Urban climate in urban design
How land use patterns and building types influence the urban comfort

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ABSTRACT

This paper will argue the importance of consider urban climate in the urban spatial quality, improving urban comfort in the public spaces. The main topics taken into consideration were the land use patterns and the building types. The role of the architect here takes importance in the way to get a sustaintable future.

INTRODUCTION

The climatic behavior in any urban space depends on many factors such as surrounding vegetation, urban furniture -lamps, and benches. Traffic signals, small commercial sites, etc- , the orientation of the space, other climatic conditions such as solar radiation and wind direction and speed.

Also the shape of the buildings, their height, materials and the width of the street.

Another factor that is often neglected is the land use pattern -morphology- that creates the public space. Basically there are three main land use patterns in Medellin, Colombia, that influence the character of the public spaces they are:

i) **Traditional:** Courtyard houses ("Indian" laws)
ii) **Planned:** Rowhouses (modern pattern)
iii)**Informal** invasion of land by squat ters (transit step).

During the architectural design process, the building's orientation and the size of roads should be taken into account, but most of the time the street orientation is not considered. There are very wonderful examples in this matter in traditional architecture, in Mompox, located in Magdalena river bank, with hot and humid climate, where the orientation of the streets give the public space very efficient climatic conditions all day round.

This document tries to deal with the idea that if the public space is treated like a volume, made of the facades of the structures that contains it, and the streets, and the roof of that volume, the so called "canopy layer" -boundary between the street "volume" and the atmosphere above-, or the trees planted in the street, and this space is transferring climatic conditions to the surrounding buildings through their walls and windows and also through the access streets, then it has it's own properties which vary according the height, the materials and the solar radiation and ventilation it has.

COLOMBIA

Is located in the north western part of South America between the Atlantic (Caribbean) and Pacific oceans and crossed by Andean mountains region in the centre of the country and Amazon forest in the south.

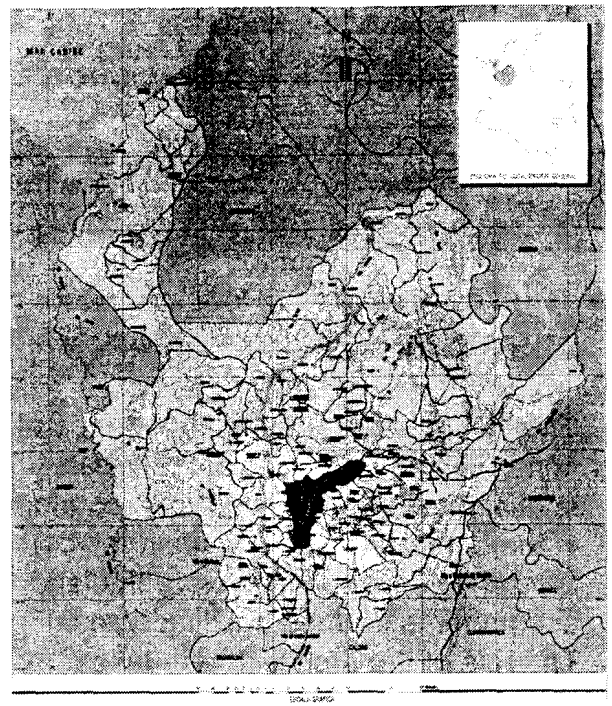


Figure 1: Antioquia -Colombia- & Medellin Metropolitan Area

It has about 35.000.000 inhabitants, about 70% lives in cities. The major cities are Santafe de Bogota (Capital) with almost 6.000.000, Medellin and Cali with about 2.500.000 and Barranquilla, Pereira, Cartagena, Santa Marta, Bucaramanga and Manizales with 1.000.000 each.

THE CLIMATE OF COLOMBIA

Colombia presents a great variety of climates, and the principal factor that determinates this is the altitude. The land rises from sea level up to about 4750m.
Basically the country can be divided into the following climatic regions:

- Hot and humid along the coast and the amazon.
- Hot and dry in the north Caribbean coast and south central area.
- Temperate and Cold and medium humid in the Andean region.

Another common classification is:

0-1000m	Hot	Equatorial
1000-1500	Medium hot	Low Andean
1500-2000	Temperate	Medium Andean
2000-4750	Cold	Andean
>4750	Cold	Snow

ARCHITECTURE IN COLOMBIA

Two main classification of architecture has been taken for this study. The examples are either low income housing or expensive ones, both in land use patterns and types.

Traditional

Due to great variety of colombian climates and ethnic groups there are many different traditional architecture styles made of different materials. All of them well adapted to the climate conditions al least in essential meaning.

The principal heritage, apart from the native ones, came from the Arab house through the Spanish conquerors. It is a patio house that during time has varied in size, and has been decreased for economical reasons.

There is move towards modern architecture with a lot of variety in types and morphology (land use pattern) mainly because of economic factors and land development opportunities.

There are good recent examples of modern houses following the old patio pattern, which are very successful. The low-income housing follows modern patterns but not because people like it, but because it is the only affordable offer.

