VOLVER AL ÍNDICE

BIOCLIMATIC ANALYSIS FOR A LOW INCOME ARCHITECTURAL PROJECT

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The aim of this paper is to perform a study on a project of low-income houses proposed by an architecture team for the city of Santa Fe, in Argentine. This region presents a complex climate to be attained by architecture designers, due to the diverse conditions presented by hot and cold seasons. The basic source model is a vernacular habitat typology and its characteristics to capture the prevailing winds during summer period by means the Ventury effect, and shielded against the cold winter winds. Also the project presents some improved architectural characteristics adapted to the foreseen implantation site and new user requirements.

Thus, the analysis considers computer simulations and calculations to study the role of natural ventilation through the house. Thermal loads due solar energy, people and appliances are considered for an envelope energy balance. The software RADLITE and CFX-ANSYS are used. Also, is made a comparison between two forms of arrays, random and peripheral, for the houses in the terrain under a possible harmful urban noise incidence. With help the SoundPLAN software is obtained that the implantation site offers acoustical acceptable conditions for people to stay indoor.

The results show the adequacy of the project for the new free-running low-income houses designed. Also the project inspired in part by a vernacular typology improves the use of new building materials, sanitary conditions, and gives facilities for occupation. Also the implantation site offers acoustical acceptable conditions for people indoor.

1. INTRODUCTION

The subtropical humid climate, identified as Cfa or Cwa from the Köppen`s classification, presents a hot humid summer and a cold winter with heavy rains on the coast, and a dry climate inland, (PEEL et al, 2007). This climate is known as *pampeano* in South-America and occurs in the northeast of Argentine, Uruguay, south of Brazil, and east of Paraguay. It is a complex climate and demands of the architect great ingenuity to design free-running houses, (KONYA, 1981). The low-income housing projects for these regions commonly use natural ventilate houses to attend the climatic and socio-cultural conditions. A typological reference for this kind of housing project can be based upon a vernacular approach. In Argentine and Paraguay, for instance, there is a peasant passive house typology *Culata Yovai* , a well adapted habitat to these regions, see figure 1. This house has a central living space, open during the summer to the prevailing winds, creating an intense air flow by Venturi effect, to give inhabitants good conditions to stay in.

Figure 1. The vernacular house typology Culata Yovai,

The architect team directed by CARLI (2010) developed a project for a set of low-income houses for the city of Santa Fe, Argentine, figure 2, being part inspired in the vernacular Culata Yovai[88].

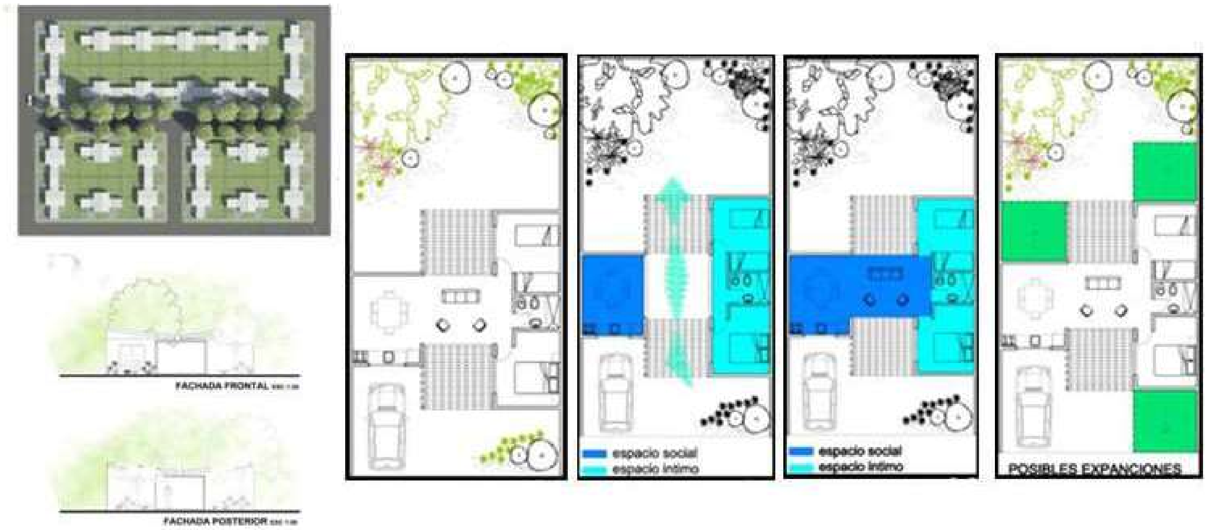

Figure 2. Low-income houses project, Santa Fé - Argentina (2010). Author: Arch. César Carli

