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Analysing the Resilience of Brasília's Superblocks in a Changing Climate

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Abstract

In *Six Degrees: Our Future on a Hotter Planet*, Mark Lynas describes possible world scenarios as global temperatures rise. The central region of Brazil, where Brasília is located, will suffer major changes in its microclimate.
Brasília's built environment has already provided a comfortable indoor and outdoor condition through planned urban design and vegetation. However, the constant increase in population and built area is threatening the local sustainability.
From damage prevention to future survival strategies, this paper highlights the importance of climatic design and urban directives in the struggle against a warming planet and resource depletion. One of Brasília's first super blocks, designed by Niemeyer, will serve as a case study. The discussion will focus on Brasília's iconic first housing estates and the ways they may contribute to energy efficiency as well as to the creation of strategies enabling the local community to respond to the climatic challenge. Monitored data of the present situation were analysed. The findings have suggested passive and active bio-climatic design and technology as a way forward. It is suggested that, under the current environmental circumstances, buildings are required to perform, like cars or refrigerators, like true "machines à habiter"; and their urban surroundings need to accommodate an ever-changeable microclimate in order to support the buildings' performance.

Keywords: Six Degrees, built environment, energy efficiency, urban design, microclimate

1 Background

Mark Lynas published Six Degrees: Our Future on a Hotter Planet in 2007 (2008 in USA) (Lynas, 2008). It is a non-fictional book about global warming. In his work Lynas describes the consequences of rising temperature on our planet, degree by degree, after very comprehensive and thorough research in the subject. An extra two degrees, threatens over a million species with extinction, including "163 tree species currently found on the Brazilian Cerrado savannah…"(Lynas, 2007:95) - the central high plain of Brazil.

This central region was strategically chosen to be the new capital of Brazil by the President Juscelino Kubitschek de Oliveira in order to fulfill an old plan of integrating the almost unpopulated western side of the country to the cosmopolitan and more developed coastline. During Juscelino Kubitschek de Oliveira's mandate, from 1956 to 1961, Brasília was designed, the construction started and the new capital was established.

The depletion of the region’s natural resources has been a source of concern for quite a long time. According to Schenkel (Schenkel and Matallo, 2003), in the nineties, an assessment for vegetation loss in the Federal District of Brazil prompted a study about desertification in Brazil and the Caribbean. This document was published by UNESCO first in 1998 and then in 2001.

The desertification of fragile eco-systems has been discussed globally and there are several international groups of studies developing expertise for an alternative, more sustainable development for these areas. The Brazilian Centre for Strategic Studies and Management (CGEE), in preparation for the world conference and parallel international debates, RIO + 20, published a special edition of the report *Strategic Partnerships* (Redwood, 2012). In this report the significance of the dry areas in the world is well described by Redwood in his paper *Climate, sustainability and development in dry areas.* “Dry areas represent 40 % of the world’s land and houses 30% of its population, from which 35% is poor and 16% lives in extreme poverty (around 50% of the world’s poor). The dry areas are the most affected areas by climate change (Redwood, 2012, p.168). However those areas are also full of opportunities, responsible for a great part of the world’s food production, rich in minerals, bio-diversity and a possible source for alternative energy – especially solar energy”(Redwood, 2012, p.177). In his conclusions, between threats and opportunities, Redwood highlights the importance of more planning and governance if those areas are to be protected.

Brasília was created with both a very precise plan and a very strong political will – a vision. However, Brasília was planned for a population of just 600,000 people and the “greater” Brasília has now around 3 million people (SDUMA, 2009). From the beginning of its construction, satellite cities have been mushrooming around the capital in order to accommodate the working class that built the capital but cannot afford to live in the heart of it. And since then, over the decades, a series of unlicensed settlements have been built, and later accepted within an underdeveloped political vision, hindered by profit motives and political gain.

Some of these “horizontal” settlements (Ribeiro e Póvoa, 2011) were not destined for the poor, but part of a lucrative continuum development without meaningful regulations. The fact that the region has very important aquifers was never an impediment.

One of the fastest growing administrative regions of the Federal District of Brazil, *Águas Claras* (Figure 1) (Clear Waters, hence the volume and quality of local water) is now served by a very modern metro service that connects the centre of Brasília to the satellite cities. Local construction has increased at an exponential rate, but, unfortunately, the budgets do not account for the protection of water resources, implementation of extra vegetation, and regulations on buildings distance in order to promote natural ventilation and appropriate climatic design for the area.

