



The Dots Density Method as a Cartographic Tool for Population Analysis: The Case of the City of Jeddah (Saudi Arabia)

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Abstract

This work proposes an application of the dot density method to the spatial representation of the population in the city of Jeddah, the second-largest agglomeration of Saudi Arabia, marked by a strong demographic dynamic and a contrasting spatial organization. This city is a relevant field in which to experiment with cartographic approaches based on the visualization of statistical data. First, we outline the conceptual foundations of the method, its objectives and the different ways in which it is implemented. The study is based on official demographic data and involves several geomatic tools, including ArcGIS Pro for data structuring, Philcarto for thematic maps, and ScapeToad for specific treatments such as anamorphosis. The mapping was produced from a variety of backgrounds, including local topographic maps and OpenStreetMap resources. The results obtained confirm that this technique is among the most commonly used for the visualization of demographic phenomena. Its design is relatively simple, and its realization can follow three distinct approaches: a distribution of points based on the real location of the phenomenon, an arbitrary distribution within spatial units, or even a regular arrangement according to a homogeneous frame. Although specifically applied here to population data, this method remains adaptable to other themes of human or physical geography. It is distinguished by its legibility and ability to synthesize, while presenting some limitations in terms of spatial interpretation.

Subject Areas

Cartography, Geographic Information System (GIS), Population Geography, Urban Geography, Spatial Analysis, Regional Studies

Keywords

Thematic Mapping, Dots Density Maps, Spatial Distribution of Population, Geographic Analysis, City of Jeddah

1. Introduction

Like many large cities in the Kingdom of Saudi Arabia, the city of Jeddah is facing rapid population growth and sustained urbanization. This dynamic is part of a context of major socio-economic transformations, marked by the modernization of infrastructure, an expansion of the urban fabric and a gradual reorganization of the metropolitan area. This process of development results in an uneven spatial distribution of the population, which varies according to the major geographical areas of the city: North, Center, South, East and West, as well as between different neighborhoods with contrasting functions and morphologies.

This disparity in population distribution raises important questions about urban planning, spatial justice and territorial sustainability. It requires a thorough analysis to better understand not only the logic of settlement but also the effects of urban growth on the organization of space. However, despite its strategic importance, this subject has still not been explored in scientific work on the Saudi context, especially at the intra-urban scale.

This is the purpose of this research. We propose to analyze the spatial distribution of the population in Jeddah by using the dot density method, a mapping tool that allows for the visual representation of human concentrations according to different modes of dissemination of symbols on the map. This method offers an interesting alternative to classical representations, by emphasizing the spatial fineness of the data while ensuring a synthetic reading of the studied phenomenon.

The study has two main objectives. The first is to produce a series of dot density maps in order to visualize and interpret the distribution of the population at the neighborhood level. The second objective is to compare this method with other forms of cartographic representation such as the map in proportional symbols, the anamorphosis map, the choropleth map or asymmetric maps. This perspective will make it possible to evaluate the specific contributions of the dot density method, both from the point of view of graphical readability and analytical relevance in the context of geographical studies.

2. Study Area, Tools and Methods

The present study focuses on the spatial distribution of the population in the city of Jeddah, which was chosen as a field of application to illustrate the use of the dot density method. This choice is explained by the demographic weight, the economic centrality and the strategic role that the city plays on a national scale. Located on the shores of the Red Sea (**Figure 1**), Jeddah is the second largest city in the country with an area of 74,762 km², and the second most populous after

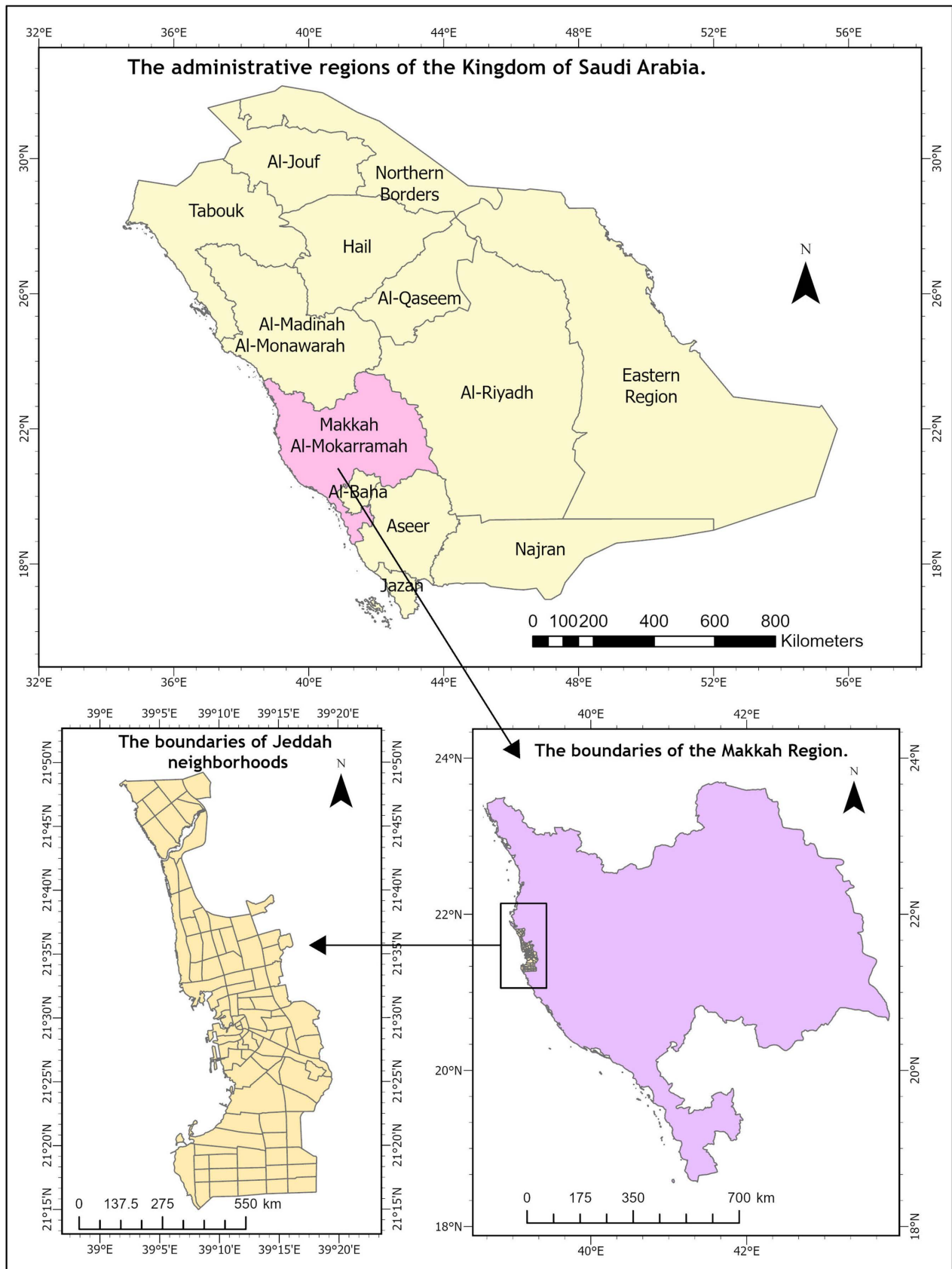


Figure 1. Study area. Source: [12].

Riyadh. It is distinguished by a network of modern infrastructures, a major port on the Red Sea, upscale residential areas, a dynamic commercial fabric, as well as a leading tourist and religious influence. It also plays a major logistical role and is a magnet for both residents and temporary populations [1].

Data from the latest national census (2024) indicates that the population of Saudi Arabia is 32.2 million. The Riyadh, Makkah and Eastern regions alone account for 68% of this population [2]. Riyadh remains the most populous city, followed by Jeddah, Makkah, Medina and Dammam respectively. Between 2010 and 2024, the national population grew from 24 to 32.2 million, with an average annual growth rate of 2.5%. During the same period, the number of Saudi citizens increased from 14 to 18.8 million, while the non-Saudi population increased from 9.9 to 13.4 million. In 2024, the population of Jeddah is estimated at 3,751,700, representing 46.8% of the total population of the Makkah region (Makkah Al-Mokarramah), distributed as follows: 1,708,800 Saudis (45.5%) and 2,042,900 non-Saudi (54.5%); with 2,292,400 men (61.1%) and 1,459,300 women (38.9%) [1].

All these elements: population growth, economic attractiveness and geostrategic position give the city of Jeddah a privileged status in this research, and justify the special attention given to it in this study.

In order to carry out this work, we have built a geographic database using the ArcGIS Pro Geographic Information System (GIS) software, which has allowed us to produce different types of thematic maps. Other representations were generated using the Philcarto software [3]. The digitization of the base map was carried out via Phildigit [3], while the conversion from .ai to .shp was done with the Xphil tool [3]. Anamorphosis maps were also developed using the ScapeToad software [4]. We also used the Inkscape software [5] for some maps made with Philcarto.

Demographic data were obtained from the General Authority for Statistics [6], while the Jeddah base map was taken from the Jeddah municipality website [7] [8] and new development plans in Jeddah [9] and the Saudi Geological Survey [10]. Road networks and other spatial data come from different thematic maps, the 1/25,000 scale topographic map of Jeddah, and the OpenStreetMap platform [11].

3. Mapping the Population of Jeddah by the Dot Density Method and Its Alternatives

Population mapping relies on a variety of methods to represent population distribution, density and dynamics at different scales.

3.1. The Dots Density Map

The dots density map is a method of representation that allows the visualization of the spatial distribution of a quantitative (and even qualitative) phenomenon through a dispersion of points. Each point represents a fixed value (for example: one point = 100 inhabitants) and is distributed among the geographical units concerned in a random, ordered or based on the actual location. The higher the

density of points in an area, the greater the concentration of the phenomenon there.

The dots density map is a cartographic method that represents data as counted points, each indicating an absolute value. This technique offers an innovative way of visualizing information, both conceptually and graphically, and is designed for a specific purpose [13]. It is particularly useful to indicate the presence or absence of certain items, such as schools, pharmacies, dispensaries, homes or shops, using point symbols.

This type of map offers an intuitive reading of the distribution of populations, activities or other variables, while maintaining an expressive visual dimension. This approach is particularly suitable for the localization of phenomena, especially when the number of points to be displayed remains moderate. However, if this number becomes too high, visual readability may suffer, thus reducing the effectiveness of the map [13]. The symbols used to represent these points may vary (circles, squares, triangles, diamonds, etc.), but they must be small enough to ensure legibility.

Although the dots density map is not frequently used in scientific work, it remains an effective educational tool. Its simple and accessible legend allows a clear interpretation of the data, since each point represents a unit, thus facilitating the direct calculation of the quantity represented [14].

The use of the dot density method allows for a wide variety of graphic symbols, whether in different shapes, Colors or sizes, thus offering flexibility of representation adapted to the nature of the data, the scales of the maps, and cartographic objectives.

3.1.1. Dots Density Map Methods

The use of points in mapping is explained by their graphical simplicity: they are easy to draw manually, especially when there are few, and do not clutter up the cartographic space. On the other hand, other types of symbols are often more complex to draw by hand and occupy large areas. However, with the use of computer-aided mapping software, drawing points in any shape has become extremely simple and fast. In Dots density mapping, three main methods are generally distinguished:

1) Arbitrary distribution method

This approach consists of randomly positioning the points within each geographical unit, without any relation to their actual location. The objective is only to reflect the total number of phenomena per unit. Its main drawback is that it can give a distorted image of reality [13]. For example, an uninhabited desert may appear to be as populated as a densely urbanized neighborhood. This method can thus impair the legibility and credibility of the map.

2) Regular distribution method (uniform)

The points are here placed in a grid, in an orderly and equidistant manner. In manual mapping, a millimeter paper is often used; in digital mapping, the software automatically takes over distribution. This method offers a harmonious

visual appearance and is easy to produce, but it also has an important limitation: it does not necessarily reflect reality. Uninhabited areas such as deserts, water bodies or green spaces may appear to be occupied, which is misleading [13].

In the first two methods, it is assumed that the exact location of objects is not known. A point represents a variable numerical value depending on the scale of the map, the size of the spatial units and the number of phenomena. A large scale allows the symbol to be enlarged and a high number of points, while a small scale imposes a reduction in the size and quantity of the symbols. One solution is to use dots of different sizes (and therefore different values) in the legend. This facilitates the work of the cartographer and the reading of the map, but this method is similar to that of proportional symbols, which undermines the originality of the point method.