This project considers houses with six modular spaces of 3,45m x 3,15m x 2,80m, and a roof with two 15% sloped tiles of cement. The rooms are placed in opposite positions, and a central space is able to be used as living or dining room provided with sliding doors to control the ventilation needs. A design improvement is made with a kitchen and a bathroom. The walls are made of hollow bricks, with plaster and white painted.

2. OBJECTIVES

The aim of this paper is to analyze by means of calculations and computer simulations a house designed of this contemporary architecture project, in terms of air flow circulation conditions during the summer period for the Santa Fé city.

The required intent for this house is if it verifies a free-running behavior, as shown by the vernacular model, despite using industrial built materials, and to include more rooms, a kitchen and bathroom. Natural ventilation due to the prevailing winds is the preponderant

[88] https://www.clarin.com/arquitectura/titulo_0_r14EmZq6Dml.html
https://www.elciudadanoweb.com/santa-fe-innova-en-los-planes-de-vivenda-social/

way to refresh the envelope and penetrates indoor through windows and mainly by the open central space due to the Venturi effect.

Also, as this house is well ventilate during the summer period, a point to be examined is the influence of the incident urban noise on a house under two assumed arrays of terrain implant.

3. METHODOLOGY

3.1. Natural ventilation

Firstly, by means of computer simulations is studied the air flow conditions for this new house. A virtual model is made in AutoCAD 2004, able to be performed airflow CFD simulations by means the software CFX-ANSYS, (ESSS, 2013). This software utilizes a finite volume method, and is established a rectangular prismatic volume as the domain, and then object of discretization by a control volume set.

The mesh is refined and verified by the Mesh Metrics function of the CFX. After several tests were obtained: aspect ratio = 217.64; orthogonal quality=0.1824; skewness=0,89, indicating according the software the mesh is refined.

The k-C turbulence model is used, with $30 < y^+ < 300$. Thus, the simulation performed results are accessed by visualization for each defined point in the virtual model in terms of air flow path, values for pressure coefficient, air velocity and volumetric flow-rate through the building zones. These obtained values for the volumetric rate of air flow will be compared with the required levels established from an energy balance and calculations for the building envelope during the summer conditions.

3.2. Thermal loads and volumetric rate of flow

The energy balance is performed for each envelope surface using solar irradiance average values along a day on December for Santa Fé (31°38´S, 60°42´O). The irradiance levels were obtained with the help of software RADLITE, which is based on the solar energy and illuminance Dogniaux`s model, (CASTRO et al, 2002).

The thermal loads due to solar energy are obtained from equations and procedures defined by the NBR 15220 standard (ABNT, 2003) for each surface. Thus, are considered for the envelope parts, the following values, solar absortances: walls (α = 0,20), tiles (α = 0,40); thermal transmittances: walls (U= 2,48 W/m²K), roof (U = 2 W/m²K). The other thermal loads are due to occupancy (three people per room) and electric appliances (varying according the room use).

Thus, from the obtained total indoor thermal load for each room Σq (W), is possible to determine the required volumetric rate of flow Q (m³/s) by means the equation 1. The temperature difference ΔT used is obtained from the adaptive thermal comfort for a free-running (naturally ventilated) building with 80% acceptance, ASHRAE (1992) for summer conditions in the region.

$$Q\ [m^3/s] = \Sigma\ q\ (W)\ /\ [\ \rho\ (kg/m^3).\ C_p\ (KJ)\ /(kg\ K).\ \Delta T\ (K)] \qquad (1)$$

Where:

- ρ : specific air mass (= 1,165 kg/m³) at 30°C Cp : specific air heat (= 1,009 kJ/kg K)
- ΔT: selected temperature difference between indoor operative temperature and the monthly mean outdoor temperature from the Standard 55 ASHRAE (= 3K).