Figure 1. Águas Claras built environment and the metro line Source: (Brito Batista et al., 2013)

A new development in the Northwestern sector of Brasília, beside the National Park of Brasília, (an area that houses the reservoir responsible for 30% of the capital's water) was accepted despite enormous media and community outcry. This expensive residential area also sits on top of a significant indigenous site and an aquifer. The developers had to introduce systems to respond to the environmental impact of the new construction but the full picture is still unknown. The Paranoá Lake, an artificial lake designed in the creation of Brasília and part of the strategy to change the new capital's microclimate, should be monitored for sediments that will jeopardize its capacity. The large green areas designed and planted over the decades for surface water infiltration are not enough to face the unplanned growth the region has had. Bad consequences and flooding is starting to block the original road system.

2 Brasília's superblocks (superquadras) as planned

Lúcio Costa designed Brasília's master plan. Costa's design was inspired by Ebenezer Howard's Garden City (Howard, 1965); the key idea was to integrate green spaces within the built environment (marrying the town and country) and Clarence Stein's Neighbourhood Unit (Stein and Parsons, 1998); creating self-contained units to reduce travelling to amenities, each unit being large enough for a secondary school. The design of the city did not take into account an exponential growth in population. The Pilot Plan (masterplan) design for Brasília was developed by looking at the topography of the site and the natural flow of water. Two axes were formed which became the two main routes through the city (Figure 2).

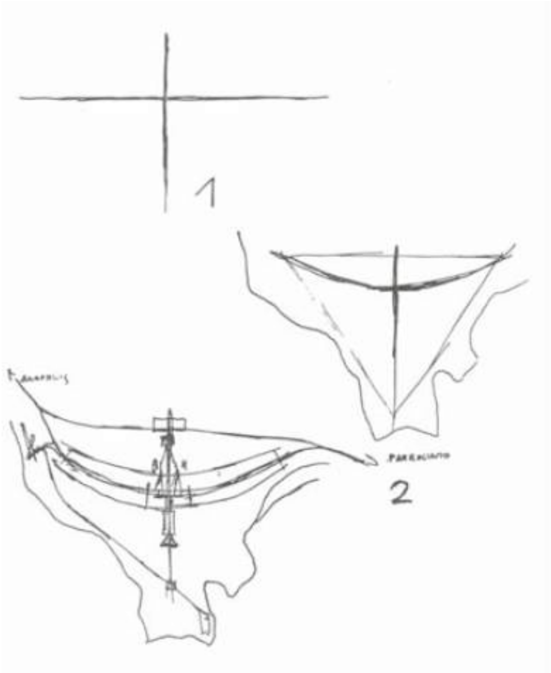

Figure 2. Lúcio Costa's sketch proposal for Brasília's Pilot Plan Source: (Staubli, 1966)

The two main routes are known today as the 'Eixo Monumental' (Monumental Axis) running East/West and the 'Eixo Rodoviário' (Road Axis) running North/South (Figure 3). Institutional, work and leisure sectors are located along the Eixo Monumental and the residential sectors, schools, cinemas and shops are located along the Eixo Rodoviário in the form of superblocks (Figure 3).