3) Method of actual localization of phenomena

Unlike the previous two, this method relies on the precise location of each object represented. Each point corresponds to a unique geographical phenomenon (for example: a school = a point), and it is placed exactly at its actual location [13]. Although conceptually simple, this method is demanding to implement. It requires a fine knowledge of the study area, as well as reliable sources: large-scale topographic maps, high resolution satellite images, aerial photographs, and field work. Its main advantage is to ensure a faithful and accurate representation of reality. However, in the case of very numerous phenomena (such as population), it becomes difficult to represent each individual [13]: we then opt for high-value points (e.g. one point = 1000 or 10,000 inhabitants). Using this method, the point-based map of the population of Jeddah was produced by combining several sources: aerial photographs, a satellite image and a 1/25,000 topographic map. This combination has allowed us to ensure the most rigorous possible location of human concentrations in urban space.

3.1.2. Symbolic Choices and Visual Effects in Dots Density Maps

1) Effect of symbol shape on perception of mapped phenomena

By representing geographical phenomena using the dot density method, it is possible to use various symbols to represent the units observed. These symbols can be simple geometric shapes (circles, squares, triangles), but also figurative or abstract symbols, depending on the nature of the phenomenon depicted and the objectives of the map. The choice of symbol has a direct impact on map readability and perception of the map message.

Figure 2 shows the population distribution in Saudi Arabia in 2020 at the regional level, using dots density based on different symbolic representations. This map is a relevant visual support for analyzing spatial disparities in the population across the national territory. The geographical distribution of the points makes it possible to visualize the areas of high density, especially in the west of the country (region of Mekka, Medina and Jeddah) and the region of Riyadh as well as the less populated areas in the desert interior.

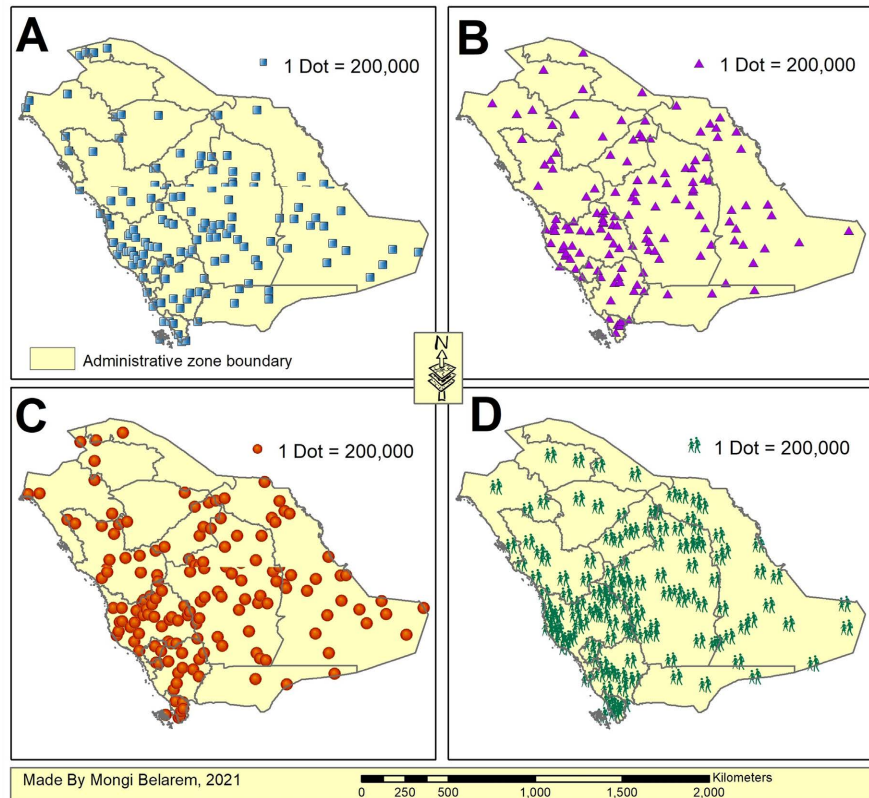


Figure 2. Regional distribution of the population in Saudi Arabia in 2020 by the dot density method with variation in symbol shape (A: squares, B: triangles, C: circles, D: figurative symbols).

The variation in symbols between maps in **Figure 2** also shows the impact of map design on visual perception and accessibility of demographic information. Each of the four maps representing the population distribution in Saudi Arabia in 2020, at the regional scale, uses the dot density method, with a uniform representation threshold (1 point = 200,000 inhabitants). These Maps are distinguished by the shape of the symbols used: squares (A), triangles (B), circles (C) and figurative symbols (D). Map A (blue squares) Offers a sober and structured representation, well suited to an administrative or institutional reading. Map B (purple triangles) offers a more expressive graphic alternative, but sometimes less readable in dense areas. Map C (red circles) for intuitive reading of human concentrations. Map D (pictograms of characters), more illustrative and visually attractive, this map attracts attention but may lose clarity in densely populated areas.

2) Color variation in point representation: visual impact and semiology

The Color of the symbols in the Dots density maps can be changed to introduce an additional dimension of information, such as differentiation by category, sex or nationality [15]. This graphical choice has a strong influence on the visual perception of data and facilitates comparative reading between the represented subgroups. **Figure 3** shows the spatial distribution of the population in Jeddah at the neighborhood level. The symbol used (one point per 1600 inhabitants)

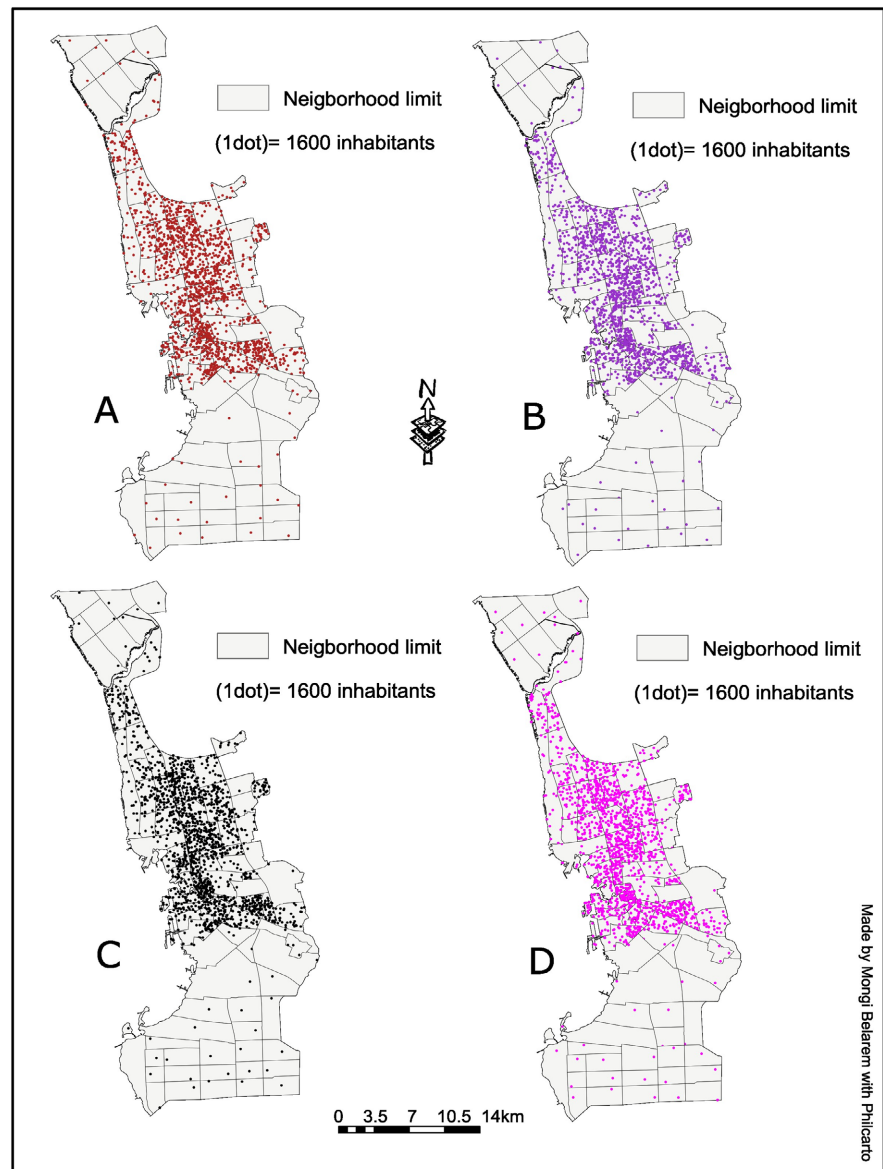


Figure 3. Population distribution by neighborhoods in the city of Jeddah in 2020, using the dot density method with color differentiation.

remains identical in size and shape on all maps, only the Color code varies (A: red, B: purple, C: black, D: pink magenta). The change of Color can be used to examine the visual effect of symbolization on cartographic readability and perception. For example, black map C provides strong contrast and highlights high density areas, while light pink map D visually softens concentration but can make reading more delicate on a light background.

3) Variation of the size of symbols in Dots density maps

The size of the symbols used in Dots density maps can be adjusted according to the scale of the map, the density of the phenomena represented or the readability sought. This visual parameter directly influences the graphic impact, the perceived hierarchy of values and the overall clarity of the map. Although the type of map

remains the same, the choice of symbol size strongly influences the visual perception of spatial distribution.

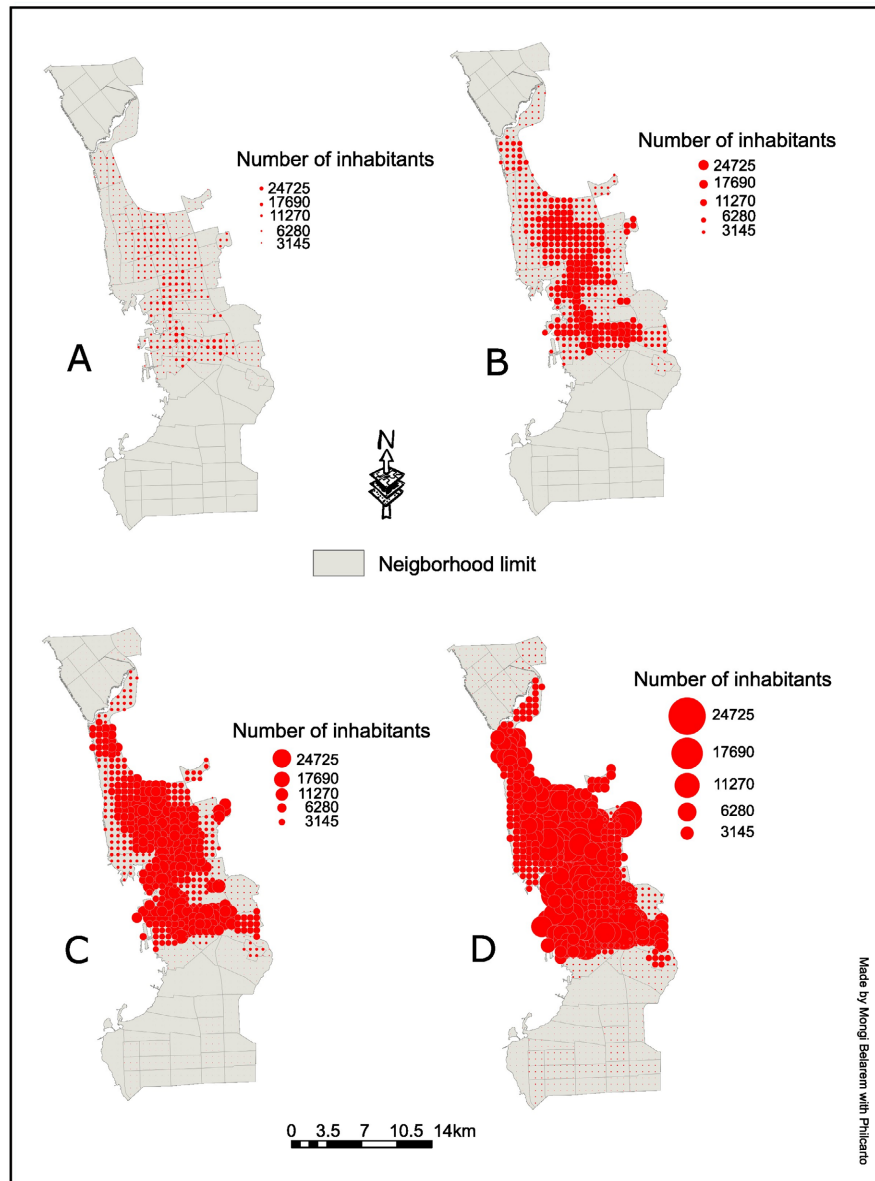


Figure 4. Visual impact of symbol size variation in population maps: Four representations of Jeddah.