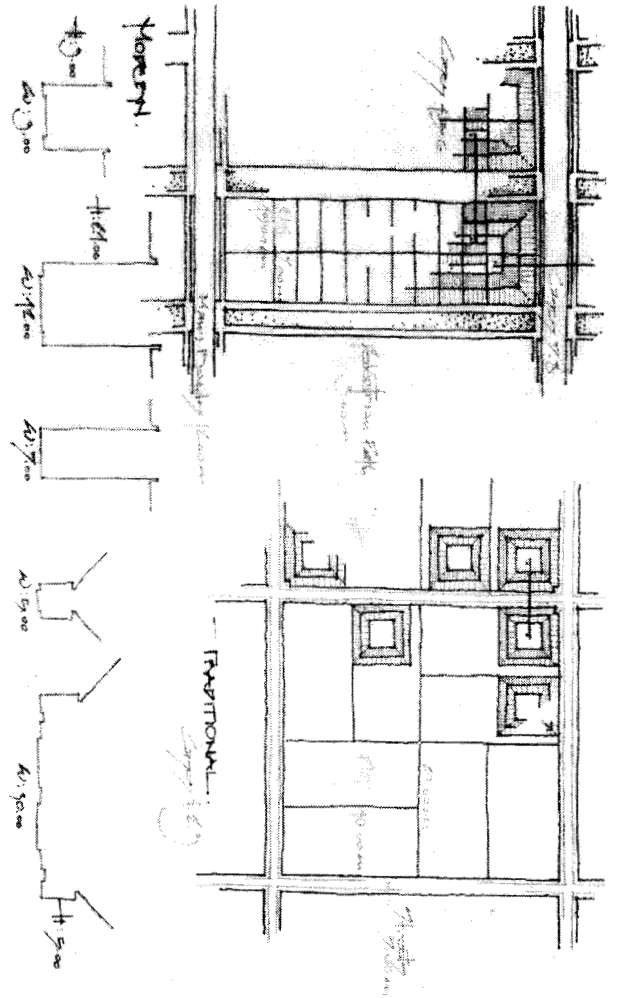


Figure 2: Traditional and Modern patterns. Case sections.

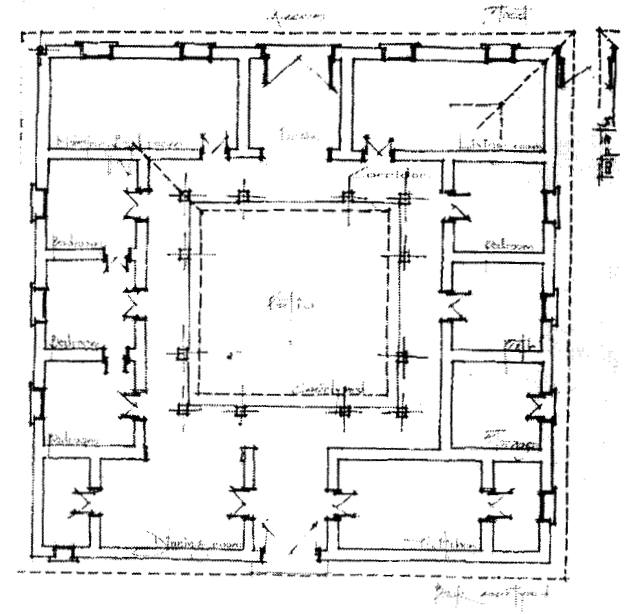


Figure 3: Old Traditional Patio House

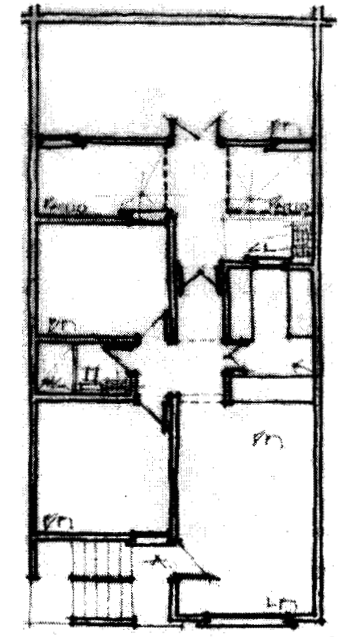


Figure 4: Modern Apartment

Modern

Modern architecture is trying to follow, at least in the used materials, the traditional examples, like for instance using bricks. There are some examples of glass curtain façade buildings with steel construction system The construction system for high rise buildings is, in most of the cases, reinforced concrete for columns and beams, following the earthquake norms.
The urban texture in today's architecture in Colombia follows the modern concepts in most of the cases. Some differences due to topogrhapic conditions and economical aspects, always trying to follow the traditional patterns. As Alberto Saldarriaga Roa says. "One of the most interesting aspects in the conceptual field of Latin American architecture in the past decade has been the moral awareness of the need to propose urban and architectural approximations from a reinterpretation of the past and present of Latin America, as an alternative to the offer generated in the international field of Post-Modernity".