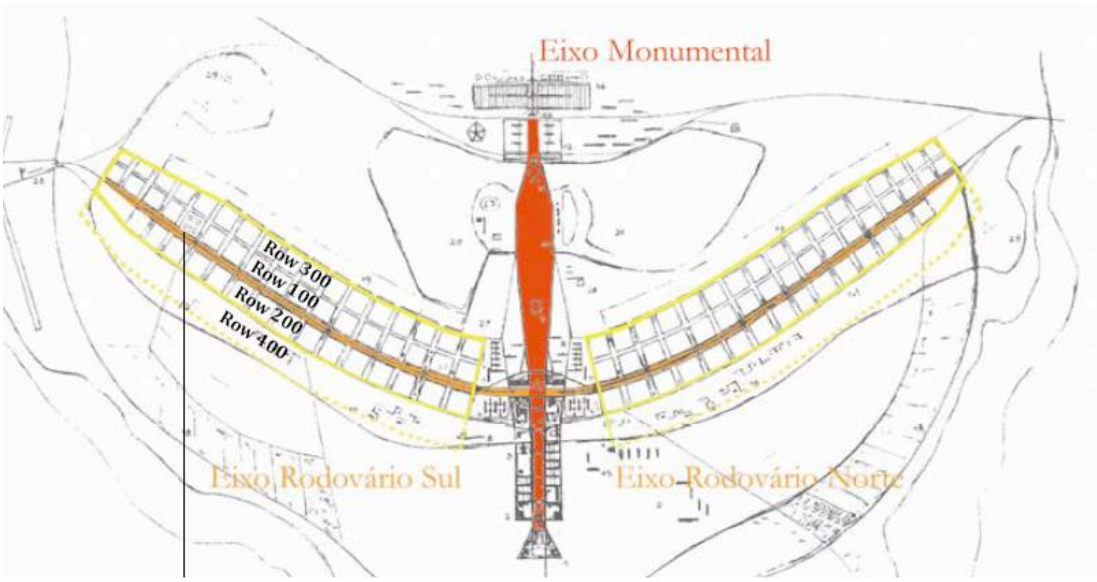

Figure 3. Location of the Axes, Superblocks and neighbouring units on the Pilot Plan

Source: (Authors own, M S. Franco)

The buildings in Brasília were built at two different periods; the first set in the 1960s-70s and the second set from 1980 until the present day. The first set of buildings inside the superblocks were designed by Oscar Niemeyer in the 1960s. They were designed on stilts (pilotis) to allow free movement at ground level. Vegetation was planted at ground level, covering most of the superblocks. Each superblock was given its own character by planting different species in the grounds. As talked about above, the land that Brasília was built on did not naturally have much vegetation; Niemeyer's plan increased the existing planting (Figure 4 and Figure 5).

Figure 4. Superblock South (SQS) 108 under construction Source: (DesignKULTUR, 2013)

Figure 5. Superblock South (SQS) 108 today. Source: (Google maps)

The adaptation of the block designs are shown in Figure 6. Niemeyer designed the residential blocks as long and thin rectangles (12.5m by 85m) where the flats spanned the entire width of building (Plan A), allowing for good cross-ventilation. The 1960s Building Regulations did not allow any windows on the end elevations of the blocks. This then later changed by adding the service cores as blocks outside the rectangle (Plan B), due to the 1967 Building Regulations. Balconies were added in later designs (1975) (Plan C), which was confirmed by the 1989 Building Regulations requirement for balconies. These building regulations later resulted in Plan D, where smaller balconies were added (shaded in orange) and sections were taken out of the rectangular block (up to 1m) for services (shaded blue). These regulations later resulted in Plan E, where it was permitted for the cores to be inserted inside the rectangular block, which led to the flats no longer spanning the width of the block (1989). This led to the reduction of natural light and ventilation for the flats (Braga, 2005).

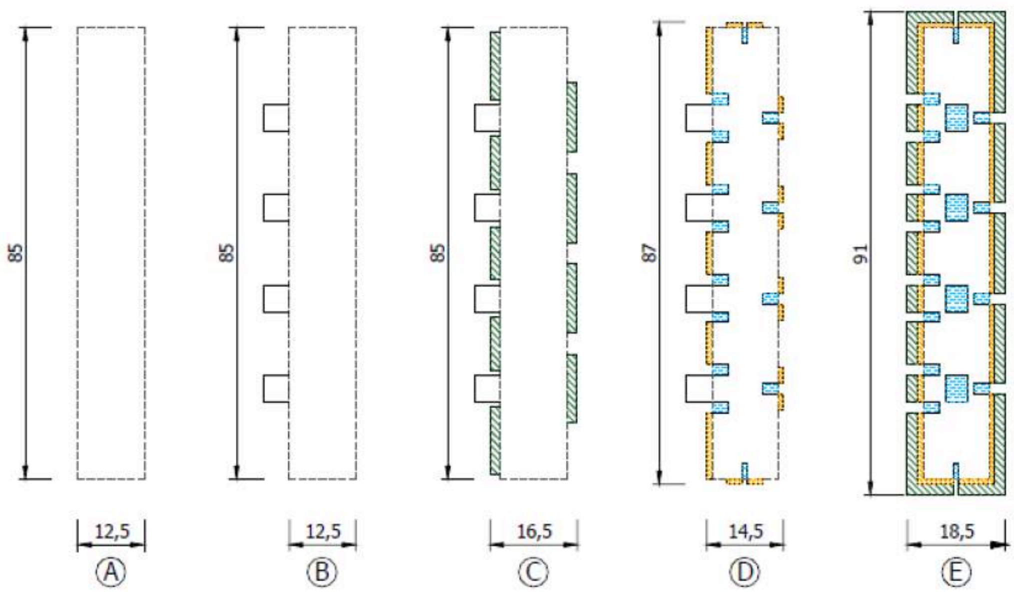

Figure 6. Successive changes in residential block plans over time (measurements in metres)

