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Adaptation of Urban Law to Micro-Climate parameters Inalgeria-Case of Collective Housing in a Semi-Arid Area

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The law of urban planning in Algeria is armed with a regulatory and legislative armory that governs all urban acts at various scales. However, compared to contemporary urbanism, which strives to adhere to the principles of sustainability, this law demands a reevaluation of some of its provisions, particularly from an environmental standpoint.Urban density, which is frequently dictated by the climate in issue, is also one of the sustainability principles. Due to this, we have opted to examine it in its regulatory context in connection to Ain Smara's microclimate (Algeria). On the basis of the two indicators mandated by Algerian urban regulations, namely the COS (vertical density indicator) and the CES (horizontal density), its effect on the microclimatic parameters, in particular the air temperature, was evaluated at the level of the various collective housing sites dispersed throughout this city. In order to quantify these two indicators more precisely, we have associated them with quantifiable geometric factors such as the height of the structures (H) and the distance between them (L). The resulting H/L ratio has a close link with the sky view factor (SVF) that will be tested in the aforementioned city at a collective housing site. The primary objective of this technique at various urban scales is to establish a morphoclimatic indicator that will enable the selection of the optimal urban density based on local and particular microclimatic data. Several technologies, including GIS, the simulation models "Envi-met4" and "RayMan," were utilized for this purpose. On the basis of the geometrical dimensions of the urban forms in issue, we were able to define for the first time in Algeria a Morphoclimatic indicator of urban density suitable to Algerian urban regulation. Therefore, urban planning and sustainability can already be combined in the Algerian regulatory texts.

Key words: Morphoclimatic indicator, Collective housing, Urban density, COS, CES

INTRODUCTION

According to the Algerian legislation governing urban planning, the Coefficient of Land Use (COS) and the Coefficient of Land Take (CES) appear to be of major relevance in evaluating and controlling urban density. Therefore, it appears vital to define, interpret, and assess them. Before being regarded two density indicators, the COS and CES are considered as building rights. In fact, the Executive Decree n°91-177 of 28 May 1991, as amended and supplemented in its article 17 of chapter III, stipulates that every master plan for urban development and planning (PDAU) must have its own regulation that fixes the general density, whereas the latter is primarily expressed by the COS, which is, from a regulatory standpoint, inseparable from the CES (David, 2009), which represents the ratio of the built-up area on the ground to the land surface (Golany, 1996). Despite its relevance as a tool for determining urban density in Algeria, the COS has been subject to various criticisms in recent years due to the fact that it does not permit perfect qualitative control of building forms, particularly from a microclimatic perspective (Sylvain, 2012). If the CES and COS established by Algerian urban law pertain to strictly geometrical characteristics, they are in fact morphological density indices. There is an indisputable connection between these indicators and the microclimate of every urban entity, regardless of its location. This relationship can be defined by the concept of "morphoclimatic indicators".

By defining urban morphology as the three-dimensional shape of a collection of buildings and the consequent spaces, Nikolopoulou(2004) emphasized that the application of a variety of form indicators permits the establishment of connections with environmental performances, particularly climatic ones. According to Golany (1996), the adaptation of urban form to diverse climatic profiles can be broken down into four types of urban organization: compact, semi-compact, related, and dispersed. In this context, we have frequently discussed the impact of building geometry on sunlight, wind, and noise in urban open space. Therefore, these morphoclimatic indicators are descriptors that incorporate urban morphology, climate, and the environment in general (Stella, 2011). Benzarzour(2004) asserts, from an operational urban planning perspective, that indicators contain less specialized information and are therefore more disseminated among non-specialists in disciplines associated with climate and environmental issues, such as stakeholders in the built environment in general.This indicates that morphological markers serve as descriptors for analyzing non-morphological factors such as the climate environment.