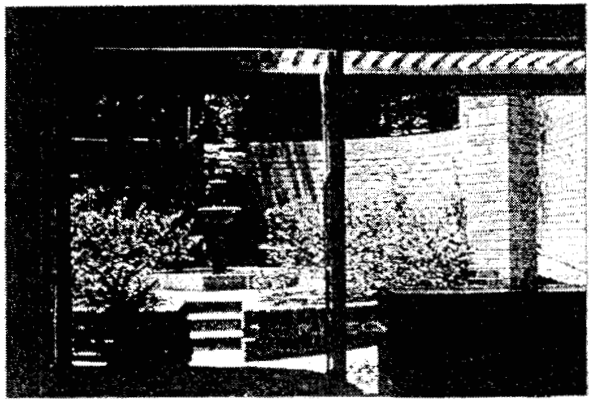


Figure 5: Photo and plans of modern patio houses.
Arch. Laureano Forero O.

Energy and Thermal comfort in buildings

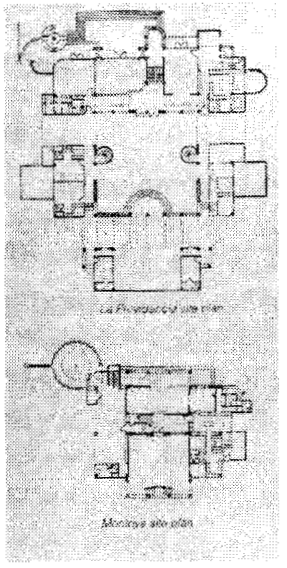
Normally there are not specific rules for this issue in the city, recently there are recently more and more buildings with artificial climate conditions which what no so common in the past. The main reason is the high increase of air contamination by noise, pollution and dust, mainly for traffic problems.

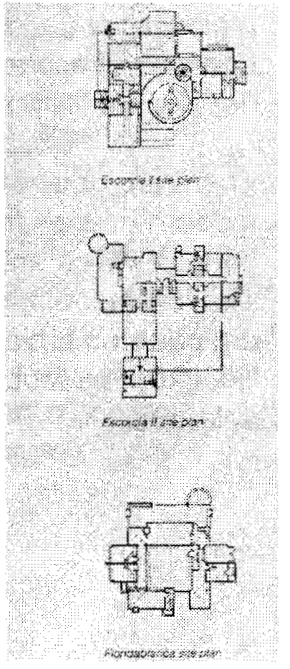
In housing there is not that kind of improvements because it is not really necessary due to climatic characteristics. There are some considerations to be taken into account to betterment the housing climate like materials, orientation and roofs materials quality to improve their performance.

Medellin. Case study

Medellin and its Metropolitan Area is one of the largest cities in Colombia, located in the north west part of the country, its climate is temperate with an average of 22 all year round, also the humidity has an average of 67. The rain season is during April, May, Jun and July, but there are some short strong rains during October and November.

The altitude is 1490m over sea level, the latitude is 06.13'N and the longitude is 75.36'W.