Source: (Braga, 2005, p.15)

3 Brasília's super blocks today

A study undertaken by Flores (2004) of 117 superblocks (1,392 residential blocks) of Brasília established that there are thermal comfort problems. The study found that people have added shading devices to the facades and air conditioning units.

Oxford Brookes University student, Mafalda Sofia Franco, funded by The Abbey Santander Scholarships 2009/2010, monitored (temperatures) one of the first and most iconic housing estates of Brasília. This paper sets M. S. Franco's results within a challenging future scenario in order to discuss resilience in the area.

Superquadras South (SQS) 108 and Superquadras North (SQN) 109 were monitored in September 2009 (mid-season) to investigate the comfort issues. One flat from each block was monitored using data loggers (ibuttons) over a period of two months and compared. The flat in 108 is on the 2nd Floor and the flat in 109 is on the 3rd Floor. Braga's (2005) study of the azimuth angle and solar radiation of the superblocks was used to select the superblocks that receive the most solar radiation, thus studying the blocks that are most vulnerable to overheating. SQS 108 is Plan B (from Figure 6, the flats span the width of the building) and SQN 109 is Plan E (from Figure 6, the flats do not span the width of the building). This section will discuss how the blocks were monitored and present some findings.

3.1 SQS 108

SQS 108, Block E (Figure 7) was chosen for monitoring as it represents the majority of the residential blocks in Brasília built in the 1960s-70s. SQS 108 was one of the original pilot superblocks designed by Niemeyer. The buildings in SQS 108 are surrounded by established vegetation and large trees (Figure 8).

Figure 7. SQS 108 Block E, North East elevation (the cobogó elevation) (top) and the South West elevation (the brise soleil elevation) (bottom) Source: (Author, M S. Franco)

Figure 8. Aerial view of SQS 108 with Block E highlighted. Source: (Author and Google maps)

The flat monitored in Block E has no air conditioning units. The positions of the ibuttons are shown on the floorplan of the flat (Figure 9).

