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Will Cities Survive?

Climatic recommendations for informal areas in Brazil

UCMaps and Brazilian technical standards

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ABSTRACT: In Latin America, more than 20% of the urban population lives in precarious urban settlements where the urban planning practices are often exceeded. The urban form and construction materials used in these areas frequently contribute to worse microclimatic conditions as well. Therefore, this paper aims to present urban planning and building recommendations, considering the climatic aspects, for informal areas of the cities of Belo Horizonte and João Pessoa, in Brazil. The method used consisted in carrying out an analysis of the results of the UCMaps, and of the Brazilian technical standard to produce a set of recommendations for the specific areas in each city. The results presented urban planning and building criteria such as shading strategies, wind corridors maintenance, materials for surfaces, sealing for external walls and coverage, and the need for cross ventilation in buildings. These recommendations may contribute to adapting the standard applied generally in urban planning and buildings to political and institutionally marginalized areas, considering the interaction between different climatic and action scales. Besides, the methodology applied could contribute to advance the discussions on climate action in informal settlements.
KEYWORDS: Informal areas, Urban climatic map, Brazilian technical standards, Climatic recommendations

1. INTRODUCTION

The urban population of the world and the extent of urban areas have increased in the last seven decades. In developing countries, much of this growth occurs in precarious urban settlements, as informal areas or slums, and often exceeds the urban planning practices. In Latin America and the Caribbean 21% of the urban population lives in these conditions, compared to 28% in Asia and 59% in sub-Saharan Africa (UN-Habitat, 2018).

People living in informal areas are particularly vulnerable to climate changes due to some factors: (i) sites that experience climate-related hazards; (ii) tenure security of the formal safeguards for their housing; (iii) lack of access to food and water; (iv) scarce social and financial services; (v) informal settlements are often left out of citywide development plans and strategies, and (vi) lack of understanding of the concrete climate changes forecasted for a specific location (UN-Habitat, 2018).

In addition, the urban form and building materials used in these areas frequently contribute to worse human comfort, especially in warm and humid climates (Baritu et al., 2019). In Brazil, few studies have demonstrated the bioclimatic characteristics of these regions. As examples of microclimate assessment in informal environments, Silva (2006) and Morais (2011) found temperatures above the maximum comfort limit in the region of Paraísópolis (São Paulo) and the Northeast of Amaralina (Salvador), respectively. Regarding housing conditions, these dwellings normally use construction materials that are inappropriate for the local microclimatic context (black plastic canvas, wood scraps, asbestos cement shingles, etc.). Some research showed that these precarious structures had a greater negative impact not only on thermal comfort but also on the respiratory health of residents (Utimura, 2010; Simões, 2021).

Despite the significant number of informal areas in Brazil (IBGE, 2019), there is no national climate policy that integrates the different scales of climate phenomena and suggests recommendations for improving the quality of life of these inhabitants in order to mitigate and adapt the effects of climate change at the local scale.

One method to help policymakers to identify areas that are more sensitive to climate change and with less adaptive capacity, guiding adaptation policies and building climate resilience is through climate change vulnerability assessments and climate action plans. (UN-Habitat, 2018).

Another method that can be used in addition to vulnerability studies is Urban Climatic Map (VDI-3787, 2015). This methodology develops an analysis of the impact of cities on the climate considering their effects on thermal aspects, ventilation, and air pollution. They generally recognize climatopes, which are homogeneous areas in terms of microclimatic characteristics, which are spatialized in the climatic analysis map – UC-AnMap. Then recommendations for action in urban planning and design are elaborated and represented in the recommendation map – UC-ReMap (Ren,Ng, Katzchner, 2011).

In Brazil, for the specific scale of buildings, the technical standard NBR 15.220 brings building recommendations in the context of thermal comfort, but they are not always applicable to the reality of informal areas. This Brazilian national standard is focused on formal housing and do not consider local climatic characteristics.

Considering the above, it is important to make specific recommendations for these informal areas that should be linked with aspects of regional climate, climatopes, climatic elements, available building materials, and socio-environmental vulnerability. Urban and building strategies provided by bioclimatism researchers (Lengen, 1980; Romero, 2000; Huigueras, 2006; Pizarro, 2012, Heywood, 2017) can contribute to the formulation of recommendations for these settlements.

