# Urban polychromy in inequality contexts: a critical-experimental methodology from the top view

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Urban polychromy is determined by geographic, cultural, historical, social, and economic factors, and reflects a combination of natural and artificial elements. This article explores an urban chromatic analysis that relates the colours present in the urban environment to the socioeconomic and racial contexts and profiles of the population. To accomplish this, an experimental scientific-artistic methodology was developed, focusing on an analysis from the top view. The study is centred on Belo Horizonte, the capital of Minas Gerais, Brazil. The primary goal of this investigation is to analyse the urban polychromy of the city through the development of an experimental methodology. It also seeks to explore the relationship between urban polychromy and the city's social-spacial and interseccional dynamics. As resources, satellite images were associated with urban parameters and demographic data such as income and race of the population by census tract (from the Brazilian Institute of Geography and Statistics (IBGE) - 2010 Brazilian Census). Eight samples were selected to support the production of predominance graphs, using the Natural Colour System (NCS). Manual collages were also assembled to bring the human scale and urban dynamics not visible in satellite images alone. The samples from Belo Horizonte show that the colour scheme is made up of shades of blue, red, green, yellow and grey, respectively, as well as mostly dark and low saturated colours. The results were analysed qualitatively and quantitatively, and reveal that urban colour highlights and accompanies the inequalities present in the city, such as the relationship between the presence of vegetation integrated into the occupation and the quality of urban life, and the choices of roofs for residential buildings. The development of an experimental methodology made it possible to explore new perspectives – intersectional, environmental and decolonial-, in the field of urban chromatic analysis, addressing previously neglected perspectives, such as the top view. It is important to note that the quantitative data obtained from the images is not highly accurate. To increase accuracy, future research should adopt the most standardised conditions possible for capturing the images. Due to the size of the object of study, the next ideal step would be to test and evaluate the methodology's performance in a smaller sample that can be analysed in its entirety.

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## Introduction

The urban polychromy of a region represents historical, cultural and social aspects, both about the place and the population, as well as formal data such as architectural styles and urban morphology. Understanding urban areas from a chromatic perspective involves more than analysing the individual colours of each building; it is necessary to look at the assemblage, considering how the buildings relate to each other and to the context to which they belong [1].

This article explores an urban chromatic analysis that relates the colours present in the urban environment to the socioeconomic and racial contexts and profiles of the population. To achieve this, an experimental scientific-artistic methodology was developed, focusing on an analysis from the top view. The study is centred on Belo Horizonte, the capital of Minas Gerais, Brazil. Located in the southeastern region of the country, Belo Horizonte had a population of 2,315,560 [2] in 2022, the year in which the research was conducted.

The primary goal of this investigation is to analyse the urban polychromy of Belo Horizonte through the development of an experimental methodology from a critical and contextualised perspective. Additionally, it seeks to explore the relationship between urban polychromy and the city's social-spatial and intersectional dynamics in a theoretical – race, class and environmental - point of view [3-4]. The goal is to contribute to advancing the field of urban chromatic analysis in Brazil.

In this study, urban polychromy is defined as the coexistence of all chromatic variations present in today's city — or as current as possible. It results from the combination of natural elements, such as earth, vegetation, and water, and artificial elements, such as street paving, roofs, and façades. For artificial elements, colours are intrinsically related to the materials used, which, in turn, reflect the conditions of accessibility and the consumer market available.

Studies indicate the differentiation between the natural and artificial dynamics that make up the urban polychromy. Throughout the historical evolution of cities, the interactions between the colours of these elements contribute to forming a unique and diverse chromatic image, characteristic of each location. At the same time, the collective memory of the inhabitants plays an important role, influencing the colours of today's buildings and generating typical painting patterns that became familiar and appreciated by the local population [5-6].

The time factor plays an important role in analysing the chromatic relationships of a site. Some elements are more permanent, while others are more transient. According to Cesar [1], buildings tend to remain in the urban landscape for long periods. In contrast, components like vehicles and vegetation are subject to change at shorter intervals.

Like Cesar [1], Lenclos [7] addresses this relationship, noting that permanent colours, such as those of minerals in the soil and building materials, have a stable visual character and can be analysed objectively. Impermanent colours, on the other hand, include changeable elements such as lighting, vegetation, bodies of water, the sky and other mobile and random chromatic contributions that bring dynamism to the landscape.