A good balance between readability and accuracy is necessary according to the objective of the map [13]. **Figure 4** illustrates the differences between maps A, B, C and D, which mainly lie in the choice of size, layout and density of proportional symbols [16]. On map A (in **Figure 4**), the circles are small and numerous, allowing for fine and detailed reading but making the map visually loaded. Map B adopts slightly larger symbols, making it easier to distinguish between low and high-density neighborhoods. In Map C, the circles are even more visible and occupy more space, which highlights high density areas, although this may impair

the legibility of neighboring neighborhoods. Finally, map D uses very large symbols, visually accentuating population gaps but at the risk of creating a saturation effect and obscuring administrative boundaries. In addition, some neighborhoods do not have any symbols. This absence indicates that the population is below the threshold used for the graphic representation (for example, one point = 500 inhabitants). These areas correspond to unurbanized areas, industrial or port areas (south of the city), or areas under development (north of the city). It is therefore essential to emphasize that the absence of a symbol does not necessarily mean a total lack of population, but rather reflects a cartographic choice related to the scale and mode of representation.

The use of small circles helps to preserve readability in densely populated areas by avoiding graphic overload, but can reduce the visual impact of high values. Conversely, large circles increase the perception of population concentrations but may overlap and obscure specific geographic boundaries. An optimal solution is to adopt a proportional symbol size with adjusted transparency, or to combine the circles with neighborhood contours to better anchor the distribution in the urban space.

4) Influence of mesh (grid) on spatial accuracy in dot density maps

As part of the regular symbol distribution method, the size of the distribution grid can be adjusted to influence the spatial detail level of the representation. This parameter plays an essential role in the readability and accuracy of the map, especially when the radius of the circles (R) remains constant. The analysis of the three maps (Figures 5-7) representing the population of Jeddah using the point method highlights the effect of changing the grid size on the visual quality of representation. Figure 5 (75 m grid) gives a very fine reading of the population distribution, but the high density of symbols causes a graphic overload, especially in the most populated areas. In contrast, Figure 7 (150 m grid) promotes a clearer overall reading due to wider spacing but reduces local accuracy. Figure 6 (100 m grid) is a balanced compromise between analysis finesse and readability, making it the most suitable solution for a coherent and visually effective interpretation. However, a realistic and accurate representation of the actual population distribution (Figure 8) requires a thorough knowledge of the spatial structure of the study area, as well as the use of large-scale sources such as aerial photographs, satellite images and detailed topographic maps.

5) Differential and multivariate dots density maps

Dots density maps can also be used to represent both quantitative and differential data, such as the number of men and women or the distribution of state and private schools. In this case, two different colors are used; one Color for state schools and another Color for private schools. Through this map, we can go beyond the 2 genders in several such as state schools, private schools, international schools semi-state schools etc... The legend of the card contains the value of the points and the Colors used.

The points can also be degraded in color when representing the phenomena

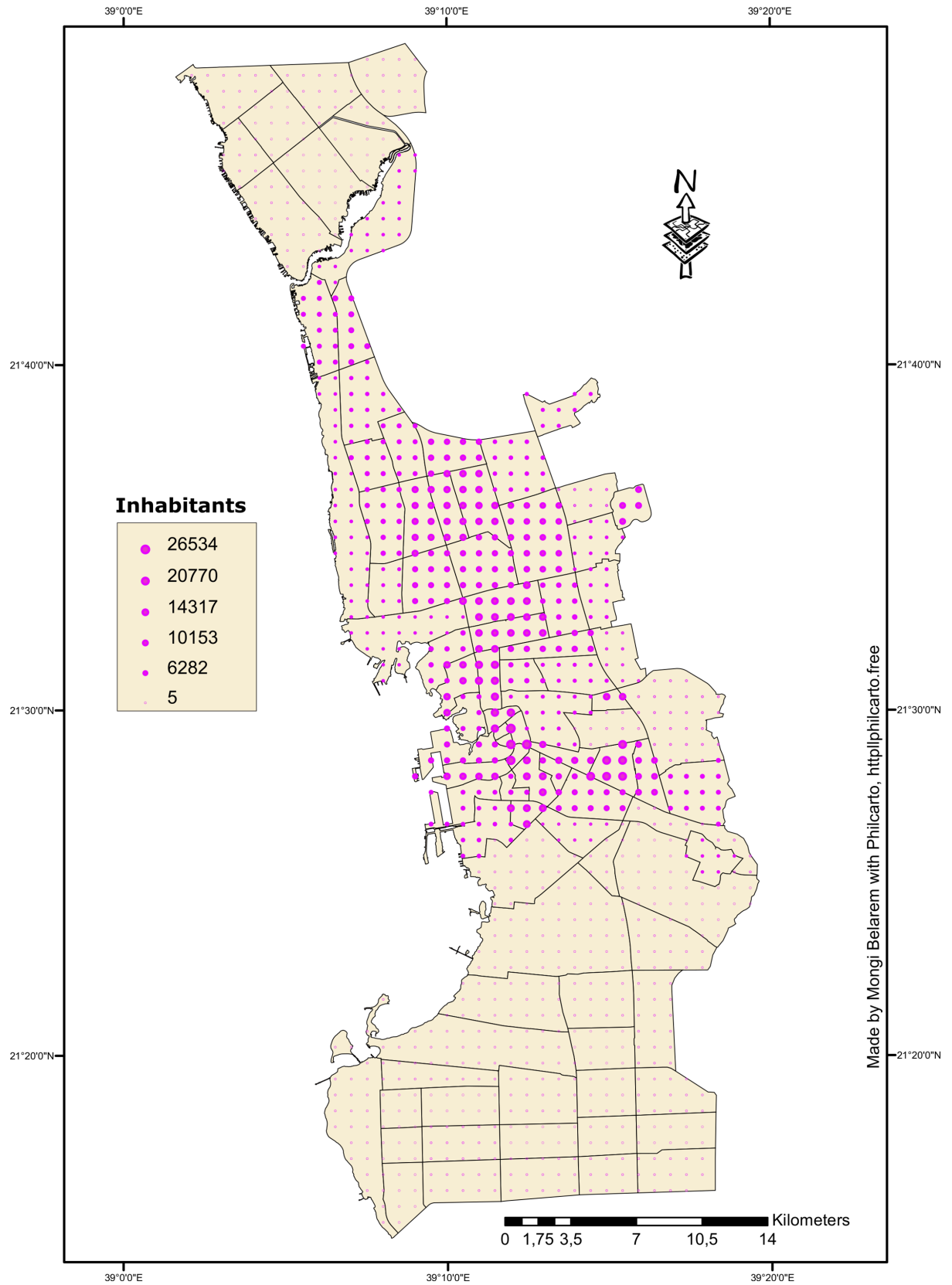


Figure 5. Representation of the population of Jeddah in 2020 using the dot density method (R5: constant radius) with a 75 m grid.

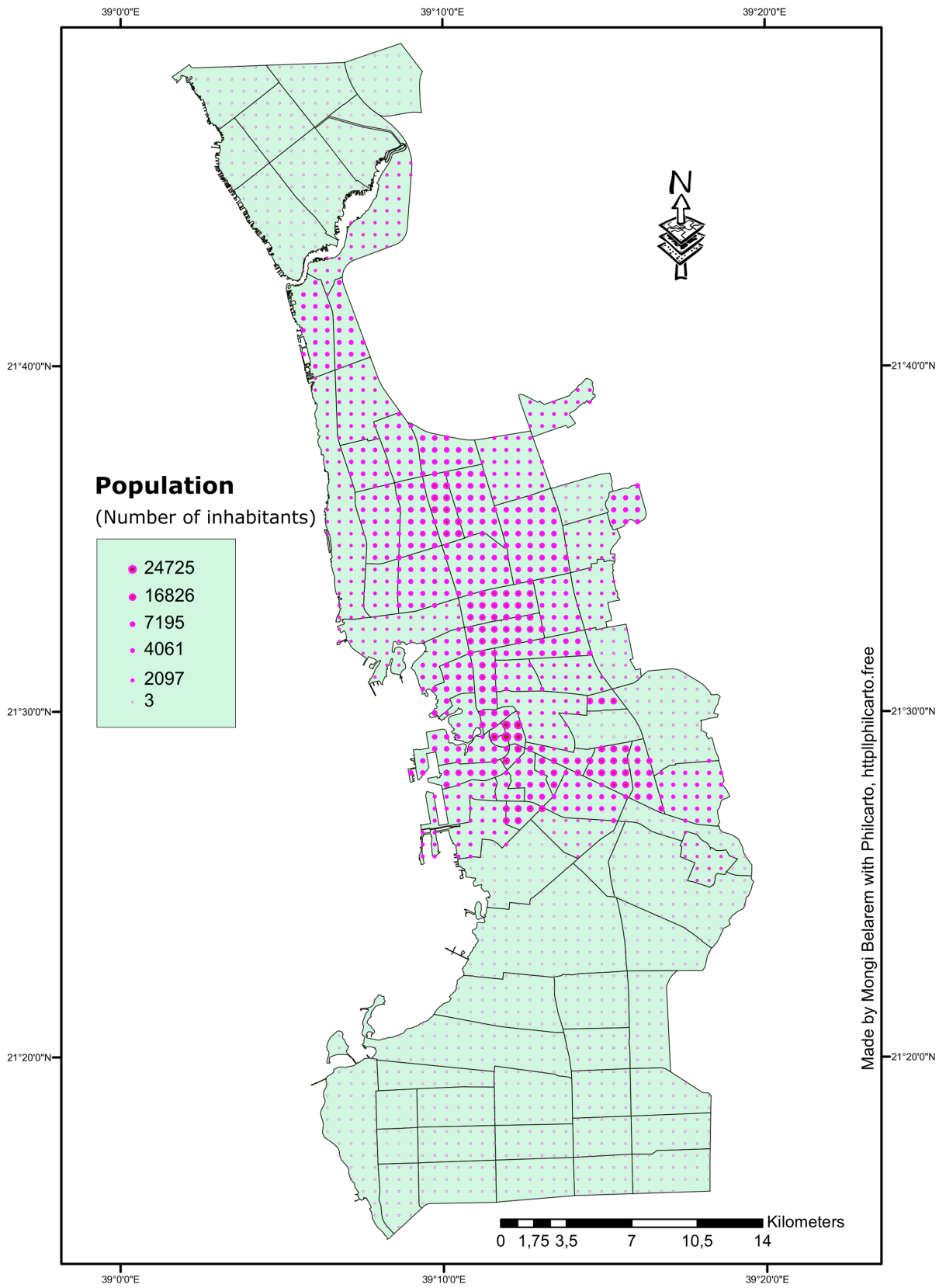


Figure 6. Representation of the population of Jeddah in 2020 using the dot density method (R5: constant radius) with a 100 m grid.