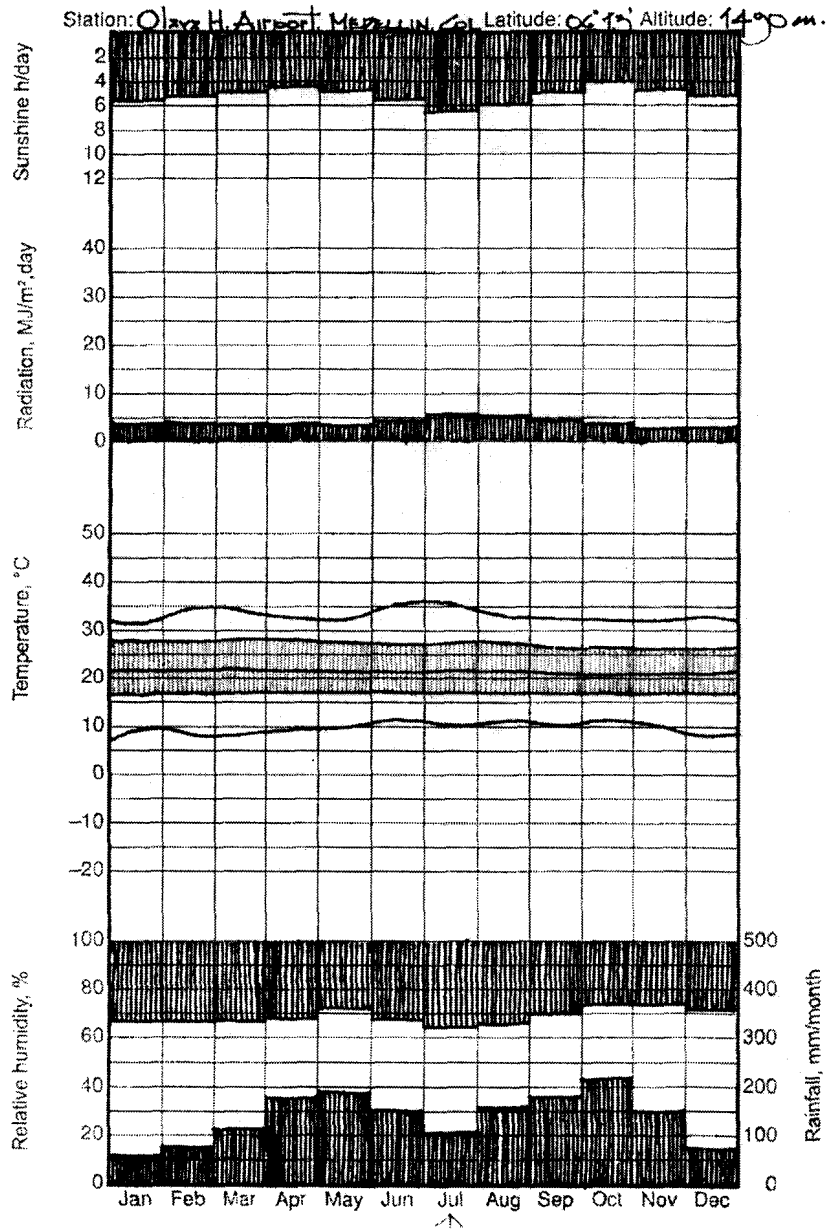


Figure 6: Climatic Conditions.

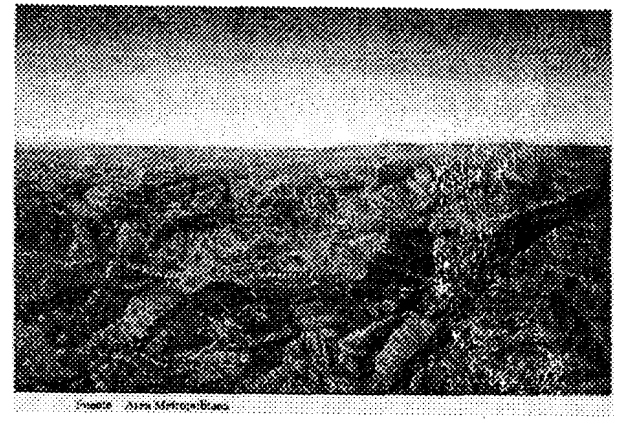


Figure 7: Medellin. Aerial view.

The Public Space

It is important not only to improve the private property conditions but also the public comfort through the urban spatial quality.

"It is the space where the common interest shows up" -Victoria Camps-, it is the space where daily events take place, where the people meet and many people spend most of the time, so it is and important place to take care of.

Problem

Climate in Medellin is comfortable but solar radiation can cause discomfort in streets and other public spaces.

Architects nowadays don't consider climatic conditions in urban design, beside it doesn't exist regulations in this aspect.

The "Indian laws" has very clear rules for settlements in different climate conditions, width and orientation of the streets, etc, now a days this rules does not exist and follows only traffic patters and economical possibilities, same as registers from one building to other.

The climate of cities can be modified by urban designers and in the urban heat island, the intensity depends on various factors, such as the size and morphology of the city. An important geometrical factor is the height to width ratio of the streets canyons.

Hypothesis

The land use pattern affect the climate conditions, and because the importance of the public space in the daily life of the communities, some regulations should be done.

METHOD

Most of the planning and design process, follow the sequence of:

Problem comprehension
Literature review
Analysis
Synthesis
Diagnosis
Alternative solutions
Plan
Implementation
Evaluation

Not in a lineal way but with many feedback to improve the process.

Also is taken into account in this methodology:

The factors: Natural aspects -climatic conditions, slopes-, cultural aspects –building's typhology-, and political aspects –norms-, all in time, space and scale.

The themes: Urban theories and housing design aspects -construction matter-.

The concepts: Architectural movements -traditional and modern-.

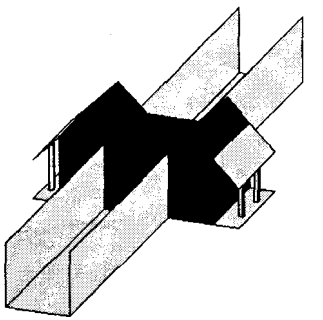
All of them under personals view. It can be said that it needs to **know** the **past**, to **consolidate the present** for **built the future.**

For the calculations the program Dynamic Energy Response Of Buildings –DEROB-. LTH was used.

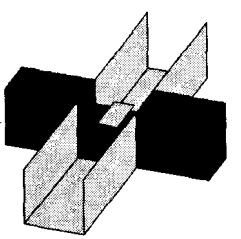
PROJECT DESCRIPTION

Three different models have been selected for this study:

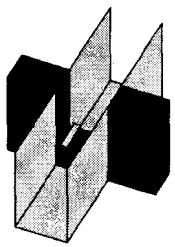
Model One: Old Traditional patio houses pattern -one story- 5 m height with a street of 5 m width.



Model Two: Modern apartment building -three stories- 9 m height, three flats), with a streets of 9 m width -pedestrian paths-.



Model Three: Modern apartment building -seven stories-
21 m height), with streets of 12 m width.



In this cases and with DEROB program simulated different conditions in the traditional and modern land use patterns taken into account different parameters.

STUDIED PARAMETERS.