3.3. Noise impingement

The low-income project considers a settlement of houses sited in a North suburban area of Santa Fe city, Argentina, near Av. Aristóbulo del Valle, and distant 100m. This avenue has ever a heavy traffic and bottled, and it can produces potentially negative impacts on this future settlement of houses, figure 3. The spaces between the lots are open offering permeability to the winds, figure 4.

The central space of this model of house operates as the cited vernacular typology, being well adapted to the prevailing NE winds. This contemporary project permits the users to made easy adaptations and house extensions, under several variants. Thus, a selected spatial settlements of houses need to be analyzed to conciliate the required wind ventilation and to forbid impinging traffic noise from the boundaries. Then, two forms are assumed for the arrays of houses in the terrain: random and peripheral. Only the summer period is examined when the houses operate as free-running. Beyond the existent avenue, in this analysis is considered new future secondary streets, to increase a noisier ambiance panorama.

Figure 3. Implantation site.

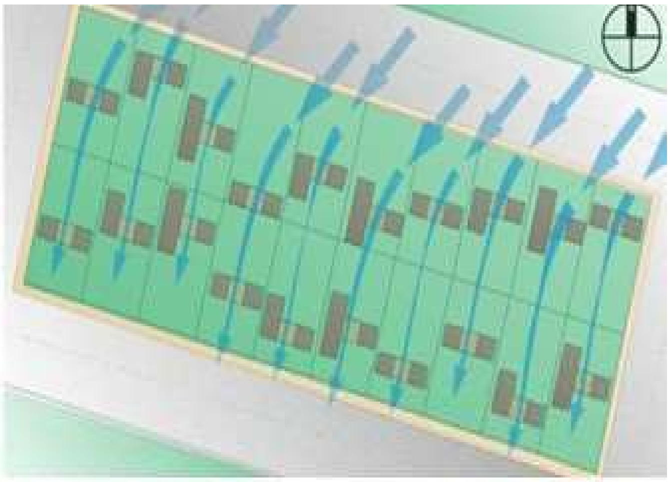

Figure 4. Settlement of houses orientated to the prevailing winds, adapted from Google.

To characterize the traffic noise sources are considered the morphological data for the streets and buildings with the cartography basis of Google Earth. The theoretical analysis considers a sound emission estimated from bibliography data (CERTU, 1980).

To perform an acoustic evaluation is employed an acoustic map furnishing a visual information about the acoustical situation for a given geographic area, at a certain time. With this map is possible to assume initial project decisions, or a diagnosis. An example of a building implantation face to the noise impacts can be seen in (CORTÊS, 2013). The software SoundPLAN, (BRAUNSTEIN et al, 2004), is used to generate noise maps for this region. Previously is defined the area by cartography, topography, and around building heights. Also, are considered the meteorological data, standards, acoustics legislations, and parameters for rendering.

4. RESULTS AND DISCUSSION

4.1. Natural ventilation

Figure 5 presents the points of measure considered at each room for the model of house under the air flow incidence.