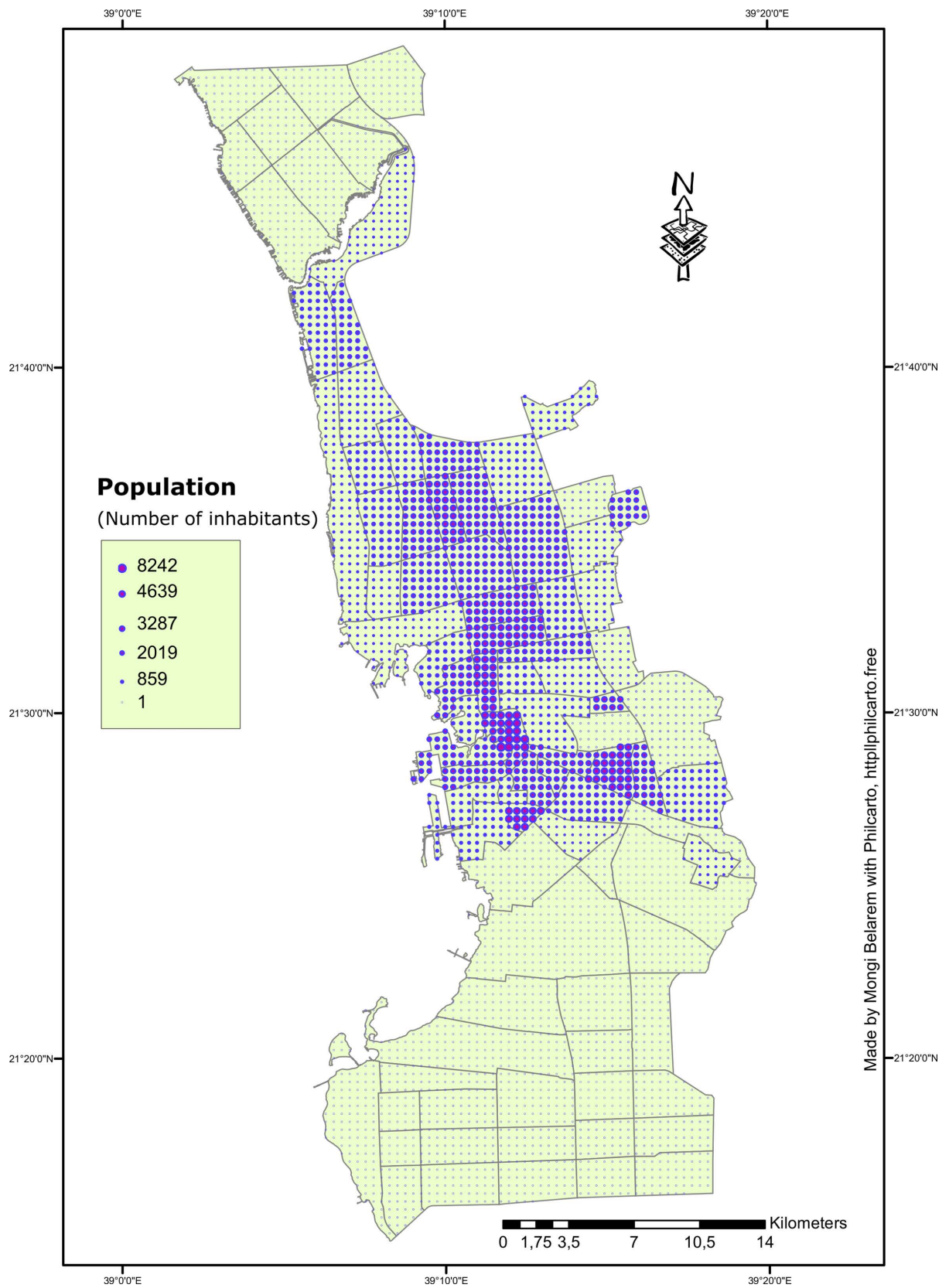


Figure 7. Representation of the population of Jeddah in 2020 using the dot density method (R5: constant radius) with a 150 m grid.

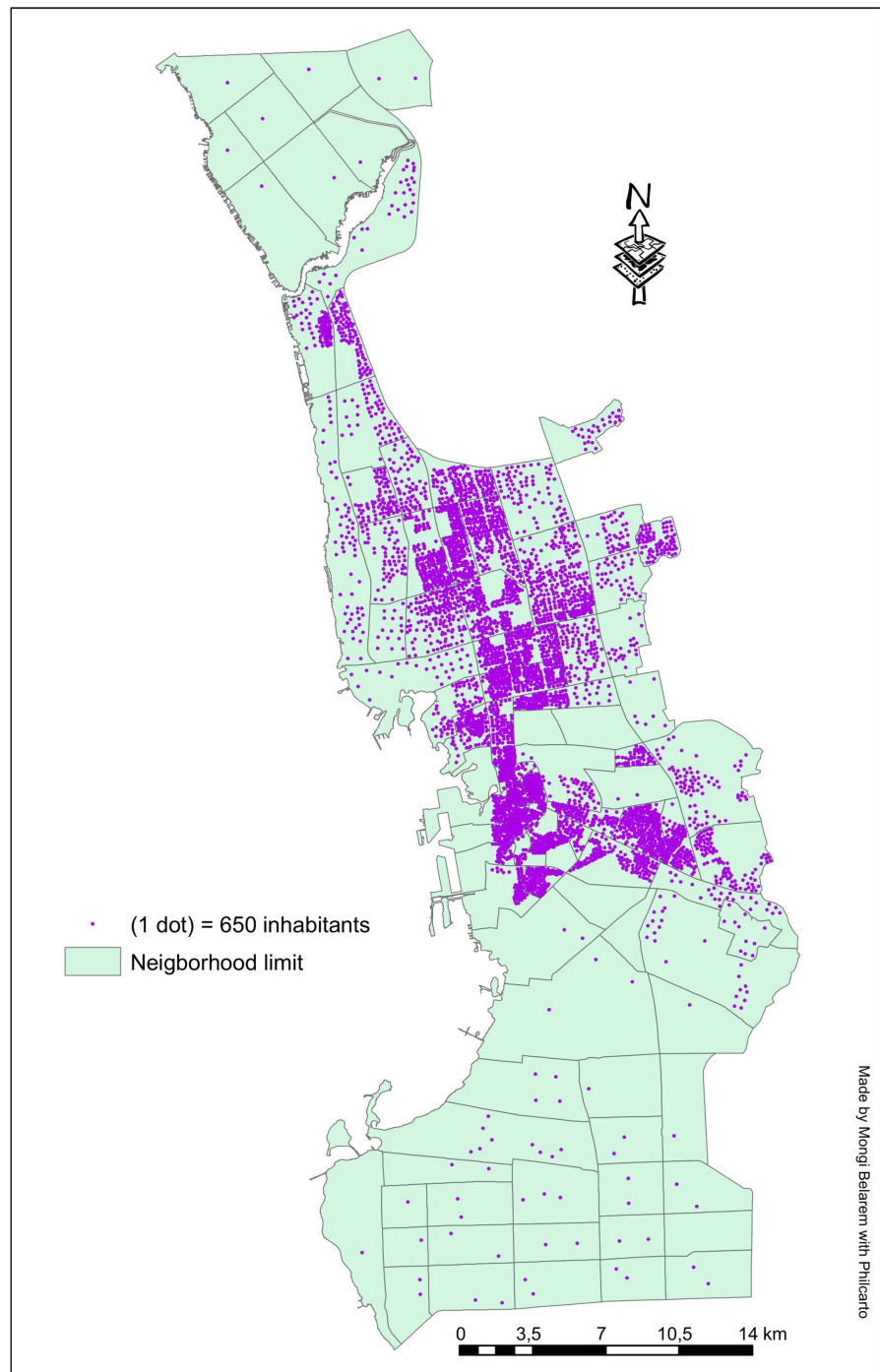


Figure 8. Population of Jeddah in 2020 (Dot density Reality).

according to their value as the success rates in each school, the gradients of colors represent the average densities of the indices. The disadvantage of this method is that it is difficult to differentiate the Color degradation on points. In the case of light color, it is difficult to see and count points [17]. **Figure 9** represents the distribution of the number of students who passed the main session of the 2025 baccalaureate exam in Tunisia by governorate and specialty. On the map, 5 categories

are distinguished: mathematics (in green), sports (in magenta), experimental sciences (in orange), technical sciences (in blue), computer science (in dark magenta), and letters (in black).

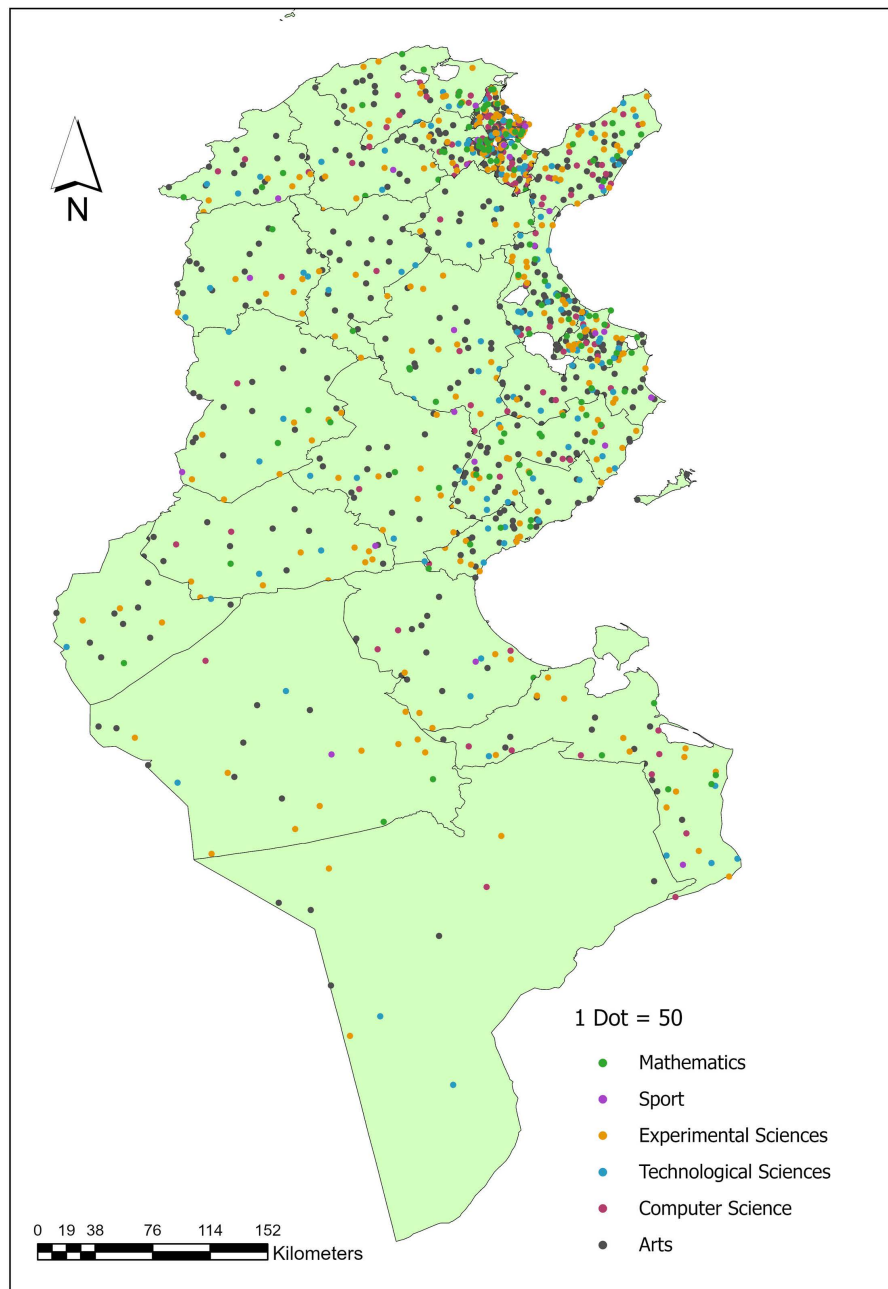


Figure 9. Distribution of the number of successful candidates in the main baccalaureate exam session in Tunisia by state and specialization in 2025.

Maps using Colored dot seeding (**Figure 10**) offer the possibility of visualizing in parallel numbers (by dot density) and continuous or discrete quantitative data such as percentages or specific measures (via the color of the dots). To enhance the legibility of areas with high Color concentration, the size of the dots can be

increased [3].