Lenclos [8] also points out that impermanent or accidental colours work as a counterpoint to the static character of architecture. Recognising their relevance, these elements are considered in the studies carried out on site, enriching the analysis of urban polychromy and its dynamics.

Most chromatic analysis research focuses on heritage discussions in historic environments and city centres. Additionally, these studies are typically limited to the perspective of façades and the pedestrian viewpoint, with little attention given to the top view. However, addressing that gap is crucial for understanding the critical role of colour in urban dynamics and regional planning. Such analysis can reveal patterns of unequal population distribution and highlight the connections between colour and materiality in the urban environment.

The elements observed from the top view are just as characteristic to a location as those perceived from a pedestrian's perspective. This approach provides access to socio-economic information about the population and offers a deeper understanding of urban dynamics, including socioeconomic and racial aspects. Lenclos observes that the predominant colours of roofs, walls and ground surfaces make up most of the visible urban space. He also points out that roofs, in particular, have a visual importance that is often overlooked, despite their impact on the chromatic composition of the city [8].

## Methodology

Here are described the methodological procedures adopted for this experimental investigation. The methodology developed is similar to those used by Cesar in his investigations about urban chromatic identity - partially published in his article "The Colors of Belém: a quest for an urban chromatic identity" [1] - and Lenclos' concept of "Geography of Color" [7] - which relates polychromy to natural elements, as the connection between the colour of the local soil and the building materials commonly used.

The critical issue added to these important references relates to a gap pointed out by Lenclos himself, at the time of the research not yet identified. By changing the point of view of the chromatic analysis, in an observational turn from top to bottom, it was possible to establish other contextualised analytical parameters, such as socio-spatial ones. This experimental methodological addition made it possible to make a critical epistemological cut-out in order to contribute to more inclusive and broader approaches to the debate on urban polychromy.

### *Survey of information about the site*

The first stage is reserved for gathering general information about the city - mainly geographical and statistics (from the Brazilian Institute of Geography and Statistics – *IBGE*), as well as urban planning legislation of Belo Horizonte [2-3, 9-11].

### *Image base*

For the urban chromatic analysis from the top view, satellite images were used. These images were accessed using an open-source software that provided high-resolution images. Considering the chromatic complexity inherent of satellite images, this study focuses on the predominance of the colours present, seeking to understand the proportion between the different chromatic elements in each image.

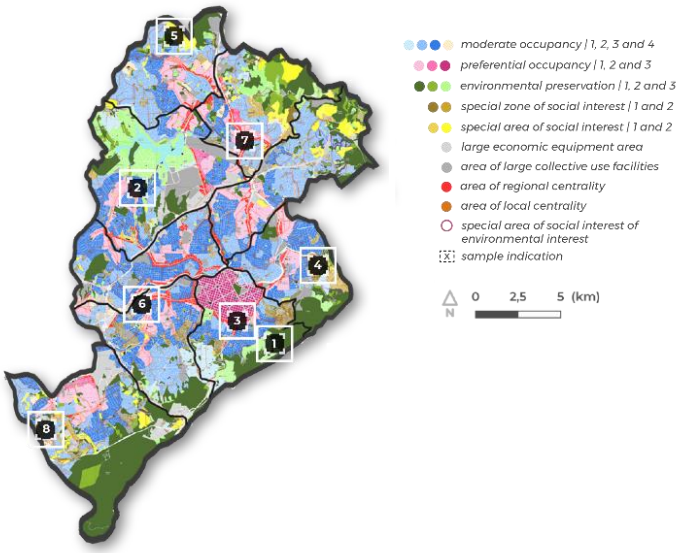
### *Sectorisation of the city*

Considering the complexity of the urban fabric of a large city like Belo Horizonte, it was chosen to understand it based on its differences. To accomplish this, the parameters defined were the Zoning from *the Master Plan* (Figure 1 [11-12]), average income in the census sectors (Figure 2 [9, 12]) and the racial map of the population (Figure 3 [10, 12]). Furthermore, in a complementary way, the *Hypsometry* (Figure 4 [12-13]) and the Urban Quality of Life Index (IQVU) (Figure 5 [12, 14]) were used[1].

The zoning from the Master Plan [11] divides the city based on urban planning parameters and is a basic tool of any urban study carried out by urban planners.

The average income can also be used for urban spatial analysis. It allows for identifying areas with higher income concentrations in the city and pinpointing where populations with lower wages live. The *Average Income in the Census Sectors Map* (Figure 2) [9] shows a concentration of higher income brackets in the Central-South region and around the *Pampulha* Lagoon. With the exception of these two locations, income levels gradually decrease as one moves closer to the city limits.

