Open Space Planning:
Climate and occupants perceptions and behaviour

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ABSTRACT: The quality of urban open spaces contributes to improve the cities' livelihood. Therefore, the relationship established between the urban microclimate variables and their impact over the environmental comfort is of most significance. This article presents the first steps of a study about the influence of environmental comfort related to a square and its uses in a hot and humid climate city – "Praça do Lido", which is located facing the seashore. During the research, the users' sensitivity and behaviour were observed and registered, highlighting uses and activities developed at different hours of the day and on different days of the week. The study of the physical aspects of the areas aimed at verifying the interaction among the climate variables, as well as with the city's morphological elements. Nevertheless, it is possible to assert that, in spite of the fact that in winter most square users look for a sunbath, covered areas attract users to play table games, specially elder people, who remain for long periods in the square.
Keywords: bioclimatism, urban spaces, trees in squares, thermal comfort.

INTRODUCTION

The ongoing process of urbanization is hampering the fulfillment of human needs especially in relation to environmental comfort and physical and psychological health of the population. Moreover, the squares ("plazas") are extra spaces in the city and allow the socialization of the population, serving as places of leisure, health and welfare of the population.

The bioclimatic planning together with the analysis of space usage can treat each as unique, without losing the overall characteristics of each space. The guidelines obtained from this combination of features and values allow to establish guidelines which, allied to the other requirements of the project, may support architects, landscapers and urban planners in the task of producing environments more comfortable and focused on the preservation of the environment on the planet.

Copacabana, in Rio de Janeiro - Brazil (Figure 1) has one of highest rates of density built in the city (340.3 inhabitants / ha) and is characterized also by housing a population consisting of 50% of elderly, high-index for the Brazilian average. The few squares distributed in the neighborhood function as "islands" of sweetening, which is open to the winds, provide shade and entertainment for the population, that overlaps and squeeze on concrete slabs that form real walls in the wind, and increase the paved areas, which difficult the natural drainage of the soil.

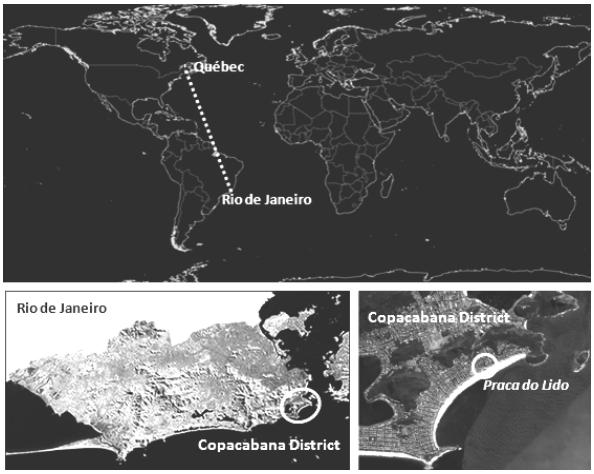

FIGURE 1 – Localization - http:// www.ibge.org.br - http://portalgeo.rio.rj.gov.br and Google Earth

The Praça do Lido (Official name: Irmãos Bernardelli) is located by the sea in the continuity of the sidewalk edge ("calçadão da orla"), which was treated landscape to house leisure activities and is known worldwide for its artistic and cultural value. Despite the proximity to the sea, the square is often used by a high percentage of users of the third age, because their difficulty of locomotion, or according to the furniture that is available, either in terms of security. Also there are an expressive number of babies during the firsts and last hour of the day.

MATERIALS AND METHODS

The proposed methodology in the study was based on theoretical-experimental method - using mobile equipment measuring through fixed transepts covering the study area. This method is frequently used in environmental research, for its convenience, especially when there is not availability of equipment and / or weather stations throughout the city. Therefore, it was used a single set of instruments, measuring instantaneous data of the several variables involved in the phenomena, in pre-determined points of the transept (See, for instance, reference [4]).

In it the categories of analysis, that are independent and complementary, were worked in accordance with the scale of intervention. At the city and district scale were treated urban, climatic and socio-cultural characteristics and, in the scale of the square, the morphological characteristics of the built environment, the field microclimatic measuring and observations of the behaviour of users (uses and developed activities) .