Despite the considerable variation of climatic factors across the Algerian territory, the use of the CES and COS in urban design remains haphazard, and there is essentially no examination of the effect of urban density on microclimatic parameters. Consequently, there is a desire to investigate the effect of these morphological factors on the urban microclimate in Algeria. This is the primary issue addressed by this study, which also seeks to provide a suitable method for defining a new morphoclimatic indicator in compliance with national urban standards. In order to accomplish this, we selected a site of collective housing in the semi-arid city of Ain Smara as our operational sample. Ain Smara is a small town in Constantine's wilaya. Located in the north-east of Algeria (figure 1), it is approximately 16 kilometers from the wilaya's capital city. Its constant geographical location is 36.26°N latitude and 6.50°E longitude[1].

Figure 1. Location of the city of Ain Smara (Source: Google map)

METHODS AND MATERIALS

In order to conduct this study, we decided to create a geographic information system (GIS) using the «ArcGis9» program. The selection of this primary inquiry and analysis tool in the present study is justified by its suitability in terms of thematic and cartographic analysis. To accomplish this, we first compiled a database containing microclimatic and geometric information about the study site. We clarify that the data pertaining to the various microclimatic parameters are derived from our in-situ measurement campaign using a thermocouple (figure 2), whilst the geometric data pertaining to the height of the buildings and the width of the streets are derived using a disto-meter (figure 3). We utilized numerical simulations of the Envimet.4 and Rayman models to evaluate potential parameter modifications and reevaluations in order to effectively utilise this substantial database. In addition, the field measurement campaign spanned two distinct time periods (summer from 10 to 15 July and winter from 1 to 10 January) and two distinct spatial scales. The first involves all of the collective housing sites in the city of Ain Smara in order to cover a significant portion of the morphological and microclimatic realities of the sites in issue. Consideration of the entire city is recommended as a preliminary step in the search for such indications (Solène et Laëtitia, 2014; Marjorie, 2010). Given that the typology of collective housing is poorly controlled in terms of COS and CES, our second scale of measurement focused on a single group of collective housing, where we conducted bi-hourly daily measurements of the various microclimatic parameters in question on the hottest day of summer and the coldest day of winter. We remember that the ultimate goal of this study is to provide a tool for the regulation of the CES and COS by establishing a new «Morphoclimatic» indicator tied to urban density.

Figure 2 . Thermocouple **Figure 3.** Disto-mètre

RESULTS AND DISCUSSION

Influence of COS And CES on the Microclimate of A in Smara City

We remember that the COS and CES in a particular location connect directly to the land's occupation. For the city of Ain Smara, which spreads like an oil stain on nearly 328 ha (Cherrad, 2017), its land use is dominated by individual housing at a rate of 60 % as demonstrated in Figure 4, while collective housing occupies nearly 38 % of the city's territory and semi-collective housing accounts for only 2 %. The results of measuring the influence of COS and CES on this city's microclimate pertain to two seasons: summer and winter.

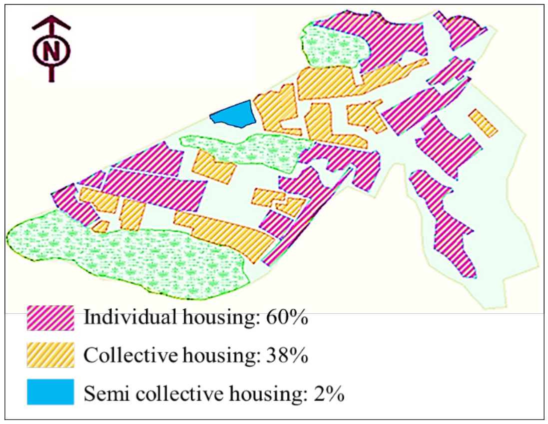


Figure 4. types of housingin Ain Smara(Author, 2022)

Measure of Impacts in Summer Period

During warm periods, the air temperature at the analyzed collective housing sites varies between 29°C and 35°C (Figure 5.A and Figure 6.A). Nonetheless, as shown in figure 5.B, there is no direct correlation between the measured temperature fluctuations and the CES values of the various sites. Although the Land Take changes from site to site, we may conclude that it has little effect on air temperature, which is subject to other variables. The investigation of fluctuations in air temperature as a function of COS led us to a nearly identical conclusion; where the direct effect of COS on air temperature has not been validated (Figure 6.B).