In the coming decades, projections related to climate change are of higher and increasing average temperatures. In informal areas, the high density of buildings, little open/public space, and often, inadequate roof materials and poor ventilation lead to higher indoor temperatures. So, it is necessary to use strategies for adaptation. And the first step is to understand the physical conditions, the demographics, and the differentiated vulnerability to adequately plan feasible interventions. In addition, it is important to make possible a multi-level governance, which opens inclusive and accountable adaptation space across scales of decision making (IPCC, 2022).

Therefore, this paper aims to present recommendations for informal areas for the cities of Belo Horizonte and João Pessoa, in Brazil, based on the results of the UCMaps, national technical standard, and specialized literature. This may contribute proposing recommendations based on those established by standards that are applied generally in urban planning and buildings to political and institutionally marginalized areas, considering the interaction between different climatic and action scales.

2. METHOD

The method used in this study consists of six steps: 1. selection and characterization of informal areas for Belo Horizonte and João Pessoa; 2. identification of the study areas in the UCMaps, evaluation of recommendations, and their application to the microclimatic scale; 3. identification of recommendations of Brazilian technical standard for each city; 4. evaluation of urban and architectural guidelines; 5. production of a set of recommendations on urban planning and buildings for the specific areas in each city.

2.1 Study areas

In this study, two informal areas were considered, delimited according to the Brazilian Institute of Geography and Statistics, which defines them as areas predominantly residential and generally characterized by an irregular urban pattern, lack of essential public services, and land use restrictions (IBGE, 2019).

In Belo Horizonte, the district of Nossa Senhora da Conceição was selected (Fig. 1). It has an area of 0.2 km² and a population density of 31,329 inhabitants/km². The altitude varies between 949 to 1,049 meters. Belo Horizonte (19º55'20"S, 43º 55' 49"W) is in the Southeastern region of Brazil, has about 2,375,151 inhabitants and a population density of 7,167 inhabitants/km².

Figure 1:
Nossa Senhora da Conceição district (Belo Horizonte).

The second area is located in the city of João Pessoa called Timbó Community (Fig. 2). This informal settlement covers an area of 0.158 km² located on the eastern edge of the city. It has 900 housing units and an approximate population of 4,600 inhabitants, which leads to a high housing density of 29,113 inhabitants/km². João Pessoa city (7º09'28S, 34º47'30"W) is in the Northeastern region of Brazil, has about 830,000 inhabitants and a population density of 3,943 inhabitants/km².

Figure 2:
Timbó Community (João Pessoa).

Both informal settlements and cities are in the tropical zone, however according to the Köppen Climate Classification, Belo Horizonte and João Pessoa are classified as Cwa/Cwb and As, respectively. Considering the Brazilian bioclimatic zoning (ABNT, 2005), Belo Horizonte is classified in Zone 3, while João Pessoa is classified in Zone 8. Table 1 presents the climatological data, showing that João Pessoa has higher mean temperature, relative humidity, and wind speed values than Belo Horizonte.

Table 1:
Climatological data (Annual data from 1981-2010)

Climatological data	Belo Horizonte	João Pessoa
Mean Air Temperature (ºC)	21.8	26.8
Mean Relative Humidity (%)	67.2	75.9
Mean Wind Speed (m/s)	1.7	3.3
Predominant wind direction	E	SE

Source: INMET. Normais Climatológicas do Brasil - 1981-2010. Available: https://portal.inmet.gov.br/normais [05 August 2021].

2.2 Analysis of UCMaps and Brazilian standard

The UCMaps from Belo Horizonte (Ferreira et. al, 2017) and João Pessoa (Souza & Katzschner, 2018) showed the climatopes for the specific areas of Nossa Senhora da Conceição district and Timbó Community (João Pessoa), respectively. Based on the german standard VDI 3787 (VDI, 2015), some recommendations were proposed for urban planning. For building design, the recommendations were proposed based on the Brazilian technical standard NBR 15.220 (ABNT, 2005), considering the building guidelines for zones 3 (Belo Horizonte) and 8 (João Pessoa).