Aspects to consider for simulation proposes:

- Geometry of the urban sector: Height Vs Width
- Orientation of streets: East-West and North-South.
- Geometry of the environment: Flat & Slope -20%-
- Design in buildings and green areas:
  Traditional: Corridor, openings, slope roofs.
  Modern: Green areas, flat roofs
- Air changes in the volumes:
  Traditional: 0-6 ach per hour.
  Modern: 0-3 ach per hour.
  Public space: 40 ach per hour.
- Thermal properties of materials.
- Surface to cover the public space: Fakeglass (emittance back of 1 and 99).
- Climatic conditions: July 1998.

RESULTS

Climate Analysis

Results from Traditional Tools.

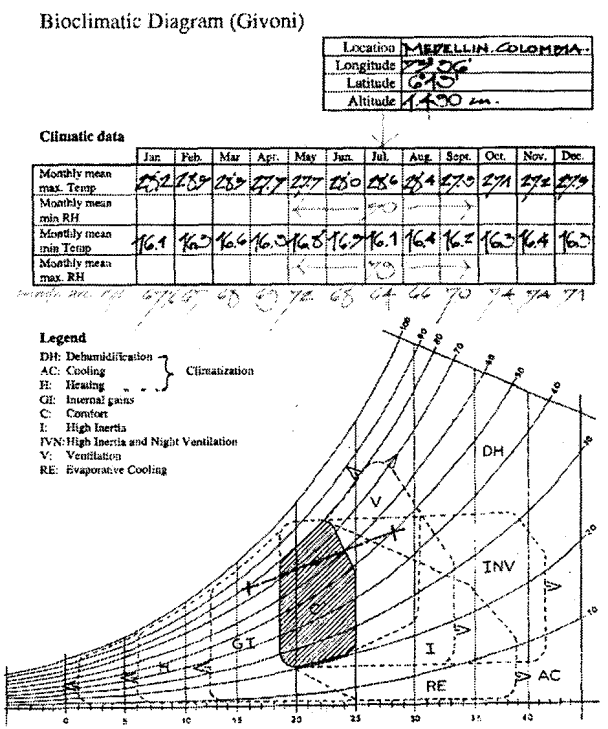


Figure 8: Givoni Table.

Mahoney recommends: -Table Apendice-

Layout. Compact courtyards planning
Spacing. Open spacing for breeze penetration, but protection from hot and cold wind.
Air movement. Rooms single banked, permanent provision for air movement.
Openings. Very small openings, 10-20%.
Walls. Heavy external and internal walls.
Roofs. Heavy roofs, over 8h time-lag.
Size of openings. Small openings, 15-25%.
Position of openings. In north and south walls at body height or windward side.
Protection of openings. Exclude direct sunlight.
Walls and floors. Heavy, over 8h time-lag.
External features. Adequate rainwater drainage.

Seems from Mahoney and Givoni tables that there are coinsidences about the way to treat the climatic conditions in Medellin. Both recommend heavy construction materials with high inertia, it means close to traditional design materials.

Results from Modern Tools.

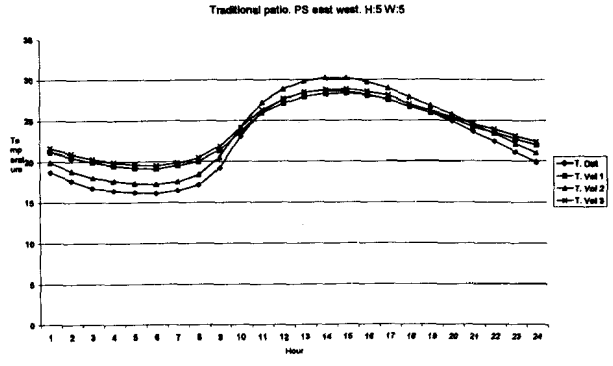
According cross ventilation rules: Due to air flows trough the streets, producing an underpresure in the façade openings; there is a suction of air from the courtyard of the old patio pattern, increasing the airflow in the public space. **(See Fig 3)**

The air is not following exactly the same behavior in the modern pattern because of multiple rooms between patios and the facade. **(See Fig 4).**

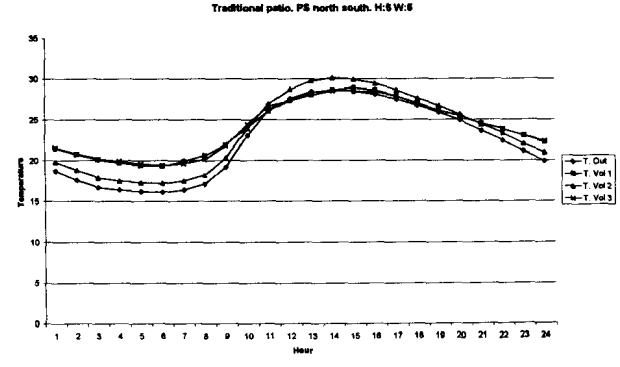
Calibration of the calculations. DEROB was not designed to simulate open spaces.