From the theoretical support and the definition of the subsystem of the roadmap analysis, a methodology was structured in three consecutive and interdependent stages (FERRARI, 1977 and CHACEL, 1995): inventory - which covers the entire process of data collection - analysis and diagnosis. This sequence allows the verification and re-feeding and / or correction of information from the feed-back mechanism proposed by FERRARI in 1977. And, depending on the depth of information in the three scales - city, district and squares-, and the steps and analysis of inventory, data were subdivided to meet the specificities of each parameter. In the city and district level, data were collected from bibliographic information (books, magazines, maps, websites, etc.). This subdivision is called inventory and literature review. The data collected across the square part of the inventory and analysis of field, where they are collected and evaluated on-site surveys of the built environment (field characterization), the microclimate (for field climatic parameters measuring) and the use (observations on the people).

The study of the urban morphology permits the perception of the built environment as a architectonic unit, that allows the understanding of the free spaces (squares) as outdoor spaces (Ashihara [1]). Since, independent of the climatic characteristics from each region, some general principles must be used for the incorporation of the bioclimatic concepts to the urban design (Bustos Romero [2]).

For the built environment data - verification of the urban shape characteristics - it was used the figure and ground method (Trancik [7]), to verify the characteristics of urban form and non-participatory direct observation for the registration of land use and gauge the height of buildings, elements and constructed of shade trees.

For the characteristics of the users, it was used the method of direct non-participatory observation, noting concepts treated by Whyte [9], and the experiments the field were based on the methodology used by Silva [6], Carvalho [3] e Vasconcellos [8] and recorded data for the climate variables: air temperature, air humidity, direct solar radiation and wind speed and direction. Regarding the observations and measurements of the built environment variables, were analyzed: the urban shape – street directions, shape of the building lot and separation between the buildings, soil use and the relationship between the square dimensions and the surrounding buildings average high, and the presence and location of trees and also the shading built elements (Figure 2). For the registration of the user characteristics the direct observation method was used, without the user participation and/or disturbing, following the concepts developed by Whyte [9]. Were observed and recorded the sensitivity and behaviour of users, with emphasis on the uses and activities at different times and days of the week, even on rainy days, taking note of the main characteristics of users (gender and estimated age), depending on the zoning of uses and activities in the square, with the purpose of verifying how the environment comfort affects the users behaviour.

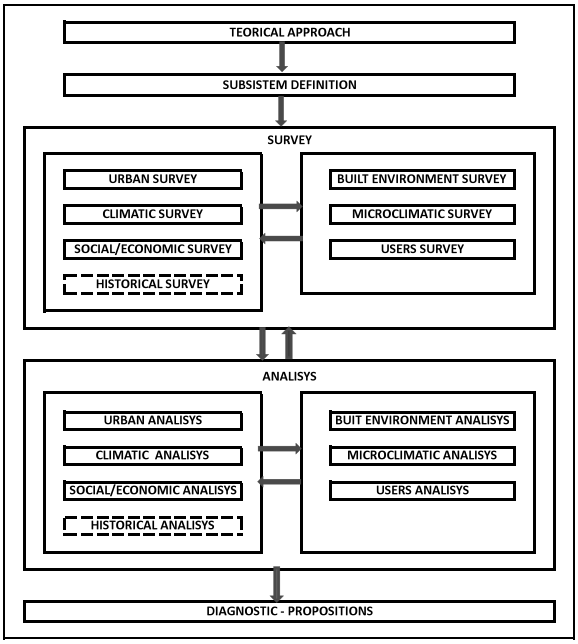

Figure 2 - Proposed methodological sketch

The searches were conducted during periods of summer and winter. The physical survey (figure and background, design and climatic parametrical measurements) of the areas had as main objective to see

how the variables interact and change in relation to morphological features of the city built environment.