[1]All the mappings cited in this paragraph were used as a basis in a georeferenced data open-source software and have overlapping editions by Bianca Monteiro Tavares Fonseca, 2022.



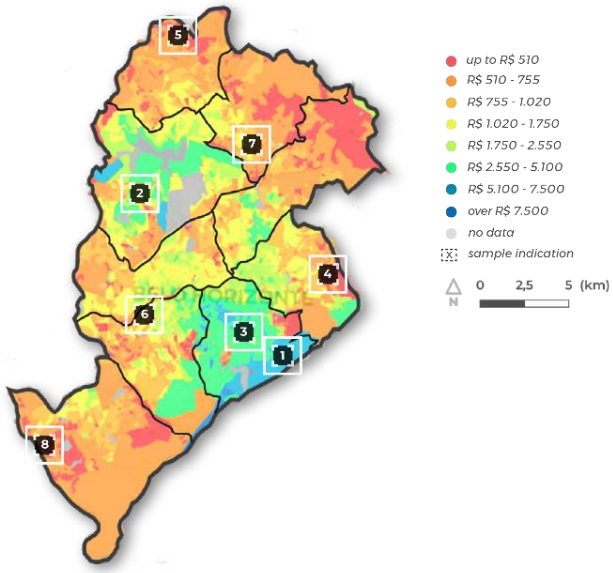
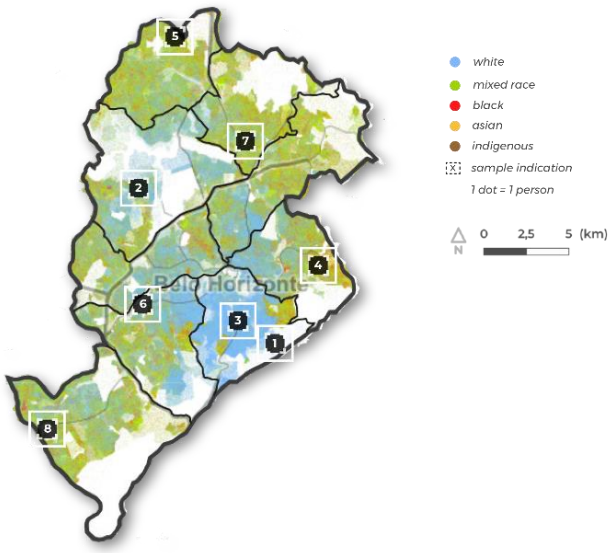
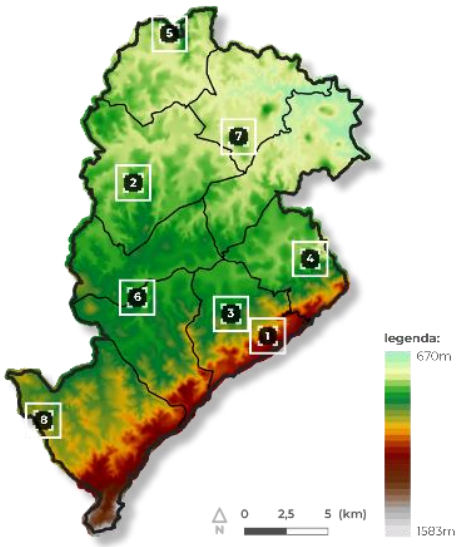




*Figure 1 (left): Urban structure map - zoning from the Master Plan of Belo Horizonte, 2022.*
*Figure 2 (right): Average income in the Census Sectors Map[2].*

With a history shaped by colonisation and enslavement, Brazil carries a legacy of racial segregation that is spatialised in the city. It is evident that the white population is concentrated in the South-Central region and around *Pampulha* Lagoon, while the black and mixed-race population increases as one moves closer to the city's outskirts, reproducing the pattern observed in the previous map.