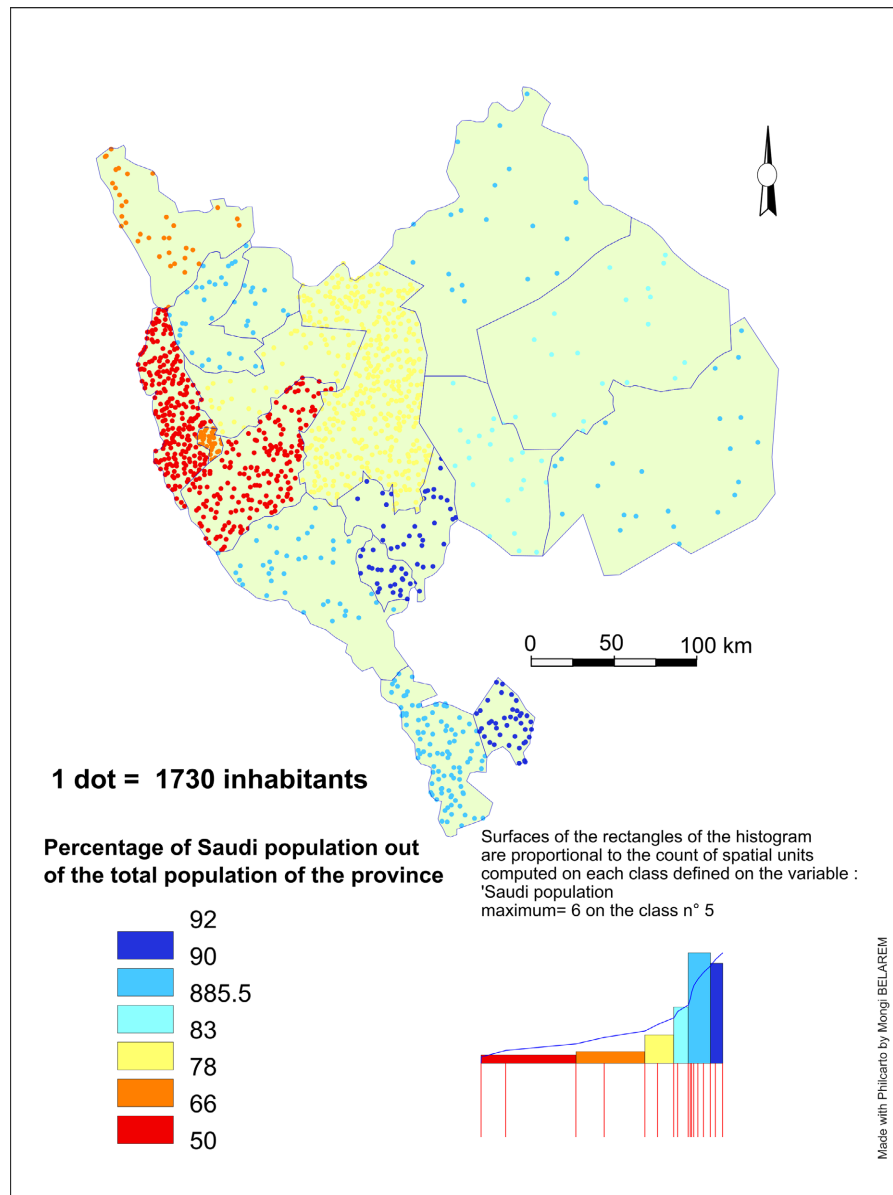


Figure 10. The distribution of the Saudi population in the Makkah Al-Mukarramah region by governorate and their percentage of the total population in 2022.

3.2. Some Alternative Methods

Several methods have been developed over time for the cartographic representation of the population, each responding to specific objectives of analysis and communication. The most commonly used approaches include.

3.2.1. The Map in Proportional Symbols

The objective of proportion maps is to visualize quantities in absolute values of the components of a geographical fact through variation in the area of symbols expressing these quantities. The visual variable used is size: the area of a figure is

proportional to quantities (Figure 11).

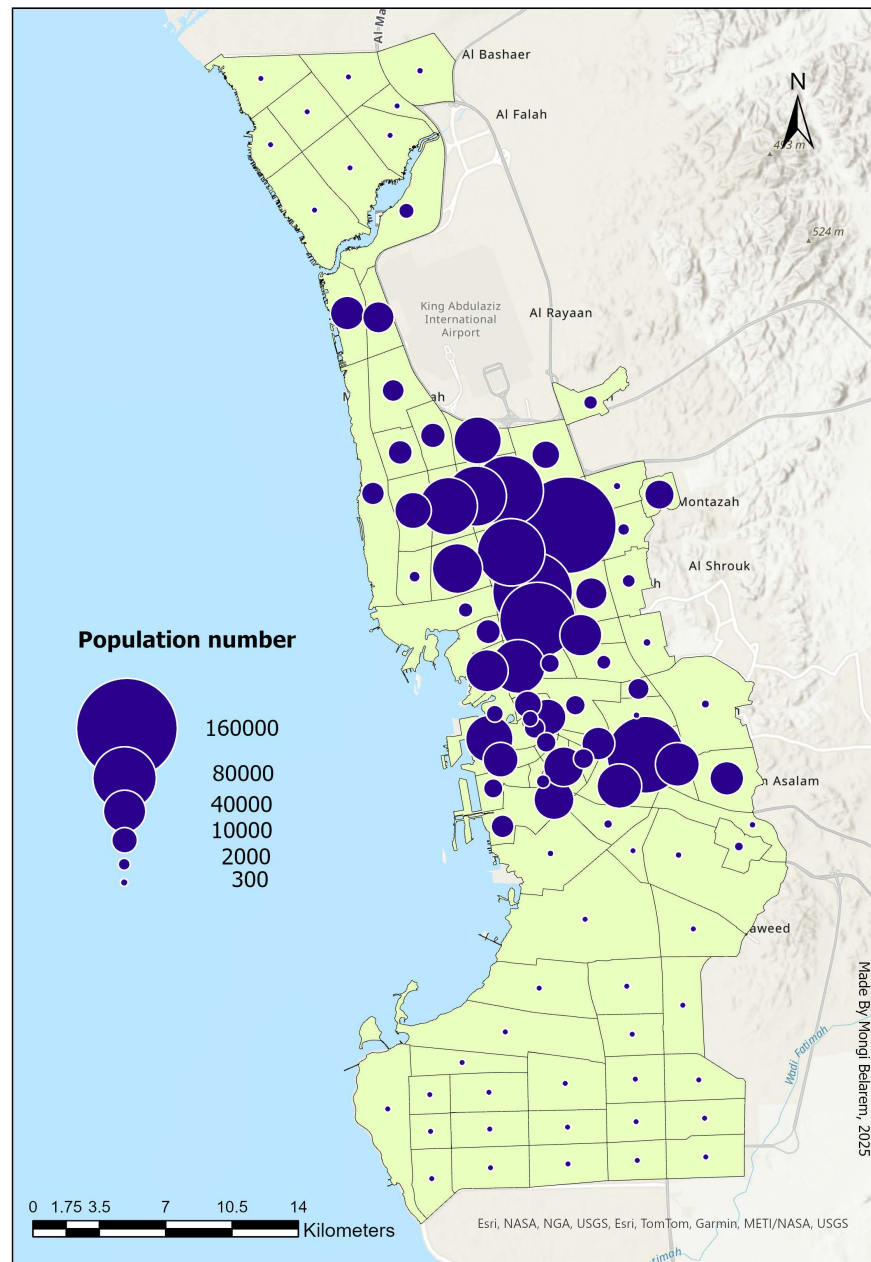


Figure 11. Population distribution by neighborhoods in Jeddah (proportional circle method) [12].

It is therefore invariably necessary to use, for the squares or for the proportional circles, the square root of the side or of the radius in order to control the proportionality of the figures [18]-[20]. The proportions are represented either by geometric figures, the most common ones being the circle, the square and to a lesser extent, the rectangle, the star, the diamond..., or by expressive figures (also called figurines or pictograms). The circle is not only the easiest figure to construct but

also the most readable. It is indeed difficult to respect the proportionality rule with complex forms that, moreover, hinder a proper vision of the information carried by symbols [13].

3.2.2. Chart Maps

A diagram map or Chart map is a map that incorporates diagrams placed at specific locations, either in a point-like manner (such as the distribution of students in different schools), linear (such as the evolution of the flow of a watercourse), or zonal (as the composition of agricultural production in a given region).

In mapping, the specificities of diagrams are added to those of the map itself, which makes the use of maps in diagrams more complex. In fact, these maps face two major difficulties: first of all, they are only effective if a sufficient number of diagrams is present; Without this, they lose their usefulness. However, the human eye has difficulty in analyzing several diagrams simultaneously, comparing them and extracting a clear message from them. For example, a chart map is more like a map to read than a map to observe. In addition, the size of the diagrams must be adapted to the format and layout of the background map, which often complicates the harmonization between these elements. It is indeed rare to obtain a good match between the background map and the layout of the diagrams [13].

3.2.3. The Maps in Semi-Circular Diagram (Half Circles Faced)

The semi-circular diagram, divided into two opposite halves, is an effective tool to compare two contrasting categories (e.g. male-female, public-private) or to represent the variation of the same variable over two distinct periods, by a differentiated chromatic coding (blue decrease, red increase) (Figure 12) [13].

3.2.4. Sector Chart Maps

Pie charts provide a visual representation of the proportions between different categories in a population (Figure 13). Each sector corresponds to a category identifiable by a known workforce, and the entire workforce must be summable to reflect the total population [3].

3.2.5. The Choropleth Maps

A choropleth map (Figure 14) expresses the variation in the mapped space of a ratio variable (percentages, rates, measures...) or a nominal variable (codes, names, labels), excluding quantities or numbers [3].

It is used for the representation of interval quantitative data on spatial units by coloring or hatching them [21]. If this map also represents continuous quantitative data, color degradation or hatching may be within the symbols [22] [23] (Figure 15).

3.2.6. Asymmetrical Method

The asymmetrical map (Figure 16) is a thematic map that represents the distribution of a phenomenon (often population) taking into account the actual occupation of the land, in order to avoid uninhabited areas and better reflect the effective distribution.

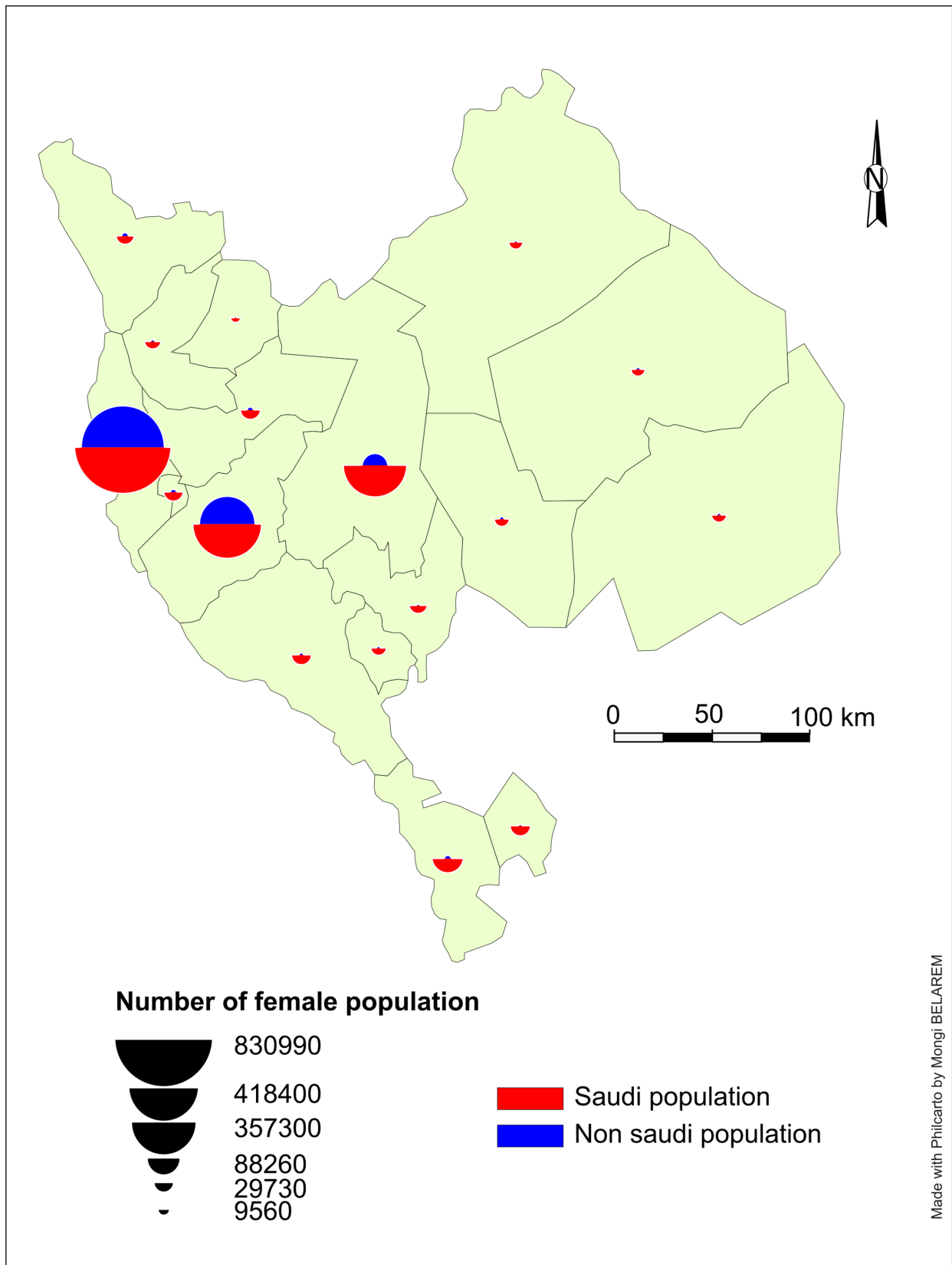


Figure 12. Distribution of the female population in the Makkah Al-Mukarramah region by governorate and by nationality (Saudi/non-Saudi) in 2022.