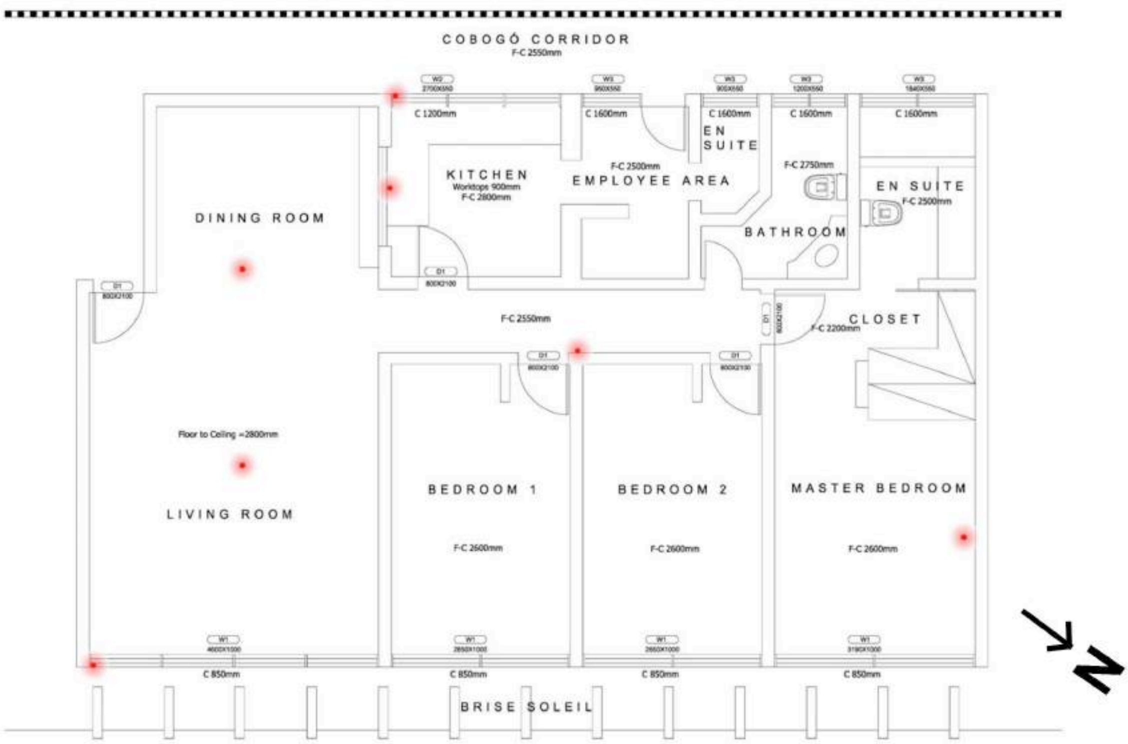

Figure 9. SQS 108, Block E Floorplan, 2nd Floor, highlighting where the ibuttons were placed

Source: (Author, M S.Franco)

3.2 SQN 109

SQN 109, Block N (Figure 10) was chosen for monitoring as it is a good example of the newer block designs (Plan E). The buildings in SQN 109 are not surrounded with much established vegetation and large trees at present and the floor plans have not been designed with cross-ventilation in mind (Figure 11).

Figure 10. SQN 109 Block N, North East elevation (top) and the South West elevation (bottom) Source: (Author, M S. Franco)

Figure 11. Aerial view of SQN 109 with Block N highlighted, showing the lack of established vegetation Source: (Author and Google maps)

The flat monitored has air conditioning in every habitable room, however the unit was rarely switched on by the occupants during the monitoring period. The positions of the ibuttons are shown on the floorplan of the flat (Figure 12).

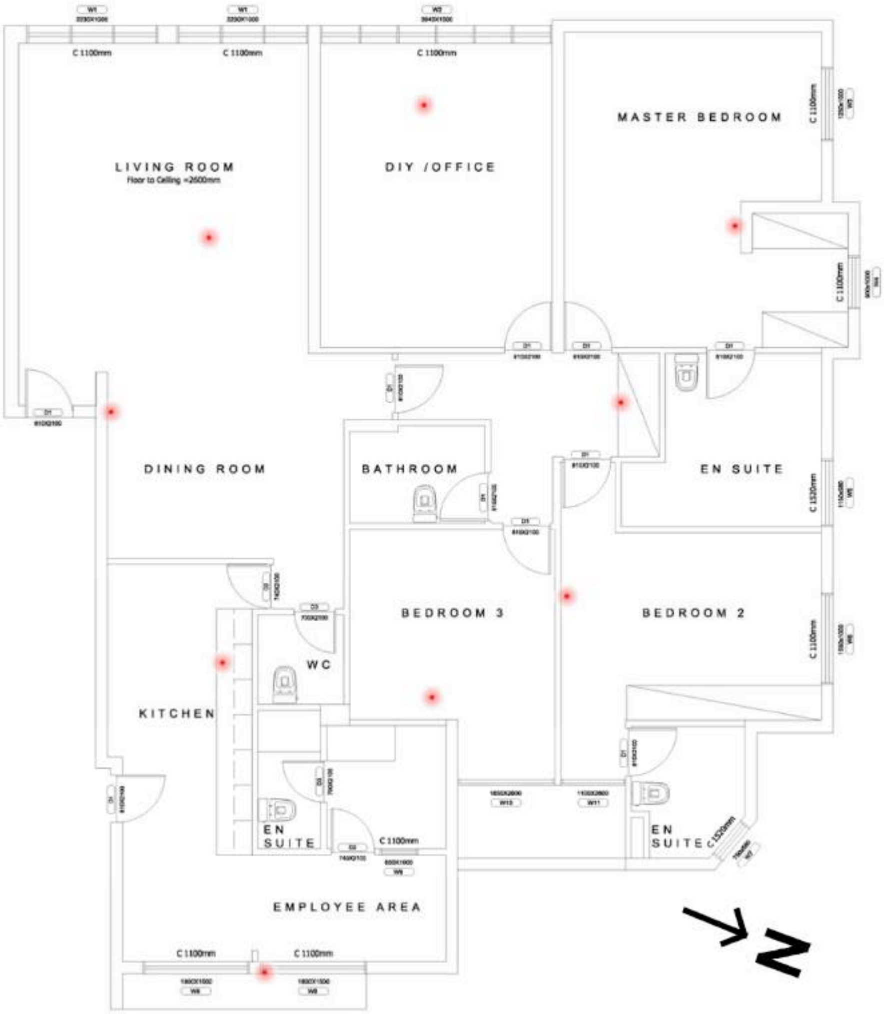

Figure 12. SQS 109 Block N, Floorplan, 3rd Floor, highlighting where the ibuttons were placed. Source: (Author, M S.Franco)