For the calculations the volumes 1 and 3 are the buildings and the volum 2 is the open space. The vol. 1 and 3 for the simulation in the modern pattern was asummed like one space,without slabes inbetween stories. Because of that there are some results that may not fit exactly with reality in those volumes, but the interest of the study is conditions of vol 2.

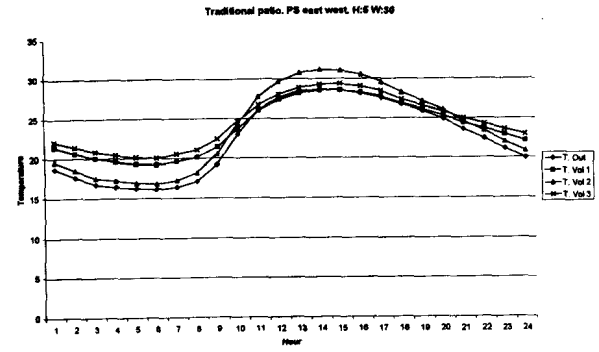
Case 1: Traditional patio. Street orientation east west. Building height -H- 5 m, width -W- 5 m.



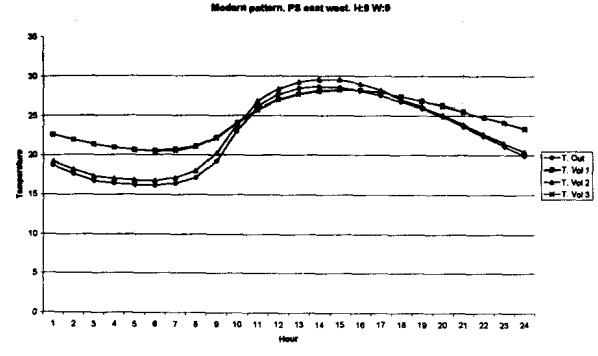
Case 2: Traditional patio. Street orientation north south.
H: 5 W: 5. H/W=1



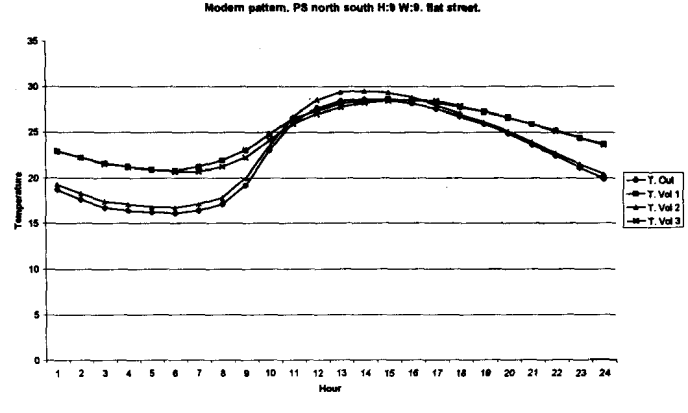
Case 3: Traditional patio. Street orientation east west.
H: 5 W: 30.



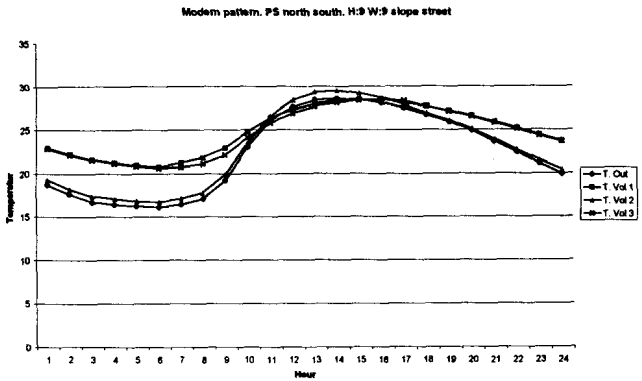
Case 4: Modern pattern. Street orientation east west.
H: 9 W: 9. H/W=1



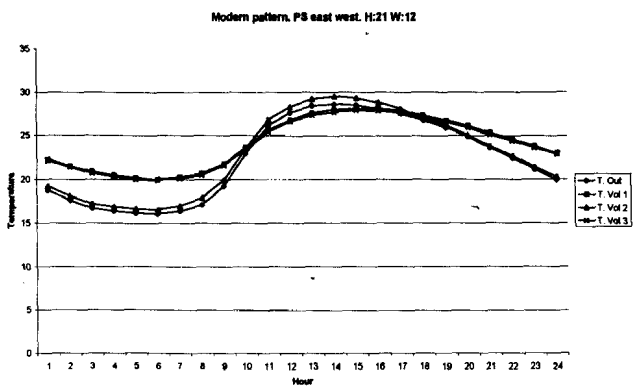
Case 5: Modern pattern. Street orientation north south.
H: 9 W: 9. Flat street. H/W=1