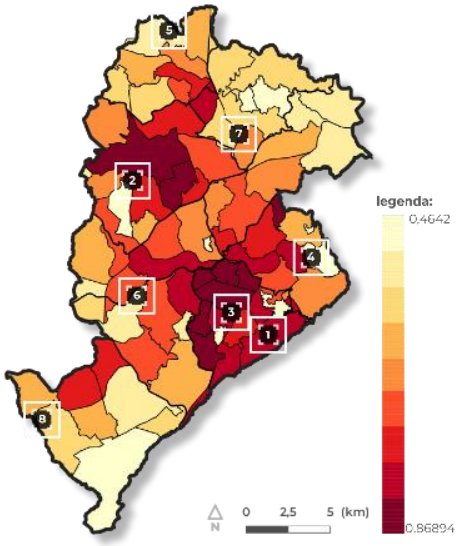




*Figure 3 (left): Racial map of the population.*
*Figure 4 (middle): Hypsometry.*
*Figure 5 (right): Urban Quality of Life Index (IQVU).*

[2] Values according to Brazil's currency, Brazilian Real (BRL), in 2010.

### *Samples and colour palettes*

After sectorising the city, eight samples were selected - one in each census sector of the Zoning from the Master Plan and with varying income ranges. This made it possible to extract satellite images of the sections defined as “representative”.

### *Chromatic notation*

The colours present in the mosaics were transformed into chromatic notation spreadsheets to enable the production of graphs for comparative purposes and subsequent analysis. See Figure 6.

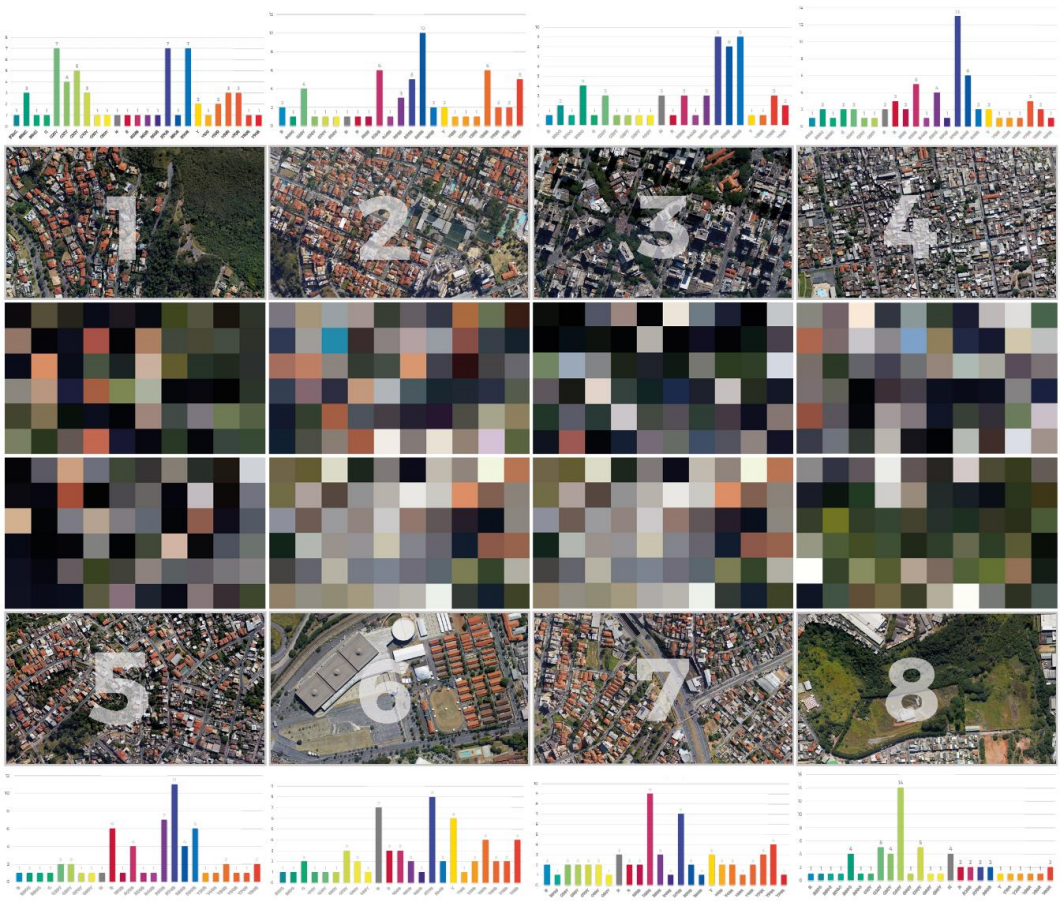



*Figure 6: Selected samples, predominant colour mosaics and hue graphs by the Natural Colour System (NCS).*

### *Graph analysis*

The results were processed using a qualitative-quantitative approach, considering that the chromatic palettes were analysed from their individual context, and the results of the graphs were evaluated quantitatively for comparative purposes.