3.3 Monitoring results and findings

Figures 13, 14 and 15 show the temperatures monitored in SQS 108 and SQN 109. SQS 108 was not experiencing temperatures higher than 26 degrees Celsius. However SQN 109 was experiencing temperatures up to 28 degrees Celsius. These findings show that the climatic design of the original blocks is currently successful; passive cooling with the use of cross-ventilation and a cooler microclimate provided by the surrounding vegetation, which are key areas that are lacking in SQN 109. Further monitoring of the flats on the top floor of SQS 108 is needed as these flats are less shaded by the surrounding trees compared with the flats lower down. This would give an indication as to how much the vegetation contributes to keeping these flats cool and how important cross-ventilation is in comparison.

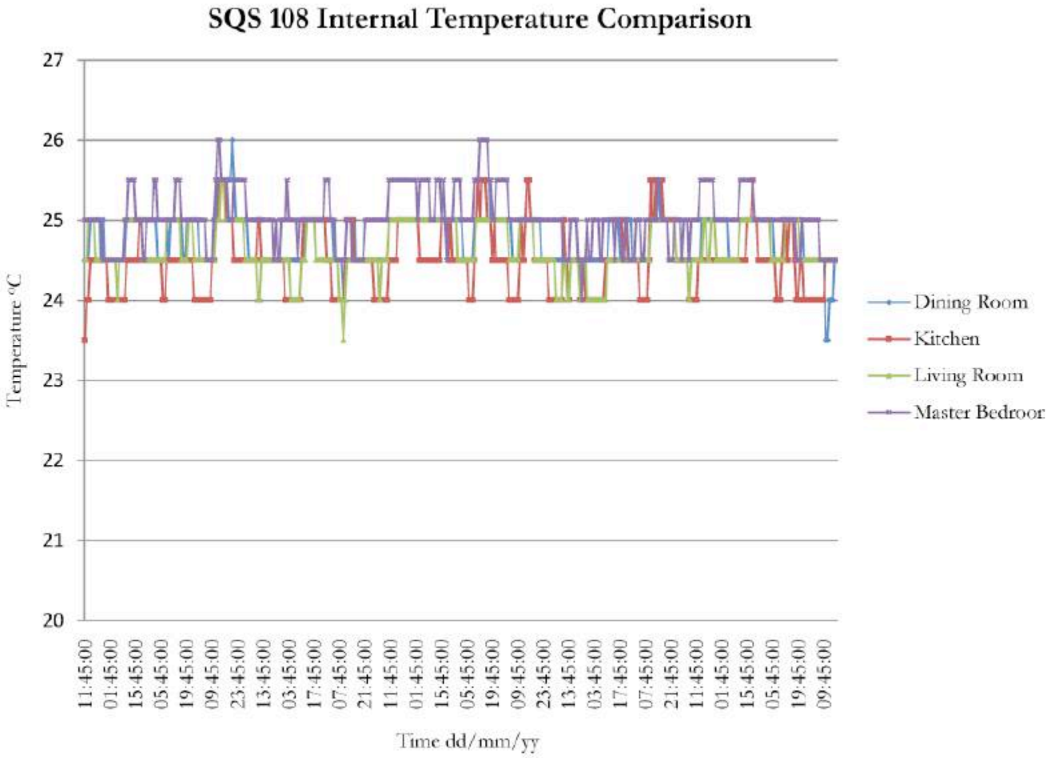

Figure 13. SQS 108, Recorded internal temperature Source: (Author, M S.Franco)