PROCEDURES

Were prepared spreadsheets for data entry of each non automatic instrument in the square and the beach. At the end of the measurements the values were converted to tables in EXCEL: wind velocity and direction on the beach (fan anemometer) and in the square (with a thermal anemometer); comparison of the data from instruments measuring air temperature and relative humidity, illumination, global solar radiation (at the square and at the beach) and the surface temperature of the surrounding elements (also at the square and beach). After given the results and learned the medium, were prepared, summary tables, where the information has been restructured, resulting in a single table called "Climate description of each measured point".

DETERMINATION OF THE MEASURING POINTS AT THE SQUARE

To determine the total number of measuring positions (points), there were studied the shadows projected by the surrounding buildings immediately, the schedules for the measurements: 9h, 12 h and 15 h, in the equinoxes and in the solstices, at summer and winter (Figure 3). During the measurements the points were visited every five minutes, keeping the instruments for one minute at the point in question[1], was made two measurements at each point in three time periods (10:00 to 10:45 h; 13:00 to 13:45 and 16:45 h and 16:00 h), totalizing ten sets of measurements for each hour and day considered.

To help the choice, it was studied, too, the Sky View Factor in each point of the squares, using the ZOOM CITY software (developed by the Federal University of Rio Grande do Sul; see webpage). There were selected five points of measurement: the first, located near the playground, in an area shaded by trees and vegetation to carry the building of a school that occupies the north region of the square. The second one, in an area for table games, is shaded by pergola and trees. The points 3 and 4 (living areas 1 and 2, respectively) were chosen in the regions of with more incidence of solar radiation, opposite to the others, facing the beach. These last two areas have different degrees of use in summer. The fifth point was determined in the geometric center of the square block (Figure 4).

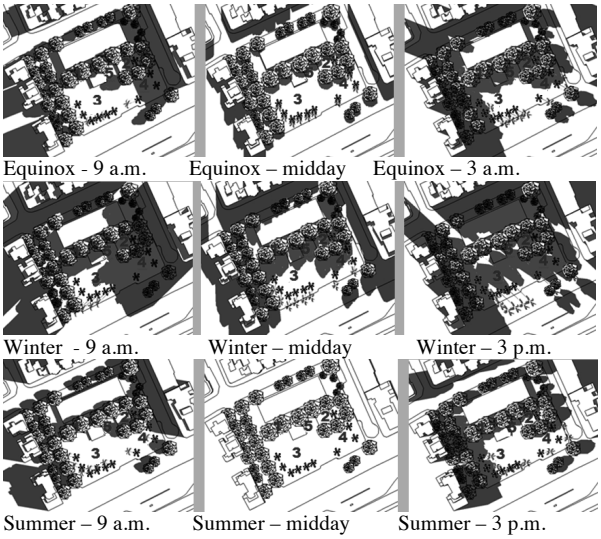

Figure 3 - Shadows at different periods and hours

REFERENCE POINT AT THE BEACH

Another measuring point was chosen on the beach (in the sand, near the water), to serve as reference point for temperature and air humidity, solar radiation and wind speed and direction measurements. The point was located at middle way between the two streets, perpendicular to the sea, that limit the square (point A in Figure 4)

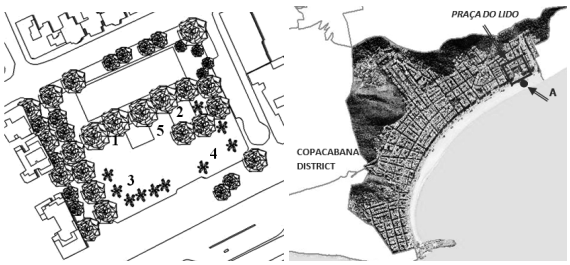

Figure 4 – Localisation of the measuring points.

USES ZONING

The quantity and location of the measurement points were determined, finally, after matching the data for the shadows projected by the surrounding buildings and the trees localisation, for the sky view factor - FVC and the foreseen use and activities in the different places. There were selected areas completely shaded, partially shaded and / or sunny, with or without wind, in distinct areas of use (playground, field or area to be the game of tables, using intensive, medium and / or weak) (Figure 5).

1 The instruments were triggered automatically without registration every five minutes and remained for a minute at each point. Thus, the intermediate four minutes were spent with the displacement between the points and adequacy of the instruments to the conditions found in the new point traveled.