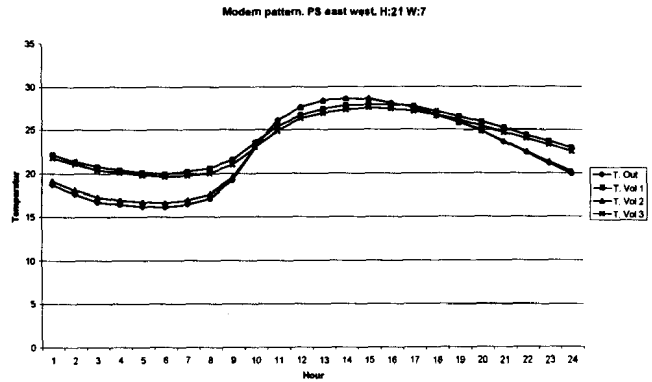
Case 6: Modern pattern. Street orientation north south.
H: 9 W: 9. Slope street -20%-. H/W=1



Case 7: Modern pattern. Street orientation east west.
H: 21 W: 12



Case 8: Modern pattern. Street orientation east west.
H: 21 W: 7. H/W=3



For the Traditional patio, when the Public Space is oriented east west - Case 1- is lightly hotter than when is oriented north south -Case 2-. Also the vol. 3 is lightly hotter than in case north south.

For the Case 3 -H.5 W.30-, the Public Space -vol. 2- is colder during nights and hotter during days than in the Case 1 or 2 – H: 5 W: 5.

For the Modern pattern there are not differences between the orientation north south or east west in the flat – Case 5- or slope streets –Case 6-.

In Case 4, Modern pattern Public Space east west H: 9 W: 9, Vol 2 is closer to outdoor temperature, it means is close to reality, DEROB was not designed to simulate open spaces. Vol 1 and 3 are hot during nights than the same volumes in traditional patio, and are cool during day's -10:oo to 15:3o-.

In Case 7 and in Case 8, the temperature in Vol 2 follows the outdoor temperature very close and the temperature of Vol 1 and 3 are almost the same for both cases.

DISCUSSION

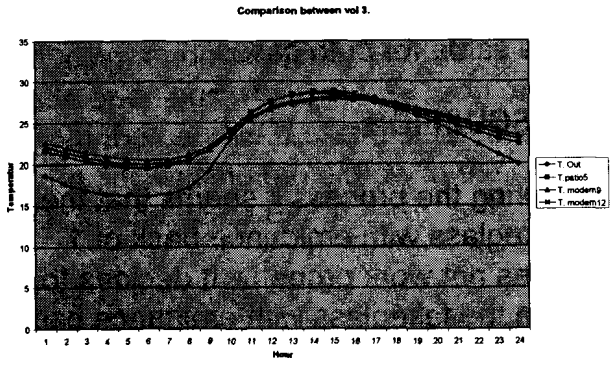
During the process it seems that the fakeglass with emittance back of 1 does not work properly. It decides to use the fakeglass with emittance back of 99.

The air changes per hour were 3 in the modern pattern, 6 in the old traditional pattern and 40 in the public space. For further studies, the ach. in public spaces may be differents according with street orientation.

Also take two "extreme" cases, one with 5m height houses and 30m wide streets, and another with 21.oom height buildings and 7m wide streets. In this two cases is clear the "tunnel effect" making cooler the Vol 2 in Case 8 -very close to outdoor temperature-, and warmer during day time in Case 3.

There are some other factors that affect, maybe not the temperature itself, but give different feelings to the body, like shadow casting by trees, height and type of roofs, colours,

Comparison between Vol 3 in cases 1,4 and 7.



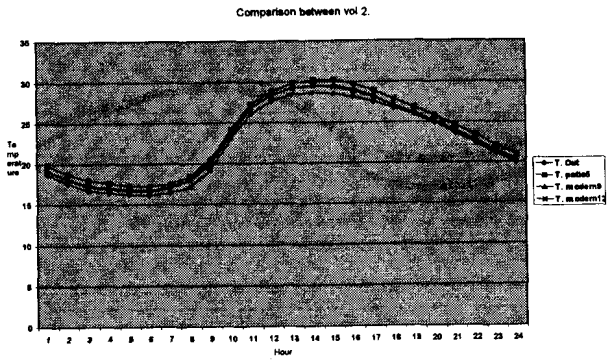
etc. These factors in this aspect are not taken into consideration by DEROB.

Five meters height for the public space has been chosen for the simulations.

Some other months of the year should be studied, in order to compare the results and had a wide view of the public space behavior. Also some other city cases, because Medellin does not have a extreme climatic conditions. Some other studies may help for the comparison of results.

For further studies Program Flow Systems –PFS- could be useful to study the air flow through the volums.

Comparison between vol 2 in cases 1,4 and 7.



CONCLUSIONS

According with the results:
In the Modern pattern the temperature in the public space is lower than in the old traditional patio ones. It means is colder during nights and fresher during days. The width of the streets and the vegetation in those spaces may help in the urban climatic conditions.

The temperature in Vol 1 and 3 - interior- is warmer during nights and fresher during days in the modern pattern than in the old traditional patio houses. The height of the floors and the materials may help in this matter.

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Also to Erik Johansson, Hans Rosenlund, Laura Liuke and Jorge Hernan Salazar T.