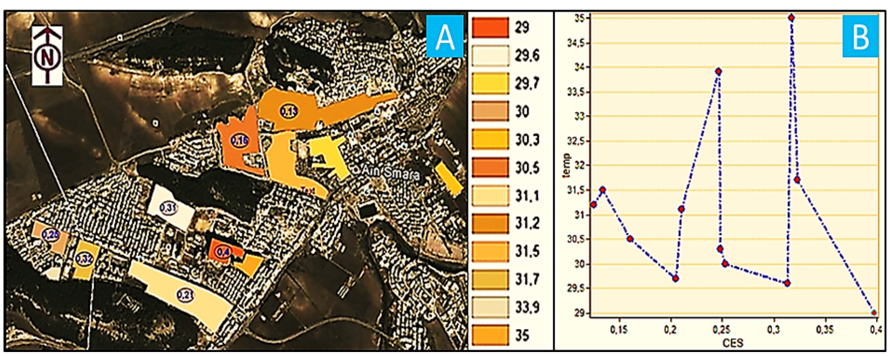


Figure 5. Summer air temperature distribution across collective housing sites as a function of CES (Author, 2022)

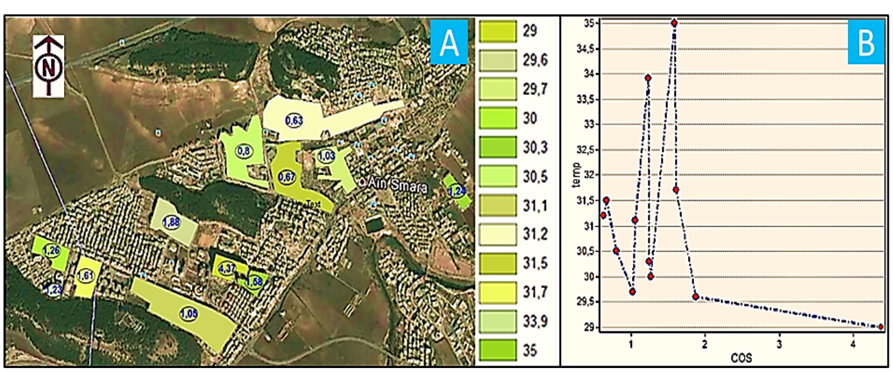


Figure 6. Summer air temperature distribution across collective housing sites as a function of COS (Author, 2022)

Measure of Impacts in Winter Period

According to Figures 7.A and 8.A, the winter air temperature at various locations fluctuates between 12°C and 14.5°C. Figures 7.B and 8.B illustrate a rising and falling pattern in air temperature values from one location to the next.

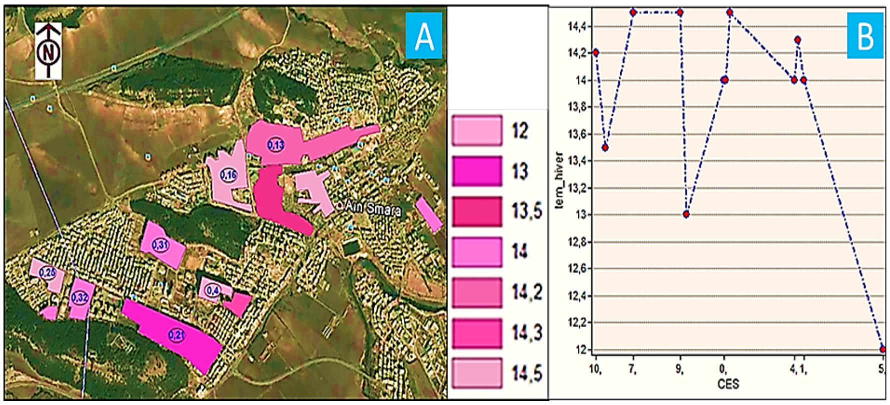


Figure 7. Winter air temperature distribution across collective building sites as a function of CES (Author, 2022)