### *General analysis*

Finally, a synthesis of the results was conducted to address the initial **question** that motivated the study and to evaluate whether the proposed methodology can effectively outline how the chromatic relationships in the contemporary city reflect segregative socioeconomic factors.

### *Collages*

Once the previous methodological-scientific stages had been completed, a freer and more artistic experiment was proposed, in an attempt to unite what had been analysed from the aerial view with elements in the human scale. The language chosen was manual collages.

The collages were used as a scientific annotation stage, with the aim of deepening the understanding of urban dynamics and contexts from the pedestrian's perspective. They served as a complementary layer of information gathered about the site, helping with the chromatic analysis.

## Results and discussion

The chromatic data from the eight samples were combined to create the overall graphs for Belo Horizonte (Figure 7).

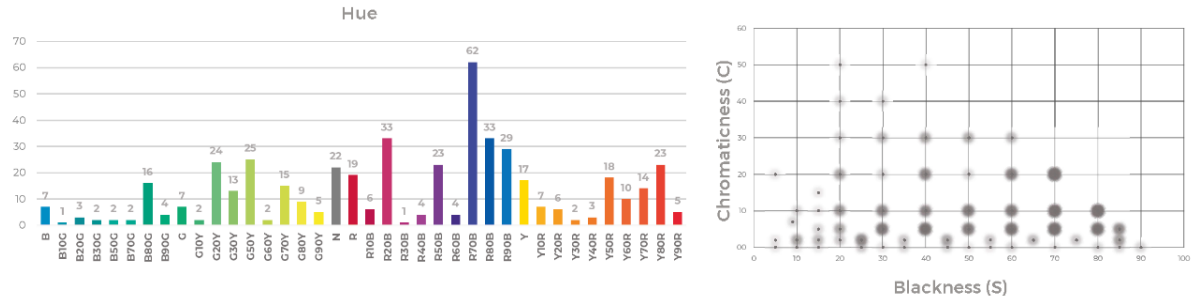



*Figure 7: Graphs of Hue by NCS and Chromaticity by Luminosity for Belo Horizonte, 2022.*

The samples from Belo Horizonte show that the colour scheme is made up of shades of blue, red, green, yellow and grey, respectively (Figure 7).

In terms of luminosity, most of the samples show low light levels, ranging from 60% and 80% of blackness, with 70% being the most common. Notably, a specific portion of colours shows 40% blackness. Across all samples, there is a predominance of colours with low chroma, with most falling between 5% and 20% of chromaticity, reaching a maximum of 50% (Figure 7).

With this result, it was noted that the identification of hues that would be visually perceived as neutral shades - whites, greys and blacks - is hindered, as most of them are read as coloured neutrals, mainly blues, by the reflection of natural light itself. This factor contributes to the predominance of blues in the samples. The phenomenon of coloured neutrals seems to be a specific condition of real-to-digital conversion, i.e. when chromatic analysis is based on photographs.

Disregarding the bluish neutrals, the predominance of blue tones in the samples demonstrates the strong occupation and density of the city, since the shadows are read as dark blue and appear more significantly where there are denser built elements, as in Sample 3 (Figure 6).

The appearance of red as the second predominant colour is due to the reddish ceramic roofs, an artificial element, and the colour of the local soil, a natural element. These relationships can be seen in the Correlation Table (Figure 8), which shows the main elements found in each hue.

The appearance of red demonstrates a tendency, as materiality, reflecting both the condition of access - material and economic - and preference of the inhabitants regarding the roofs of the buildings in each context. The same applies for the yellow tones, the fourth most prevalent colour, although it also originates from yellowish vegetation.

| CORRELATIONS | | | | | |
|---|---|---|---|---|---|
| COLOR | ORIGIN | MATERIALS | | ELEMENT TYPE | |
| | | | image | natural | artificial |
| GREEN | vegetation (vegetated masses, trees and grass) | |  | | |
| | courts | paint |  | | |
| RED | earth | |  | | |
| | roofs | ceramic, concrete and fiber cement roofing, etc. |  | | |
| BLUE | swimming pools and water fountains | water |  | | |
| | buses | paint |  | | |
| | cast shadows | | | | |
| YELLOW | earth | |  | | |
| | roofs | ceramic, concrete and fiber cement roofing, etc. |  | | |
| GREY | roofs | fiber cement, concrete and metallic roofing and concrete slabs |  | | |
| | pavement | asphalt |  | | |
| | cast shadows | | | | |

*Figure 8: Correlations Table, 2022.*

Green tones appear in third place as the most predominant in the samples, which represents the considerable existence of vegetation in the city.