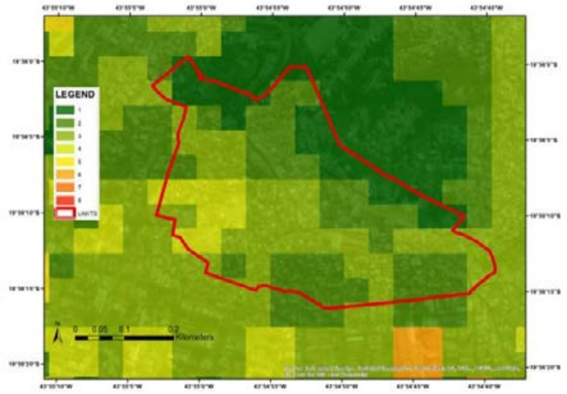
Information from the literature review complemented the analyses for both types of recommendations, urban and building scales, associated with the climatic parameters (temperature, humidity, wind and solar radiation) influenced by these recommendations. It added another layer of knowledge to propose strategies that incorporate physical conditions and differentiated vulnerability to plan feasible interventions adequately.

3. RESULTS

The UCMaps indicated different classes of climatopes for the informal areas in both cities.

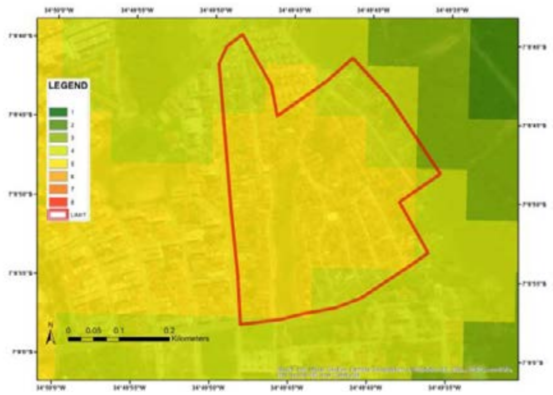
For Belo Horizonte, the UCMap is classified in 8 climatopes considering a combined data from building volume, vegetation, topography, land cover, and wind. Specifically in the district of Nossa Senhora da Conceição (Fig. 3), three climatopes are presented: climatope 2 (urban climatically valuable area, with some negative thermal load and good dynamic potential), climatope 3 (neutral climatically sensitive area, with low thermal load and good dynamic potential), and climatope 4 (neutral climatically sensitive area, with some thermal load and some dynamic potential).

Figure 3:
Climatopes of the Nossa Senhora da Conceição district



The UCM of João Pessoa contains 8 climatopes ordered according to a probable impact of physical aspects of the city (building volume, vegetation, topography, land cover, natural landscapes, and proximity to open spaces) on the thermal comfort of the population. The Timbó Community (Fig. 4) was classified with the class 3 (Low climatic activity) and class 4 (Relevant climatic activity).

Figure 4:
Climatopes of the Timbó Community



Despite the specific recommendations for each climatope class, it is understood that adaptation actions associated with ventilation and thermal load reduction are essential to improve the microclimate. Table 2 shows the recommendations based on climate and adjusted to local realities, integrating the scales - from urban planning to building design.

Because both cities are in the tropical zone, preserving the natural wind conditions and reducing heat storage are recommendations to reduce the thermal load in urban spaces. However, in Belo Horizonte, the wind speed is lower than in João Pessoa, so, for the first one, it is essential to maintain all wind corridors, while for the second one, the

Table 2:
Climatic Recommendations for Informal Areas

Strategies	Belo Horizonte		João Pessoa	
	Guidelines	Specific recommendations - climatic parameters	Guidelines	Specific recommendations - climatic parameters
Urban scale (Consider the characteristics and recommendations associated to climatopes)				
Shading	Ensure shading in summer, and allow the incidence of solar radiation in winter	All climatopes increase areas with deciduous trees install shading elements over streets, sideways and walkways (i.e.: tensioned structures, permeable to the wind)	Promote shading throughout the area during all the year to reduce thermal gains from direct solar radiation	All climatopes afforestation with species of vegetation suitable for the size of public spaces (non-deciduous trees) construct shelters with alternative materials (i.e., fabrics, plastics, wood, etc.)
Permeability to wind flow	Preserve natural wind conditions and corridors	Climatope 2: do not allow increased densification of buildings preserve and encourage expansion of green areas, allowing permeability to winds	Preserve natural wind conditions and corridors	Not applicable
		Climatope 3: maintain or aim at low-density housing (to facilitate air exchange) preserve green spaces and wind corridors		Climatope 3: maintain or aim at low-density housing (to facilitate cold air exchange) preserve green spaces and wind corridors protect pedestrian areas from high-speed winds
		Climatope 4: increase the distance between buildings replace walls with grids or hollow elements		Climatope 4: increase urban permeability by removing elements that obstruct winds or walls encourage the creation of open public spaces (i.e.: open-air fairs, sports fields) to increase wind flow
Materials and surfaces	Promote control of the incidence of direct solar radiation and reduce heat storage	All climatopes use permeable paving and materials with low albedos avoid further sealing	Promote control of the incidence of direct solar radiation and reduce heat storage	All climatopes use permeable paving and materials with low albedos avoid further sealing