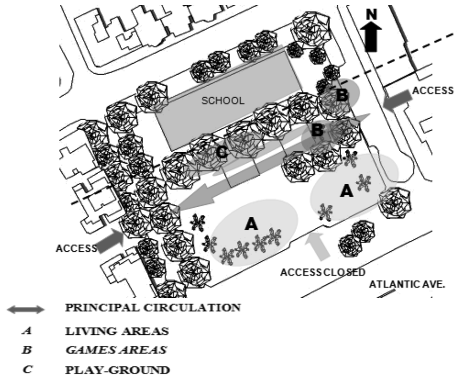

Figure 5 - Areas of different uses

RESULTS

The data obtained were analyzed from the average of the values taken at each point in each period.

As a result, it was found that in summer, under the same conditions of exposure (sun or shade), the variations of air temperature were small, although there is a little high in the middle of the day. When compared, points to the sun and shade differ more in the afternoon (1.9 °C and 6% respectively).

In winter, the variations of air temperature were lower than in summer. The maximum variation between points in the sun and the shade was 0.6 °C in the middle of the day and the average change was 0.3 °C. During the afternoon practically no differences of temperature were recorded in points in the sun or in the shade. The relative humidity also suffered minor variations that in summer, reaching a maximum difference between the points to the sun and the shade of 3.1% and an average between the shift of 0.6%.

At noon, the air temperature has a small increase and relative humidity decreased significantly, with the weak wind coming from S-SE. In the afternoon, when the air temperature decreased slightly, the relative humidity increased considerably, change attributed to the increase of the wind speed (+ 1.6 m/s) and change of direction to its S-SO, air that carries more moisture from the sea. In the final average, the differences of temperature and relative humidity in winter was 0.3 ° C and 6% respectively (Table 1). These data are reflected in the use of spaces. Despite the hot and humid climate, which has high temperature and air humidity and strong solar radiation, all areas of the square are used.

The total percentage of shaded area is 34.1%, but the distribution of trees not equally covers all areas of use, especially the step ways for the people circulation. However, in spite of the inadequacy of the trees distribution, the spaces are widely used by the population, due to the proximity to the sea and the urban morphology, which allow the ventilation of the square and the consequent improvement in the sensation of thermal comfort.

Table 1 Averages of collected data

PRAÇA DO LIDO - SUMMER										
PERIOD	TEMPERATURES (°C) - AVERAGE				HUMIDITY (%) - AVERAGE				WIND	
	SHADOW	SUN	PERIOD VARIANCE	PERIOD AVERAGE	SHADOW	SUN	PERIOD VARIANCE	PERIOD AVERAGE	VELOCITY (AVERAGE) (m/s)	DIRECTION
MORNING	29.3	30.3	1°	29.7	65.7	63.2	2.50%	64.5	2.1	NO
[illegible]	[illegible]	[illegible]	x	[illegible]	[illegible]	[illegible]	x	[illegible]	[illegible]	x
NOON	29.9	30.8	0.9°	30.4	60.7	56.7	3%	58.2	1.7	E
[illegible]	[illegible]	[illegible]	x	[illegible]	[illegible]	[illegible]	x	[illegible]	[illegible]	x
AFTERNOON	28.5	30.4	1.9°	29.6	61.3	55.3	6%	58.3	3.6	S
DAY (average)	29.2	30.5	1.3°	29.9	62.2	58.4	3.80%	60.3	1.5	NO-S