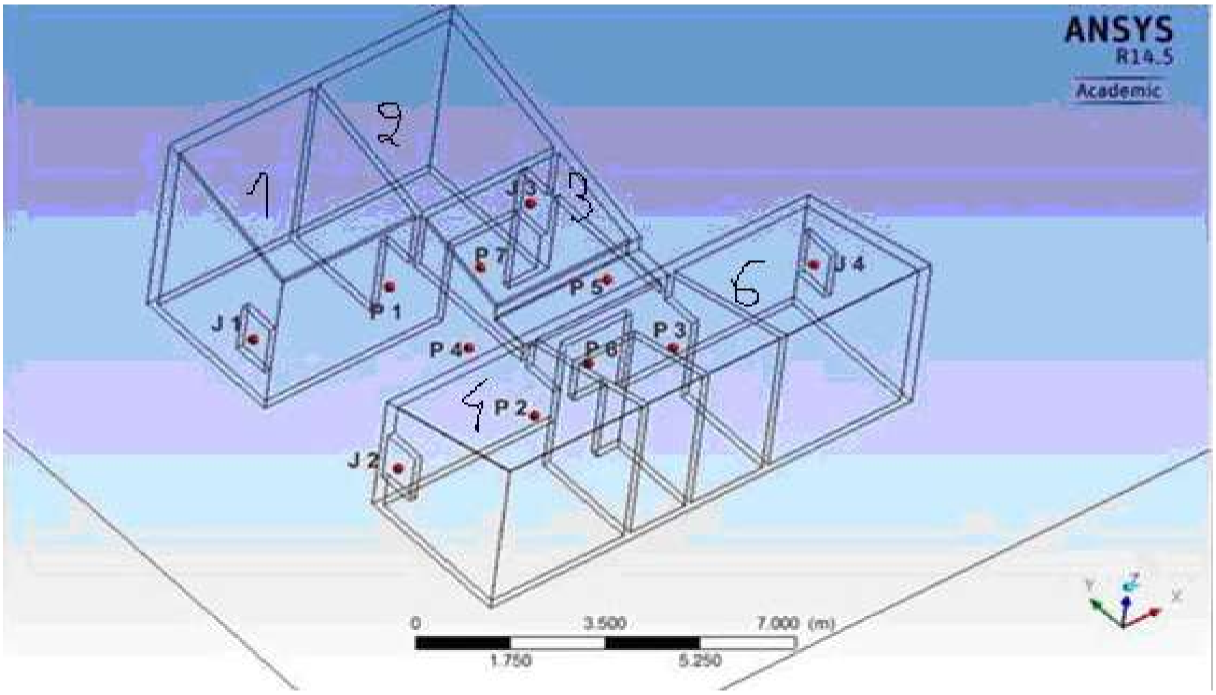

Figure 5. Selected points of measure of air pressure and velocity. Source: ANSYS CFX-Post. 2013

Also, in figure 6 can be depicted the CFD simulation results performed for the virtual model. It can be seen that there is a high air velocity through the central living room space, if is open during summer. This air flow is due to the Venture effect. Also, it can be seen the flow circulation around the house, and the low velocity vortices indoor the rooms.

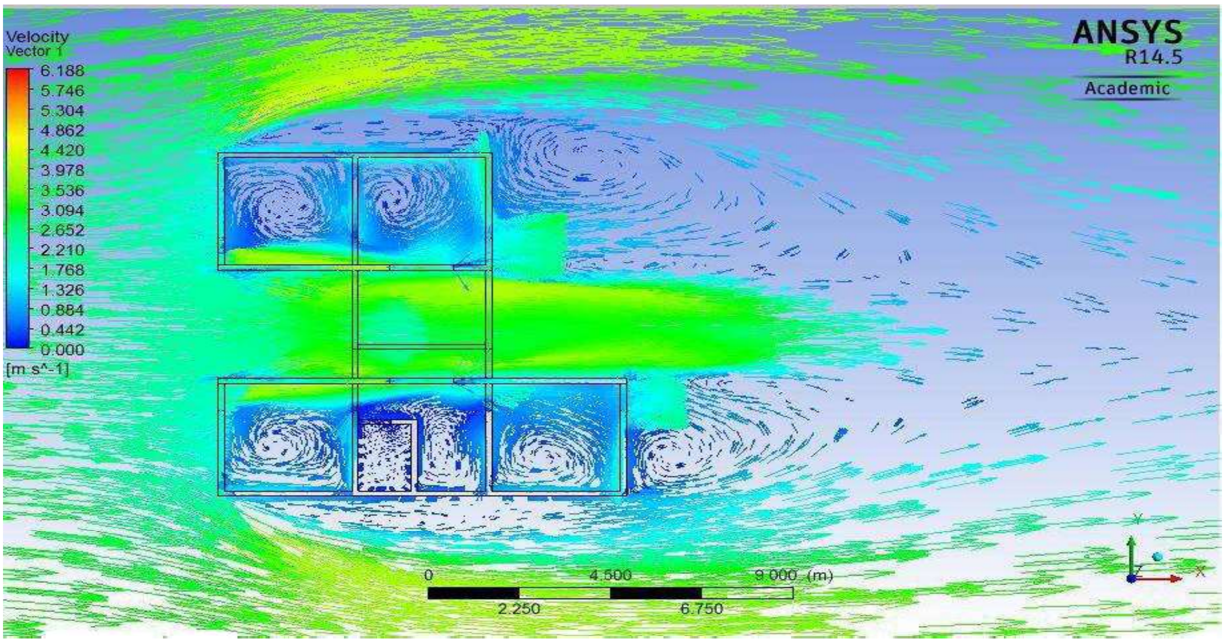

Figure 6 . Velocity vectors on a 1,20m height above the floor.