It is speculated that, with regard to the process of generating mosaics from satellite images, denser vegetated areas generate tones that are read as blue hues, while less dense vegetated areas, more open and with less shading, are read as green and yellow-green. This could justify the greater existence of green hues in sample 4, when compared to sample 5, which visually presents more green areas.

The colours present in the city of Belo Horizonte reflect, among other aspects, its cultural context. Furthermore, when we talk about urban polychromy in this research, it is impossible to dissociate it from the socio-economic reality of Brazilian metropolises. Colour is not just colour. It shows how people are living and occupying the city's territory.

The two samples with the highest family incomes and a mostly white population (Samples 1 and 3), are the places with the highest *IQVU*s and are the only (occupied) places that have green among the two most predominant colours.

This expresses the importance of the presence of vegetation for a higher quality of environmental and urban life, and also that mixed-race and black people, as well as families with lower incomes, live in the

places with the lowest quality of urban life in the city [3-4]. This inequality is expressed by the different *urbanities* [15] within the same city.

Urban colour highlights social inequalities in the city, such as the choice of roofs. The roofs with the lowest cost, durability or thermal performance are found in lower-income areas, with a majority mixed-race or black population, and are usually grey. The roofs with the highest value or quality are found in middle- and high-income areas and are red or yellow - colours that match the natural environment.

In areas with the highest urban quality of life indices (*IQVU*) and residential typologies—Samples 1 and 2 (excluding Sample 3 due to its intense commercial nature and verticalisation)—there is a clear predominance of roofs with reddish tiles.

As the *IQVU* decreases, so does the use of this type of roofing, gradually being replaced by greyish roofs, when comparing the samples with predominantly residential typology. While this could be partly attributed to personal preference, it is more likely that this pattern reflects people's access to certain materials, influenced by both the local building materials market and their economic access.

It is also important to take into account the quality of these materials. For example, ceramic tiles, generally used in a reddish or yellowish colour, have a better thermal performance than fiber cement tiles, which usually have a greyish colour. One of the conditions for determining the use of each type of roofing is its cost: fiber cement roofing is cheaper than ceramic roofing [16].

Therefore, the material chosen and its colour are directly related to the quality of life of the inhabitants of the buildings.

The samples analysed reveal a predominance of artificial elements to the detriment of natural ones. Although Belo Horizonte has a notable presence of vegetation, this result is to be expected as it is a metropolis characterised by dense occupation and intensely disputed territory.

In addition to vegetation, no other natural elements were identified in the samples. Bodies of water in their natural form were absent, with water only appearing in artificial elements, such as swimming pools and fountains.

## Conclusions

The chromatic variations of a city reflect the choices made throughout its historical and productive processes, manifesting themselves as a result of the interaction between *human action* (individual, collective and political), nature and materiality. The analysis of the samples reveals that urban colour highlights and accompanies the inequalities contexts present in the city, such as the relationship between the presence of vegetation integrated into the occupation and the quality of urban life and the choices of roofs for residential buildings.

When this urban polychromy is associated with other layers of socio-economic and spatial reading, it makes it possible to visualise the different levels of urbanity experienced by those who live in those contexts. In addition, the development of an experimental methodology made it possible to explore new perspectives – intersectional, environmental and decolonial – in the field of urban chromatic analysis, addressing previously neglected points of view, such as the top view.

Regarding the performance of the methodology, from a technical standpoint, it is important to note that the quantitative data obtained from the images is not highly accurate. This is due to the unpredictability of the conditions in which the images were captured, which can influence colour perception. Various factors affect the results, such as the quality of the images, the presence of clouds in the sky, the visibility of the air, the time at which the images were taken, as well as the lighting and temperature of the photographs themselves.

To increase accuracy, future research should adopt the most standardised conditions possible for capturing the images and consider analysing smaller sections. It is also recommended that the methodology be tested in cities with different characteristics. This would allow for a comparison of the results and help validate the experimented approach.

Given the city's scale and the research's feasibility, the analysis of the urban polychromy was carried out by selecting clippings. Due to the size of the object of study, a regional metropolis, the sample selection does not fully represent the entire city. Therefore, the next ideal step would be to test and evaluate the methodology's performance in a smaller sample, such as a small city, that can be analysed in its entirety.

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