Strategies	Belo Horizonte		João Pessoa	
	Guidelines	Specific recommendations - climatic parameters	Guidelines	Specific recommendations - climatic parameters
Building scale				
Shading of openings	Enable shading in summer and allow sun during winter	☑ grow climbing plants on facades 🌡 💧 🌬 ☑ grow trees (deciduous vegetation) in the outside of buildings 🌡 💧 🌬 ☑ install shade elements on facades to protect openings and walls of solar radiation (brises, wide eaves) 🌡 🌬 ☀	Shading throughout the year to reduce direct solar radiation input.	☑ grow climbing plants on facades 🌡 💧 🌬 ☑ grow trees-in the outside of buildings 🌡 💧 🌬 ☑ install shade elements on facades to protect openings and walls of solar radiation (brises, wide eaves) 🌡 🌬 ☀
Openings for ventilation	Ensure openings with a size between 15% and 25% of the floor area	☑ use of brick or hollow elements (i.e., cobogó), structure that allows cross ventilation 🌡 🌬	Ensure large openings, with dimensions above 40% of the floor area, to ensure night cooling and cross ventilation during the day.	☑ use of brise-soleil, cobogós, solid bricks, perforated ceramic blocks in a creative way ☑ use elements in the roof that allows cross ventilation 🌡 🌬
Facet - external walls	Use of light and reflective materials for walls	☑ grow climbing plants on facades (vegetable gardens) 🌡 💧 🌬 ☀ ☑ use light materials to increase the reflection of the sunlight 🌡 ☀	Use of light and reflective materials for walls	☑ grow climbing plants on facades (vegetable gardens) 🌡 💧 ☀ ☑ use of coatings with reflective colours (light and pastel tones) to reduce the absorption of solar radiation by external openings 🌡 ☑ build double walls with an air layer to reduce heat transfer from the outside to the inside 🌡
Facet - roof	Use of light and insulation materials for roofs	☑ grow climbing plants on roofs (vegetable gardens) 🌡 💧 🌬 ☀ ☑ use insulation materials to reduce heat transfer 🌡 ☀ ☑ use of roof with elements that allows cross ventilation 🌡 🌬	Use of light and reflective materials for roofs	☑ ensure steeper slopes in order to air space in the high area of the roof to reduce the thermal load 🌡 ☀ ☑ use insulation and reflective materials to reduce heat transfer 🌡 ☀

Legend: Recommendations: ☑ allowed, ⛔ not allowed; Climatic Parameters: 🌡 Temperature, 💧 Humidity, 🌬 Wind, ☀ Solar Radiation (the colours indicate INCREASE / REDUCE

recommendation is to protect areas of winds with high wind speed. Furthermore, Belo Horizonte has lower temperatures during the winter, so it is essential to preserve the incidence of direct solar radiation in urban spaces and buildings, avoiding shading during this season. However, for João Pessoa, this recommendation is not applicable

In summary, the recommendations show differences between the informal areas and within these sites that have to be considered for urban and building actions. For all interventions, the bioclimatic principles have to be taken into account to improve human thermal comfort and reduce the vulnerability to climate change impacts.

4. CONCLUSION

In informal areas, in order to adequately plan interventions associated with climate action, it is important to understand the physical conditions, and the differentiated vulnerability for each place. From the methodology applied here, we observed that the climatic maps show the intra-urban climatic differences of informal settlements. The accessible language of these maps enables presentation and discussion with local actors and planners for further refinement of recommendations. In addition, the Brazilian technical standard showed specific recommendations for buildings which could improve their downscale considering the climate of each city. In this way, it is understood that the principles that should be applied in considering and implementing climate change adaptation measures in informal settlements are reflected in the recommendations presented here. Besides, the methodology applied could contribute to advance the discussions on climate action in informal settlements.

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