As mentioned, the indoor thermal charges due to solar radiation, occupancy, and appliances are obtained by means of an energy balance for each room, and then determined the required air flow-rate to cool the six ambiences of the house. Table 1 shows the obtained values from CFD simulations for the indoor air flow-rate compared with the values required to extract the indoor heat at each room calculated with equation1. It is possible to see that all ambiances present high volumetric flow-rates than the required values.

Table 1. Comparison results for indoor air flow-rates

Rooms	Air flow-rate obtained by simulations - CFX	Air flow-rates required to exaust the heat of rooms (Equation 1)
3 (central)	5,47 m³ /s	0,23 m³/s
1	1,17 m³ /s	0,22 m³/s
2	0,91 m³/s	0,31 m³/s
4	1,05 m³/s	0,21 m³/s
5	------	0,18 m³/s
6	0,73 m³/s	0,22 m³/s

4.2. Acoustics evaluation

The acoustic maps are obtained by simulations with the SoundPLAN sotware, figure 7 and figure 8. From these results, is possible to say that the two assumed arrays of houses are not influenced by the main noise sources. The noise propagation due to the Av. Aristóbulo Del Valle goes in a contrary sense of the prevailing NE winds. Also other buildings around the plots have low heights (1-3 floors) and near there is an expressive vegetal cover. During summer, when the central space of the houses are open to the winds, occurs small noise levels in case of the random implantation under a sound level around 48-50 dB(A), figure 7. For the settlement of houses placed along a peripheral line, the noise panorama is similar, figure 8.

Also, considering these acoustic results is possible to make another comparison for this two array configurations. The random array of houses is more influenced by the noise than the peripheral, because the majority of plots are facing the street, and exposed to the traffic noise. The peripheral house settlement presents yards turned to the interior terrain, being more protected from the income traffic noise, figure 8,.

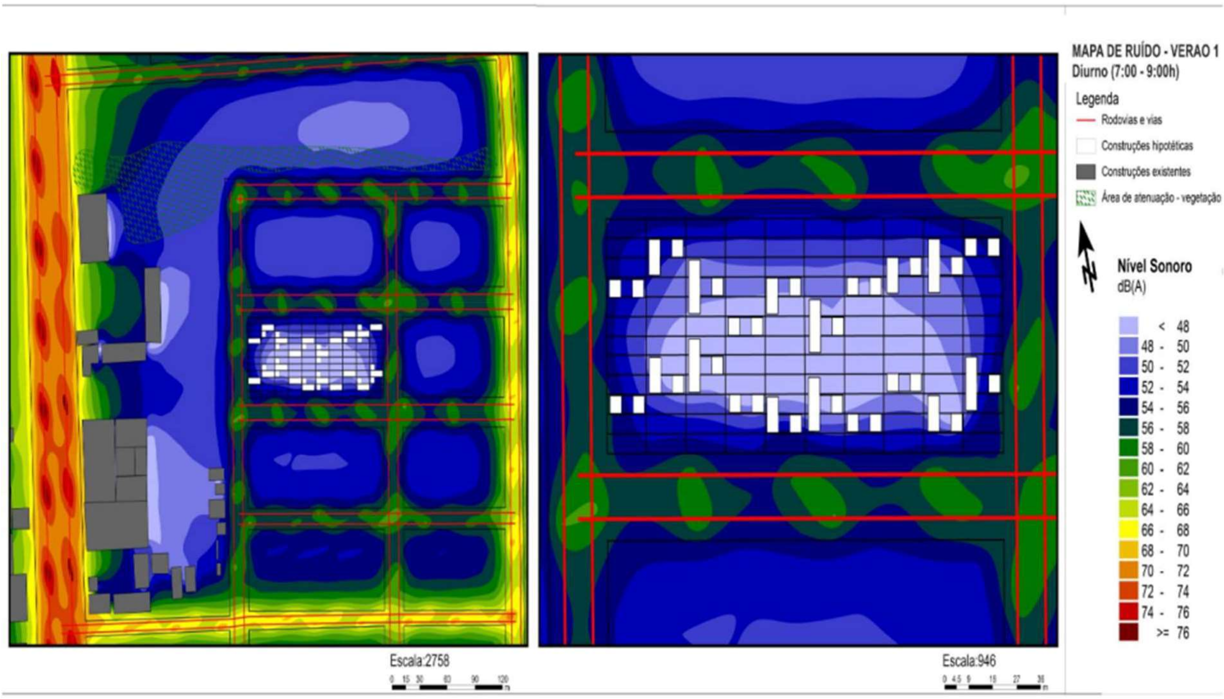

Figure 7. Noise map for a random houses implantation, with open central space doors, Summer condition.