Location	Aeropuerto Olaya Herrera.	
Longitude	75 36	°
Latitude	06 13	°
Altitude	1490	m

Air temperature °C

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	High	AMT
Monthly mean max.	28.2	28.5	28.5	27.7	27.7	28	28.6	28.4	27.9	27.1	27.2	27.5	28.6	22.35
Monthly mean min.	16.1	16.3	16.6	16.9	16.8	16.5	16.1	16.4	16.2	16.3	16.4	16.3	16.1	12.5
Monthly mean range	12.1	12.2	11.9	10.8	10.9	11.5	12.5	12	11.7	10.8	10.8	11.2	Low	AMR

Relative humidity %

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Monthly mean max am	67	67	68	69	72	68	64	66	70	74	74	71
Monthly mean min pm	67	67	68	69	72	68	64	66	70	74	74	71
Average	67	67	68	69	72	68	64	66	70	74	74	71
Humidity group	3	3	3	3	4	3	3	3	3	4	4	4

1 <30%
2 30–50%
3 50–70%
4 > 70%

Rain and wind

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Rainfall mm	53	71	112	181	191	151	104	154	178	217	150	73	1635

Wind, prevailing	N	N	N	N	N	N	N	N	N	N	N	N
Wind, secondary												

N, NE, E, SE, S, SW, W, NW

Diagnosis °C

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	AMT
Monthly mean max	28.2	28.5	28.5	27.7	27.7	28	28.6	28.4	27.9	27.1	27.2	27.5	22.35
Day comfort, upper	29	29	29	29	27	29	29	29	29	27	27	27	
Day comfort, lower	23	23	23	23	22	23	23	23	23	22	22	22	
Thermal stress, day	O	O	O	O	H	O	O	O	O	H	H	H	
Monthly mean min	16.1	16.3	16.6	16.9	16.8	16.5	16.1	16.4	16.2	16.3	16.4	16.3	
Night comfort, upper	23	23	23	23	21	23	23	23	23	21	21	21	
Night comfort, lower	17	17	17	17	17	17	17	17	17	17	17	17	
Thermal stress, night	C	C	C	C	C	C	C	C	C	C	C	C	

H=Hot
O=Comfort
C=Cold

	AMT >20°C				AMT 15–20°C				AMT <15°C			
Comfort limits	Day		Night		Day		Night		Day		Night	
Humidity group	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper
1	26	34	17	25	23	32	14	23	21	30	12	21
2	25	31	17	24	22	30	14	22	20	27	12	20
3	23	29	17	23	21	28	14	21	19	26	12	19
4	22	27	17	21	20	25	14	20	18	24	12	18

Meaning

	Indicator	Thermal stress Day	Thermal stress Night	Rainfall	Humidity group	Monthly mean range
Air movement essential	**H1**	H			4	
		H			2–3	<10°C
Air movement desirable	**H2**	O			4	
Rain protection necessary	**H3**			>200mm		
Thermal capacity necessary	**A1**				1 2 3	>10°C
Outdoor sleeping desirable	**A2**		H		1 2	
		H	O		1 2	>10°C
Protection from cold	**A3**	C				

Indicators

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
H1					1					1	1	1	4
H2													
H3										1			1
A1	1	1	1	1		1	1	1	1				8
A2													
A3													

Indicator totals from data sheet												
H1		H2		H3		A1		A2		A3		
4				1		8						
Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	**Layout**
						0	10					Orientation north and south (long axis east–west)
						11	12			5	12	
										0	4	1 Compact courtyard planning
												Spacing
11	12											Open spacing for breeze penetration
2	10											1 As above, but protection from hot and cold wind
0	1											Compact layout of estates
												Air movement
3	12											1 Rooms single banked, permanent provision for air movement
1	2					0	5					
						6	12					Rooms double banked, temporary provision for air movement
0	0	2	12									
		0	1									No air movement requirement
												Openings
						0	1			0	0	Large openings, 40–80%
						11	12			0	1	1 Very small openings, 10–20%
Any other conditions												Medium openings, 20–40%
												Walls
						0	2					Light walls, short time-lag
						3	12					1 Heavy external and internal walls
												Roofs
						0	5					Light, insulatted roofs
						6	12					1 Heavy roofs, over 8h time-lag
												Outdoor sleeping
								2	12			Space for outdoor sleeping required
												Rain protection
				3	12							Protection from heavy rain necessary
												Size of opening
						0	1			0	0	Large openings, 40–80%
										1	12	Medium openings, 25–40%
						2	5					
						6	10					1 Small openings, 15–25%
						11	12			0	3	Very small openings, 10–20%
										4	12	Medium openings, 25–40%
												Position of openings
3	12											1 In north and south walls at body height on windward side
1	2					0	5					
						6	12					As above, openings also in internal walls
0	0	2	12									
												Protection of openings
										0	2	1 Exclude direct sunlight
				2	12							Provide protection from rain
												Walls and floors
						0	2					Light, low thermal capacity
						3	12					1 Heavy, over 8h time-lag
												Roofs
10	12					0	2					Light, reflective surface, cavity
						3	12					Light, well insulated
0	9					0	5					
						6	12					1 Heavy, over 8h time-lag
												External features
								1	12			Space for outdoor sleeping
				1	12							1 Adequate rainwater drainage