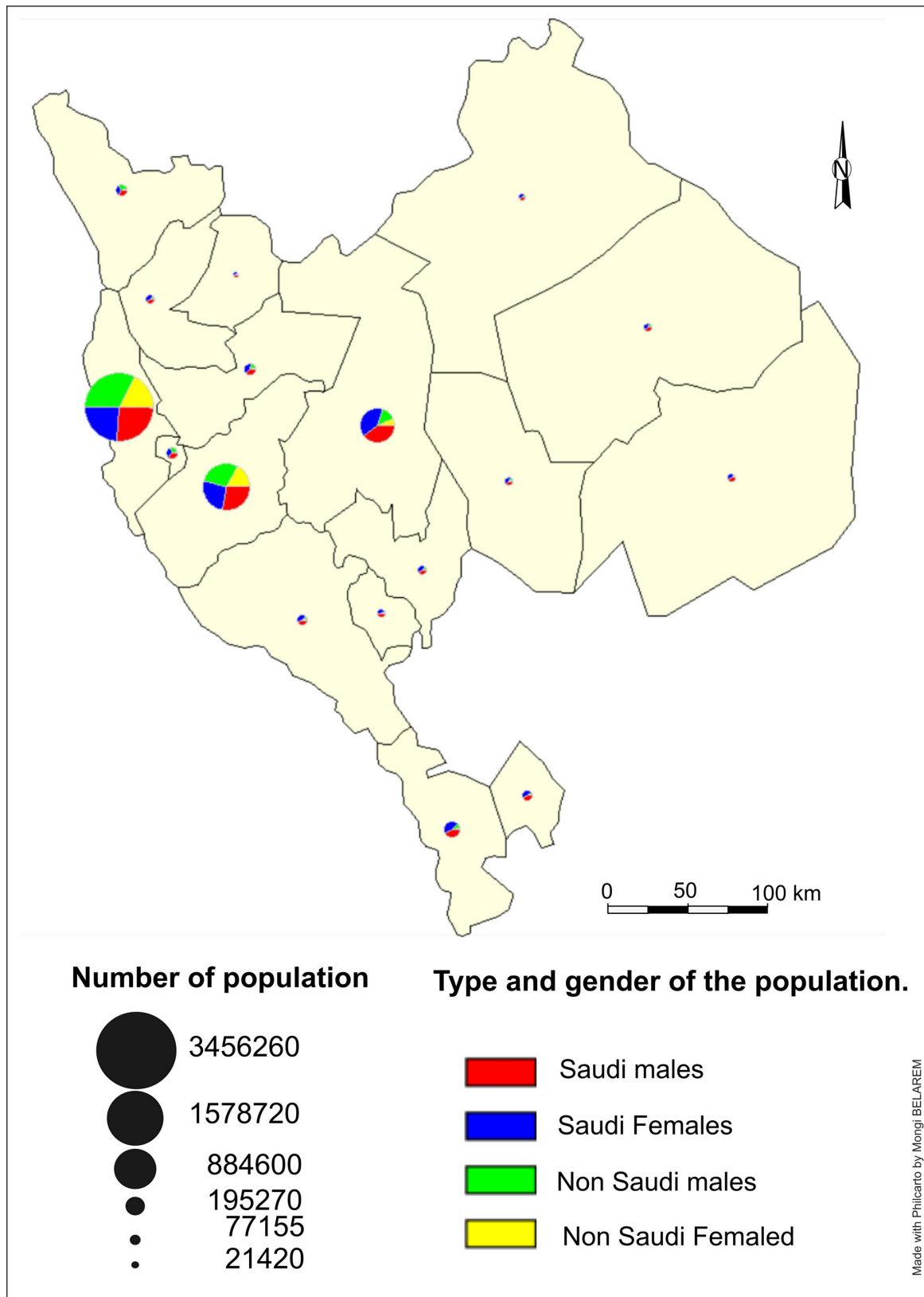


Figure 13. Distribution of population in the Makkah Al-Mukarramah region by gender (females/males) and nationality (Saudi/non-Saudi) by governorate in 2022.

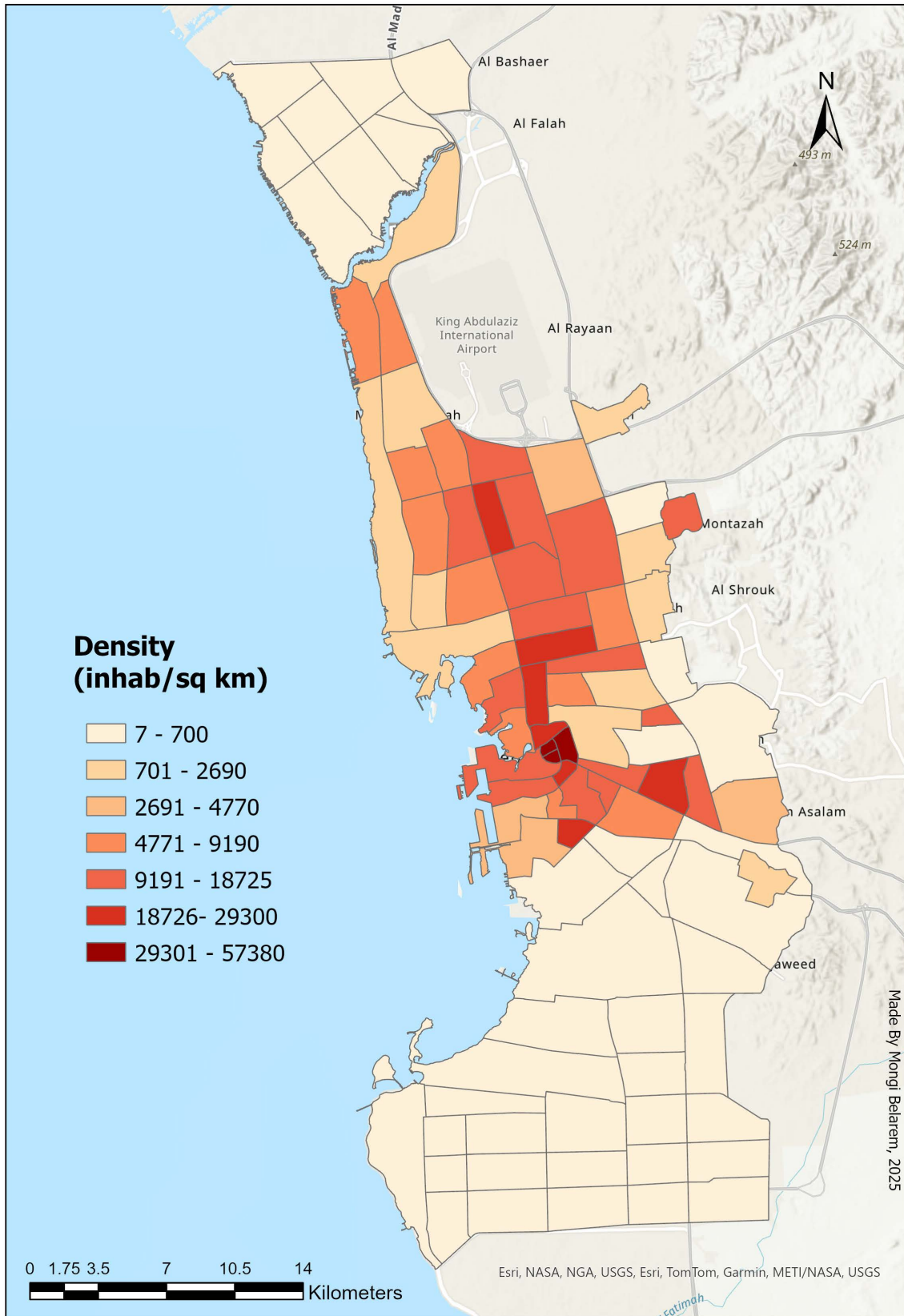


Figure 14. Spatial distribution of population density in the city of Jeddah in 2025 (inhabitant/km²) (choropleth map).

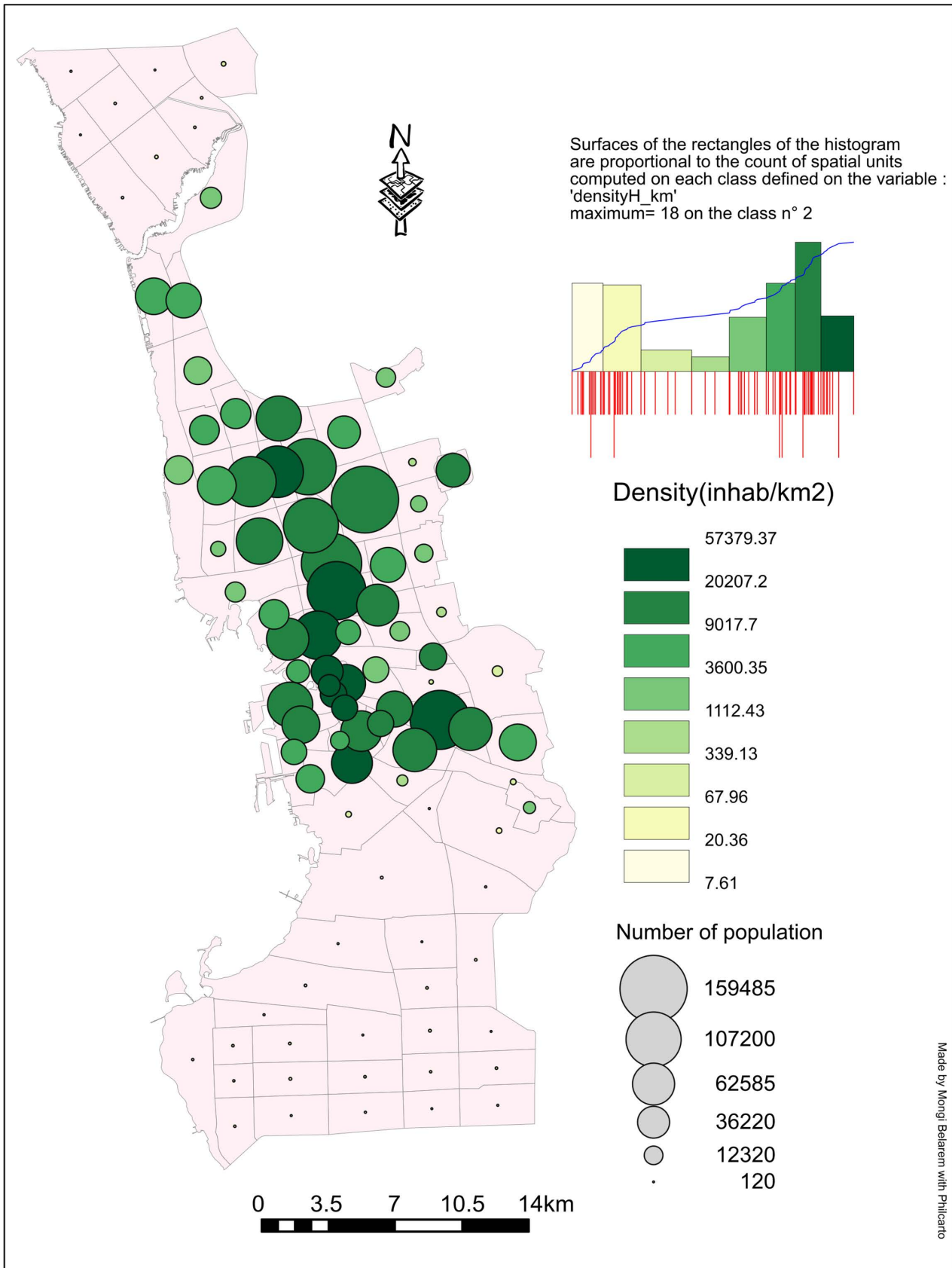


Figure 15. Jeddah population density and size by district in 2020 (choropleth maps and proportional symbols).