PRAÇA DO LIDO - WINTER										
PERIOD	TEMPERATURES (°C) - AVERAGE				HUMIDITY (%) - AVERAGE				WIND	
	SHADOW	SUN	PERIOD VARIANCE	PERIOD AVERAGE	SHADOW	SUN	PERIOD VARIANCE	PERIOD AVERAGE	VELOCITY (AVERAGE) (m/s)	DIRECTION
MORNING	21.6	22	0.4°	21.8	58.8	53.7	3.10%	55.3	1	NO
[illegible]	[illegible]	[illegible]	x	[illegible]	[illegible]	[illegible]	x	[illegible]	[illegible]	x
NOON	22.6	23	0.6°	23.0	42.6	42.6	0	42.6	3.3	S-SE
[illegible]	[illegible]	[illegible]	x	[illegible]	[illegible]	[illegible]	x	[illegible]	[illegible]	x
AFTERNOON	22.4	22.4	0°	22.4	69.8	71.1	-1.30%	69.5	2.5	S-SE
DAY (average)	22.5	22.5	0.3	22.5	58.1	55.5	6.6	55.8	1.5	NO-S

However, the inadequate distribution of trees, which are concentrated in the "bottom" of the square rather than "empty" tree in other regions interfere in length of stay and intensity of use of such spaces.

CONCLUSIONS

Initial results report that the Lido Square is well ventilated and receives daily solar radiation, thanks to the square's geometry and to its opening towards the infinite ocean. This characteristic differentiates this square from the others in the District - under greater or lesser confinement in their four sides and farther away from the beach - which receive less ventilation from the sea.

Yet, concerning the square under study, given the wrong distribution of shaded areas there is no guarantee to have an efficient use of the space, and the users have to remain to problems, both during the summer and during the winter. Based on these characteristics, guaranteeing shades for 50% of the areas in use is of most significance, especially so during the summer in cities with hot and humid tropical climate. Main sidewalks and paths used by pedestrians to get through and to cross the square should be considered in terms of shading, too. Spaces with no shade, receiving high levels of direct solar radiation, provoke great contrasts and visual sensitivity, thus creating visual discomfort.

The not uniformity of the trees distribution, that creates zones of intense shading, less used in winter, and zones used during less time as desired for the excessive direct solar radiation.

The solar radiation in the square is better distributed in the equinoxes, when the air temperature is more pleasant, allowing longer use the different areas of the square. In summer, the shade created by the surrounding buildings is small, reducing considerably

the period of use in areas without shading from around 9:30am in the morning until 2:30pm in the afternoon. In winter, the percentage of shaded area is high which favours the extension of hours of use of the square. This is crucial for understanding the use in the square, so understand the "gaps" that are formed in different hours and days of the week, in different seasons. The concentration of mass tree in the "bottom" of the square does not allow a better utilisation of their areas of use, reducing the residence time of users, especially in the living areas (points 3 and 4), located near the sidewalk of Atlantic Avenue.

Point 1 (play) - there is a low intensity of use due to excessive shading of the site, particularly in the early morning. However, this area is the most used in the early afternoon by the teenagers from school;

Point 2 (games) - although they had the largest percentage of relative humidity and low light, is the area of greater use of the square, on all days and times. This feature can be understood as a result of the predominance of users over sixty-five years, retired, male, the supply of gaming tables and the protective cover of concrete under dense canopy of trees, that protect the space from the adverse weather conditions;

Point 3 - (living place 1) - area of high intensity of use by elderly and children up to five years old, sought to sunbath, the lack of trees or other elements of shading reduces the permanence time of users, especially in summer ;

Point 4 - (living place 2) - area of little use in the summer due to lack of sun shading, in winter shows moderate use, as it is shaded by the buildings in the surroundings;

Point 5 - (circulation) - sunny area, does not show significant use, being a circulation way, that have better alternatives going by the covered regions. (Figure 6).

A bioclimatic analysis of the square shows the importance of proper specification of the type of trees for shade, especially in cities in hot and humid tropical climate. The non continued distribution of the shadow creates extremely inadequate space - a lot sunny, that do not allow the prolonged use of spaces and others that do not attract the user as being too dark or unhealthy.

Despite the intensity of direct sunlight, areas of sun are very sought, especially in the early hours of the morning and late afternoon, the elderly and children. The relationship between the built environment and the size of the square allows the passage of the wind without the formation of undesirable "corridors". The "infinite openness" to the sea also enables the place is well ventilated. In summer, the sea breezes, which blow predominantly from the southeast quadrant, helps to alleviate the thermal discomfort produced by the higher air temperatures.

Figure 6 – Points analysed [10]

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