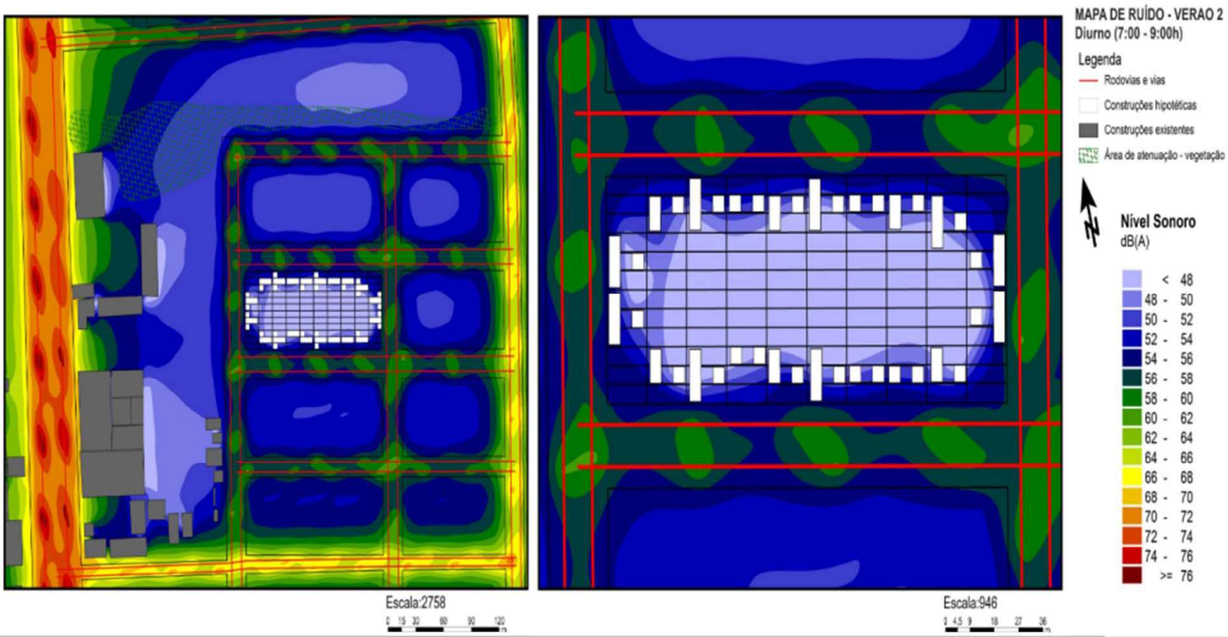

Figure 8. Noise map for a peripheral houses implantation, with open central space doors, Summer period

5. CONCLUSIONS

The methodology employed in the present research indicates its adequacy to study the free-running characteristics of the house proposed by the architect Carli. The assumed focus on the vernacular architecture typology Culata Yovai in this South America region is correct due its responsive to natural ventilated characteristic and has a compromise with the regional socio-cultural conditions.

The example studied of a new project of low-income houses for city of Santa Fé in Argentine become important for this region and adds sanitary conditions and contemporary building materials. Thus, for new low-income projects is adequate to maintain the living central space with conditions to be open to the prevailing winds during the summer period, and also to use building materials having a low thermal inertia.

Considering the assumed studied house-settlements, it is verified that the form of houses implantation is an important strategy to protect the plots and indoor spaces against incident traffic noises.

As shown by simulation results, the high air flow across the central space of the house has not influence to improve a local sound level. Thus, a recommendation is to consider for these projects of social housing to consider an analysis on ventilation and acoustics. The noise map is an important tool for a scale analysis and can able to help a diagnosis, to improve or to prevent poor solutions.

Also, it is known that generally urban noise sources come from the traffic of motor-combustion vehicles, then is ever required to improve some politics to reduce their circulation inside the city.

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