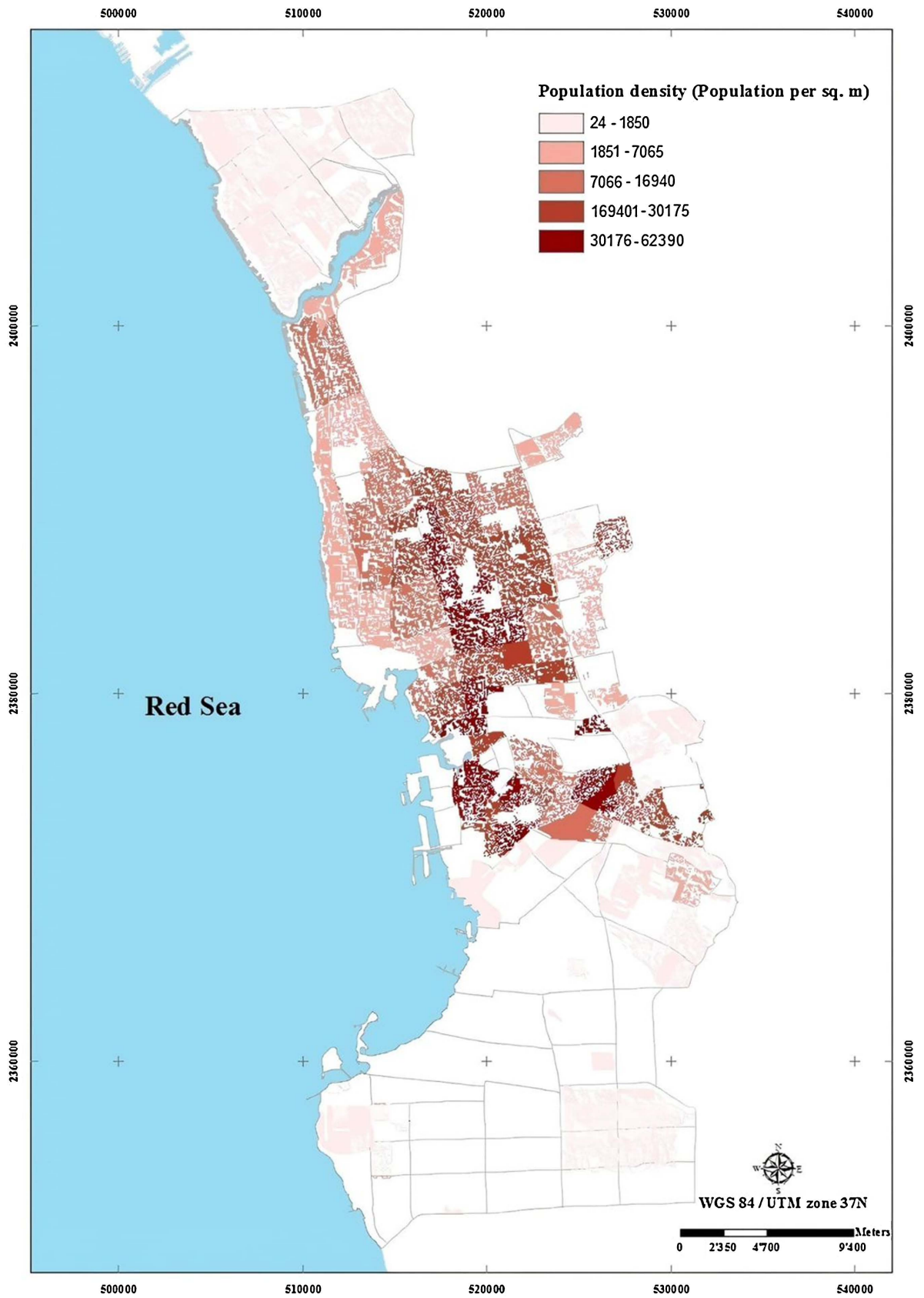


Figure 16. Dasymeric Map of the Population of Jeddah (Natural breaks, Jenks classification). Source: [24].

3.2.7. The Maps in 3 Dimensions

The “3D” maps (Figure 17) do not simulate tactile relief, but rather a visual perspective. They add a third dimension (z) to the two traditional dimensions (x and y) of a sheet. Once hand-drawn to represent relief, these maps are now used to visualize a variety of themes, not just concrete data such as thematic maps [13].

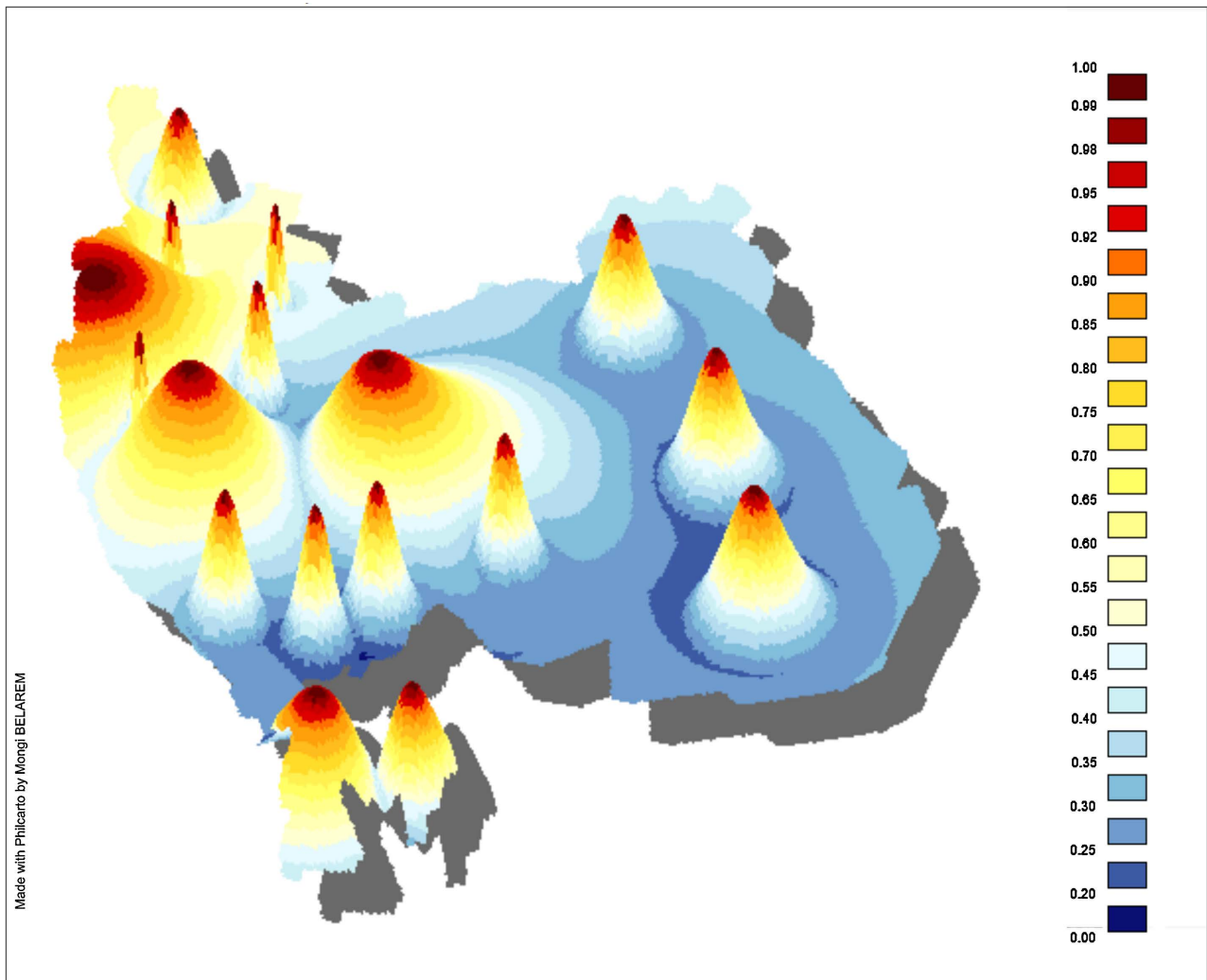


Figure 17. Three-dimensional mapping of population density potential in the governorates and areas of influence of the Makkah region in 2022.

3.2.8. The Anamorphosis Maps

Anamorphosis Maps (Figure 18) are maps in which spatial units are modified to graphically reflect a quantitative phenomenon, erasing the traditional geographical dimension. These maps are designed in such a way that the original shape of the studied space remains recognizable, with the designer establishing a “recognition threshold” to preserve this readability [13]. Their main advantage lies in their ability to illustrate phenomena in an original way, while highlighting the inequalities between different spatial units. On the other hand, their disadvantage lies in the distortion of the actual shape and surface of the geographical units.

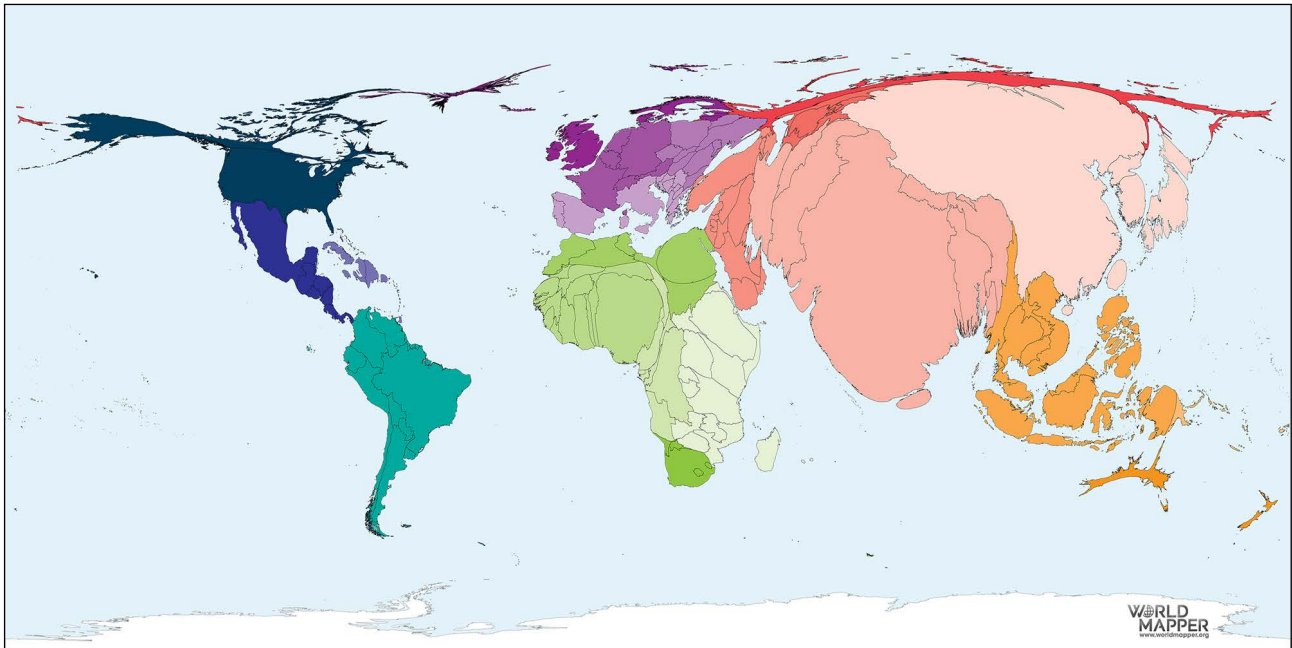


Figure 18. Global population distribution in 2018 (by the anamorphosis method). Source: [26].

3.2.9. Gravitation Maps from the Huff Model or the Reilly Model

Gravitation maps are used to represent the influence areas of urban Centers by highlighting their relationships with the upper and lower levels of the urban hierarchy either in a simple way (Figure 19) or in 3D (Figure 20). This method is frequently used to visualize the areas of attraction of cities and assess their polarizing power [3]. When applying this approach, the Huff or Reilly gravitation model and other models are generally used.

Reilly's model states that sales generated by two locations ("a" and "b") from an intermediate location are directly proportional to their respective populations and inversely proportional to the square of the distances between the intermediate locality and the two localities considered. According to Reilly, the force of attraction exerted by a city *j* on a place "i" is proportional to its size (*M_j*) (often demographic) and inversely proportional to the square of the distance (*D_{ij}*) that separates "i" from "j" [25].