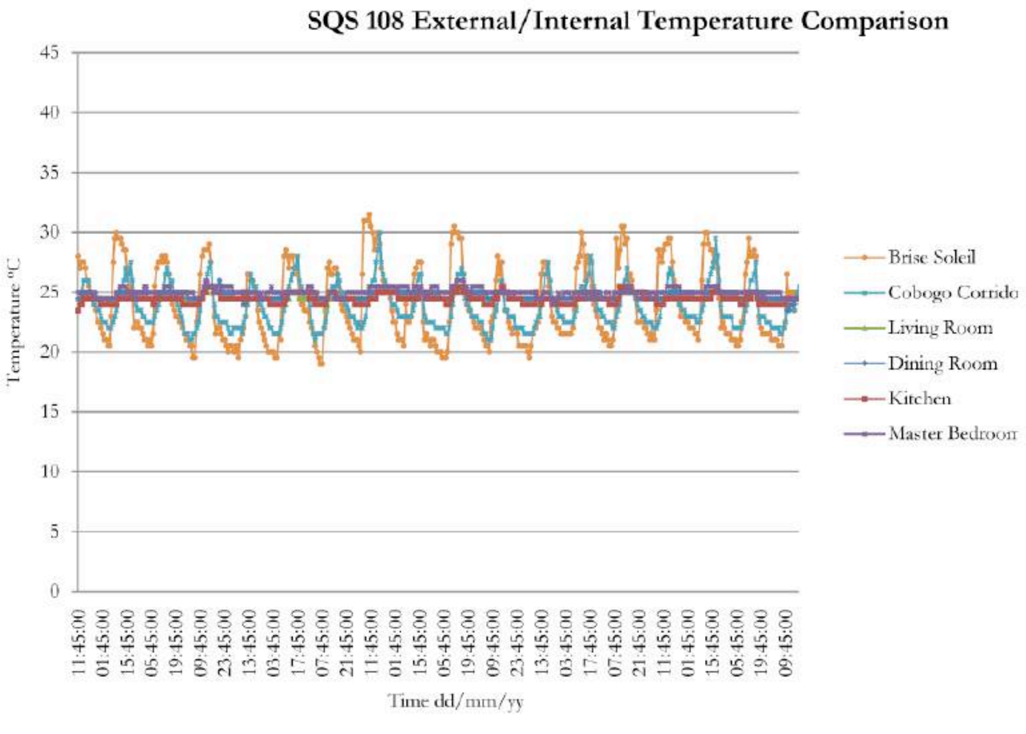

Figure 14. SQS 108, Recorded internal temperature with recorded external temperatures

Source: (Author, M S.Franco)

