growth tendencies of the city, such as gross site index (GSI), floor space index (FSI), open space ratio (OSR), and street network density. The aim was to evaluate how these factors have affected the overall urban sustainability of the city. By examining changes in urban form and habituation patterns over time, the study sought to identify how the city of Dire Dawa was transformed under different eras of governance. This includes an assessment of the city's growth trajectory and how it has evolved in terms of

morphological features.

The study revealed that organically evolved sites are typically characterized by point-type low-rise development, while plan-driven developments tend to feature block-type low-rise and block-type mid-rise forms. Moreover, the floor space index and spatial coverage patterns of the city tended to increase over time, indicating a growing concern for space efficiency and sustainable development. Apart from this, in locations near the historic core of the city, both the ground space index and the floor space index are generally quite large, suggesting that planners are prioritizing the efficient use of available space.

In addition, the street network density of the organically developed areas is generally higher than that of the formally planned areas, indicating that organically constructed elements of the city offer better accessibility. However, it is important to note that the Spacematrix approach used in the study does not consider street width, which is a crucial factor in determining traffic capacity and may impact accessibility.

Given these insights, it is crucial to assess the trend of morphogenesis in urban areas and take measures to ensure that future developments are responsive to sustainability concerns. Urban planning policies and guidelines should also consider the benefits of organic development and strive to incorporate local knowledge into formal planning efforts. This approach can help to promote sustainable urban growth and enhance the quality of life for urban residents.

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