Reilly's Law—Point of Equilibrium Between Two Centers

$$M_a/DO_a^2 = M_b/DO_b^2 \Leftrightarrow DO_a = D_{ab}/(1 + \sqrt{(M_b/M_a)})$$

where:

- *M_a*: Size (e.g., population or economic mass) of center a
 - *M_b*: Size of center b
 - *DO_a*: Distance from point of equilibrium O to center a
 - *DO_b*: Distance from point O to center b
 - *D_{ab}*: Total distance between centers a and b
-

Source: [25].

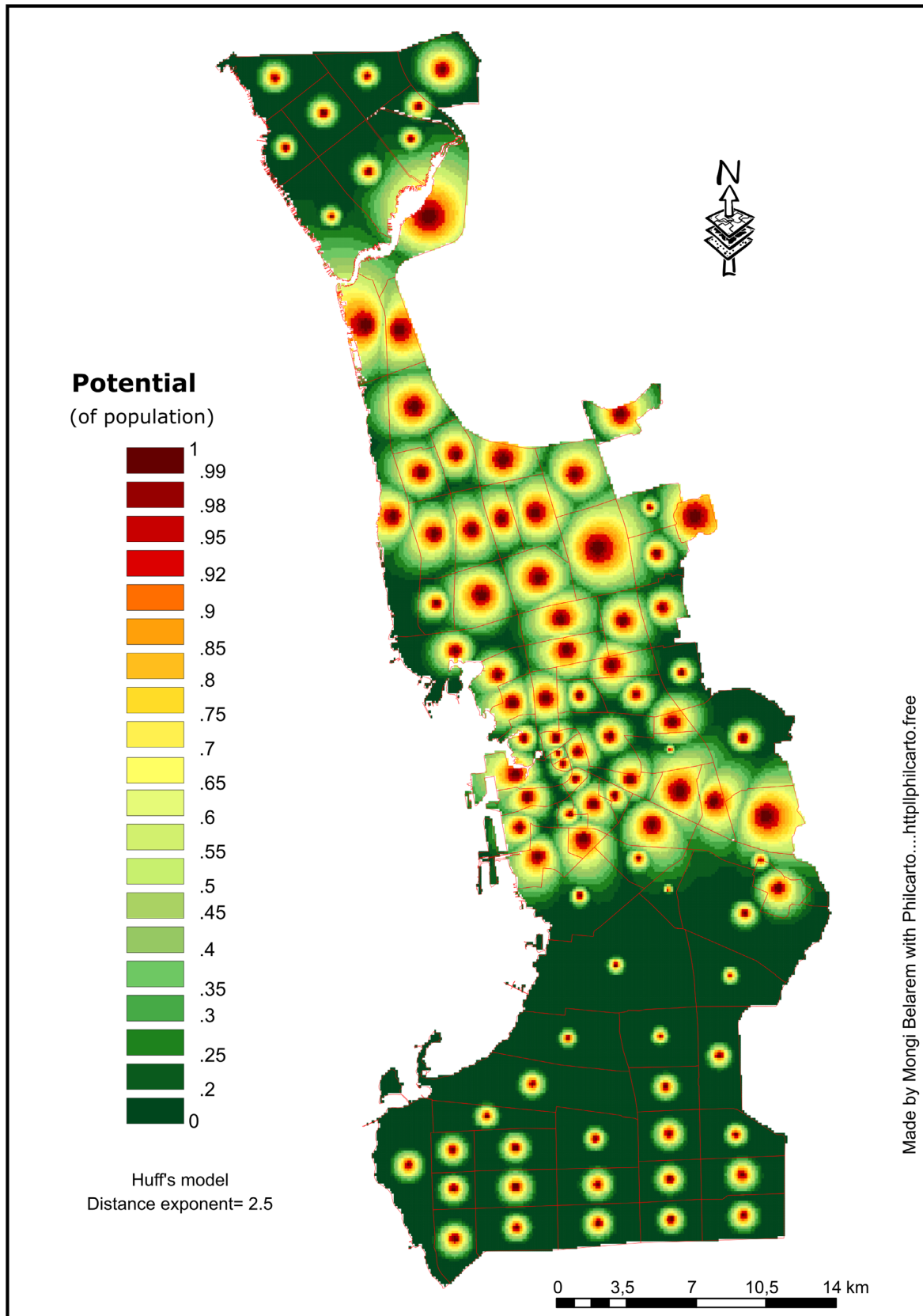


Figure 19. The potential of Jeddah neighborhoods to be attractive in 2017 according to the Huff model (2.5).

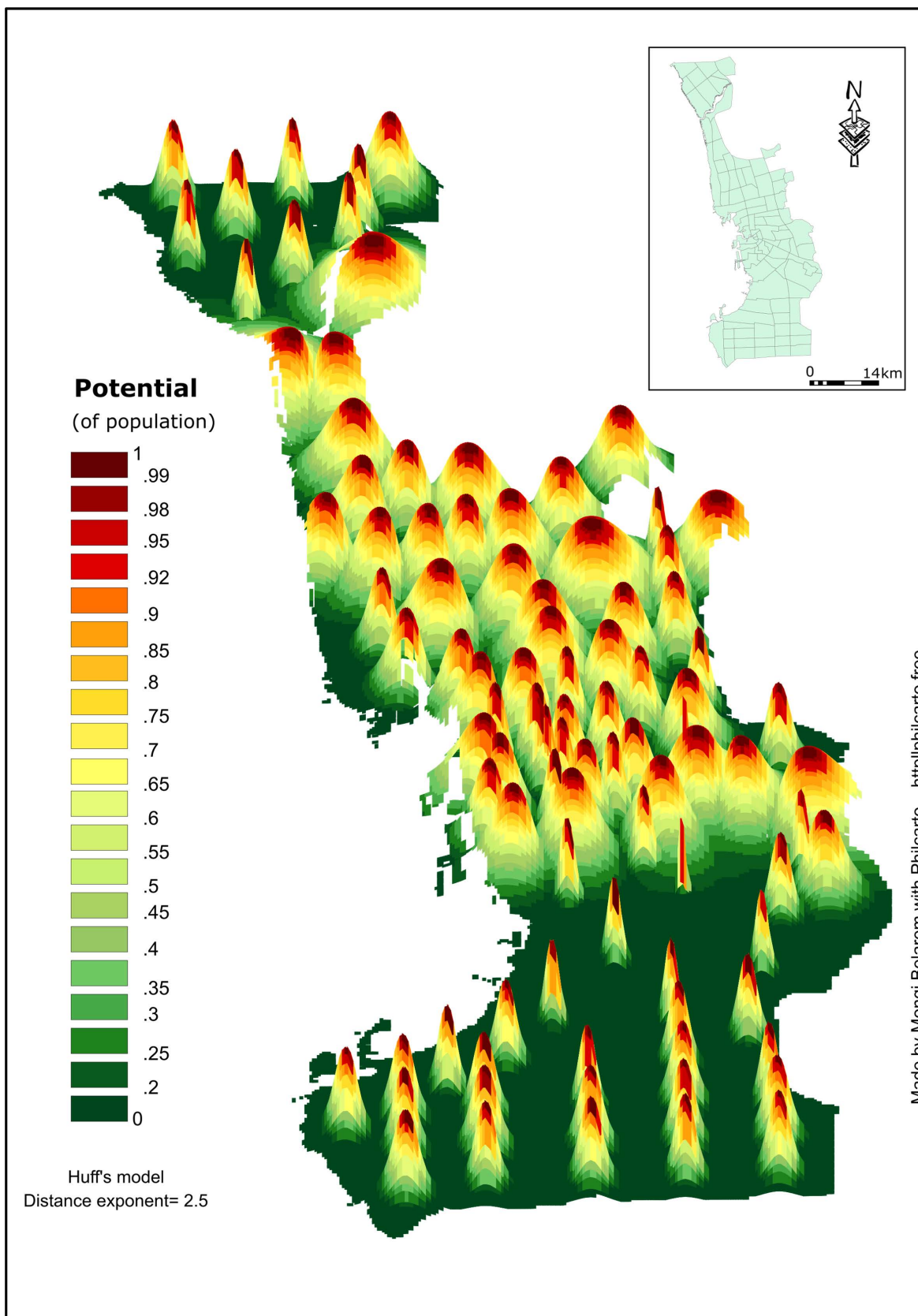


Figure 20. The attractiveness of Jeddah's neighborhoods in 2017 according to Huff's model (2.5) in 3D.

Reilly also demonstrates that it is possible to deduce from his formula the equilibrium point “O” between the areas of influence of two cities “a” and “b”, located at a distance D_{ab} , and of respective sizes “ M_a ” and “ M_b ”.

Reilly’s Law (original version)

$$A_{ij} = M_i/D_{ij}^2$$

Where:

- A_{ij} : The attraction or gravitational pull of city or center i on point or consumer location j .
- M_i : The size or mass of center i (usually its population or economic size).
- D_{ij} : The distance between consumer location j and center i .
- The exponent 2 indicates that the attraction decreases with the square of the distance, following Newtonian-like gravity.

Source: [25].

As for Huff’s model, it expresses the attraction exerted by the commercial equipment of a given locality, head of zone or sub-zone “ j ”, on the average consumer of a locality or commune. This model can also be applied to a specific shopping Center in competition with several other Centers, taking into account the demographic weight of the Centers or municipalities. It is not limited to municipalities, where P represents the probability that a consumer “ i ” will visit a shopping Center “ j ”. In Huff’s original model, “ P_{ij} ” is the probability that an individual consumer “ i ” will visit a specific shopping Center [25].

Huff Model Formula

$$P_{ij} = (W_i / D_{ij}^a) / \sum (W_k / D_{kj}^a), \text{ for } k = 1 \text{ to } n$$

where:

- P_{ij} : The probability that consumer j shops at store or site i .
- W_i : A measure of the attractiveness of store or site i (e.g., size, number of services, etc.).
- D_{ij} : The distance from consumer j to store or site i .
- a : A distance decay parameter (exponent) that reduces the effect of distance. Common values range from 1.5 to 2.
- n : The total number of available store locations.
- k : An index that runs over all available store locations in the summation in the denominator.

Source: [27].

In addition to this series of alternative dots density maps, which can serve as relevant tools for the spatial representation of the population, there are several other types of thematic maps, each with specific objectives. Each cartographic method has its own advantages and limitations, and its effectiveness depends

largely on several factors, such as the nature of the data used (quantitative or qualitative), the level of spatial scale (local, regional, national), the discretization method adopted (equal interval, quantiles, natural thresholds, etc.), as well as the objectives of the geographical analysis. Thus, the choice of the type of map - whether it is a choropleth map, a map in proportional symbols, a map in points, isarithms or an anamorphosis map—must be guided by a rigorous methodological reflection, taking into account the readability, the accuracy of the information transmitted and its relevance to the phenomena studied [28] [29]. It is therefore essential for the cartographer or researcher to master the principles of graphic semiology and adapt representation techniques to the characteristics of the demographic data to be visualized.

4. Conclusions

Based on this comparative analysis of the dot density map and other types of thematic maps, it appears that the dot density map is a particularly relevant and effective tool for spatial representation of the population. This method makes it possible to visualize the population concentration in an intuitive way, while maintaining a certain finesse in the spatial rendering of the phenomenon.

There are generally three main methods, depending on the mode of distribution of points: arbitrary distribution, ordered distribution, and actual distribution. Among these three approaches, the real method is the one that gives the most accurate representation of the actual distribution of the population on the territory. It allows the location points to be based on their real geographical position, often using map backgrounds and precise media such as large-scale topographic maps, aerial photographs, satellite images, development plans, land works... The choice of method to be adopted depends on several essential factors, among which are: the nature of the available data (aggregated or disaggregated), the scale of work (local, regional, national), the density of the phenomenon studied, and the size and shape of the spatial units of analysis...

It should also be noted that other cartographic methods can be used to represent the population, such as choropleth maps [30] [31], maps in proportional symbols, charts in diagrams, anamorphosis maps, choropleth maps or asymmetrical maps... Each type has its own characteristics, advantages and limitations. Their effectiveness varies according to the context of use, the objectives of the analysis, the readability sought, as well as the capacity of the cartographic medium to transmit spatial dynamics accurately.

Therefore, the cartographic representation of the population cannot be done in a single or standardized way. It requires an informed methodological choice, based on a good knowledge of the tools of graphic semiology and the particularities of the analyzed territory.

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Conflicts of Interest

The author declares no conflicts of interest.

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