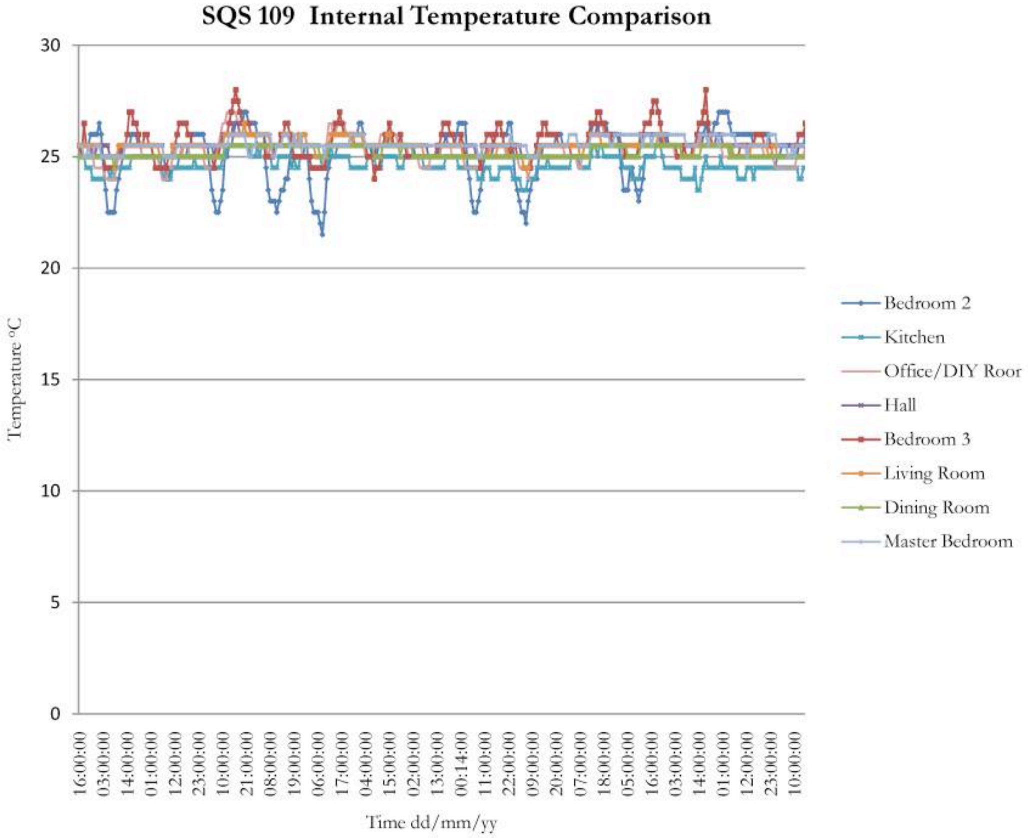

Figure 15. SQN 109, Recorded internal temperature Source: (Author, M S.Franco)

4 Related researches: the importance of urban microclimate and water conservation

L. M. B. Castelo Branco's masters dissertation for the University of Brasília, Urban Microclimates in Brasília's Pilot Plan – a case study of the SQS 108 (Castelo Branco, 2009) brings to light the importance of urban surroundings for the building's performance. Green areas as well as other ground covers and the urban morphology affect the air and ground temperature, the relative humidity and air movement.

The monitoring of outdoor conditions was carried out and the value of the airflow was measured. Findings reinforce the need to preserve the area's greenery and the quality of the ventilation if passive solutions are to be effective.

In the dry season, if trees protect the ground from the sunlight during the day, at night they can shield radiation. In this situation the low vegetation (grass or the introduction of vegetable gardens) presents better results. During this season evaporative cooling is very effective, hence reinforcing the need for irrigation.

During the rainy season the low vegetation also helps to maintain low temperatures. The lower temperatures under the trees were related to a higher level of ventilation. The humidity is related to the air temperature; and in the dry season, when temperatures are higher, evaporative cooling can be effective, however in the humid season arrangements must be made for air movement to increase (Figure 16). Raising the building off the ground, as in block 108, facilitates air movement.

The use and conservation of water in Brasília's housing estates is discussed in detail in Daniel Sant'Ana's work (Sant'Ana, 2012, Boeger and Sant'Ana, 2013). His graph relating the dry season to the increase in water consumption, as seen below, is revealing.

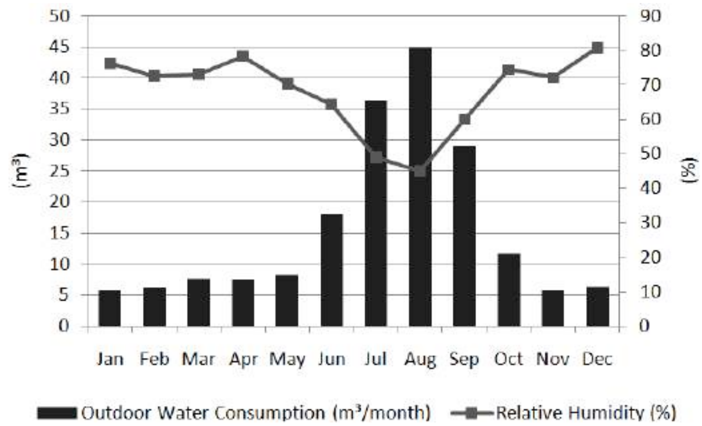

Figure 16. Relation between outdoor water consumption and relative humidity.

Source: (Sant'Ana, 2012)

According to Sant'Ana, new equipment and appliances for efficient water use, rainwater harvesting systems and even water reuse systems for outdoor non-potable use, are economically sound for today's budgets. Government policies and subsidies should promote these changes. However incorporating indoor non-potable water reuse systems is still unviable as it is expensive to change all the pipe work.

In the future, not just the new technologies but also the consequences of the inevitable high demand of the natural, regional systems of aquifers that have been so neglected over the years, could change drastically the results in the above calculations.

5 Conclusions

The research presented in this paper has highlighted the necessity of planning and political will. Regulations may be needed to guide designers and developers to create buildings like the original, naturally ventilated models from the 1960s, which were able to provide comfortable environments without auxiliary cooling. SQS 108, if the vegetation is to be preserved and water conservation undertaken, can be resilient to a warming climate. If temperatures rise, during the humid season, air movement may need to be increased. In the future, buildings will be required to have the most appropriated design and technology to perform as efficient machines, like true "machines à habiter".

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