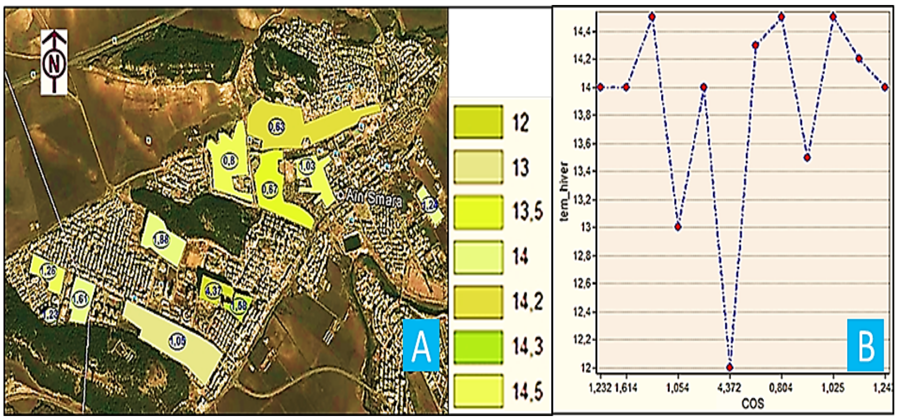


Figure 8. Winter air temperature distribution across collective housing sites as a function of COS (Author, 2022)

Regarding the summer season, it is currently unclear if a causal correlation exists to explain this temperature variance. Indeed, the COS alone or the CES alone cannot directly influence the urban microclimate, notably the air temperature, because they are two non-quantifiable, unitless, and consequently difficult to manage urban density indicators. Nonetheless, there must be one or more geometric characteristics that have affected the results of in situ measurements at the level of the individual clusters. The most persuasive of these factors are the prospect and the Sky View Factor (SVF) (Jérémy et al., 2018; Clément, 2008).

Effect Of Prospect and SVF on Microclimate

"Prospect" is represented by the ratio H/L, where "H" denotes the height of the buildings and "L" represents the distance between them and relates to the width of the street. We note that this topic has been studied for a very long time in numerous works addressing the direct effect of the street's height-to-width ratio on the illumination and natural heating of the air and buildings (Hans, Eriket al., 1997; Benzerzour, 2004). Oke (1982), on the other hand, has shown that precise ratio values achieve microclimatic control objectives (Clément, 2008; Benzerzour, 2004). Thus, building laws have begun to link height with constructed density and microclimate (Erik et Djamel, 2009; Benzerzour, 2004). Moreover, the SVF is defined as the portion visible from a fixed location in the sky (Jérémy et al., 2018). Because it is a determining factor in the permeability of urban spaces to microclimatic parameters, openness to the sky has made the regulation of street prospects one of the most appropriate provisions for ensuring an improvement in the supply of air, sunlight, and natural light to urban spaces and homes (Bourbia et Boucheriba, 2010; Benzerzour, 2004). It should be emphasized that, according to numerous global studies, the SVF and the prospect (H/L) have an inverse relationship (Boucheriba, 2017). Given the size of the urban perimeter of Ain Smara, it is difficult to measure these two factors and their effect on the microclimate at the city level. Consequently, there is a desire to reduce these measurements to a more manageable scale, which turns out to be a group of communal dwelling.

Assessing the Impact of the Prospect and SVF at the Level of the Study Case

The chosen location is southwest of the city of Ain Smara (figure 9), where three stations were planned. The selection of the three stations was based on certain geometric characteristics sufficient to support the research purpose.

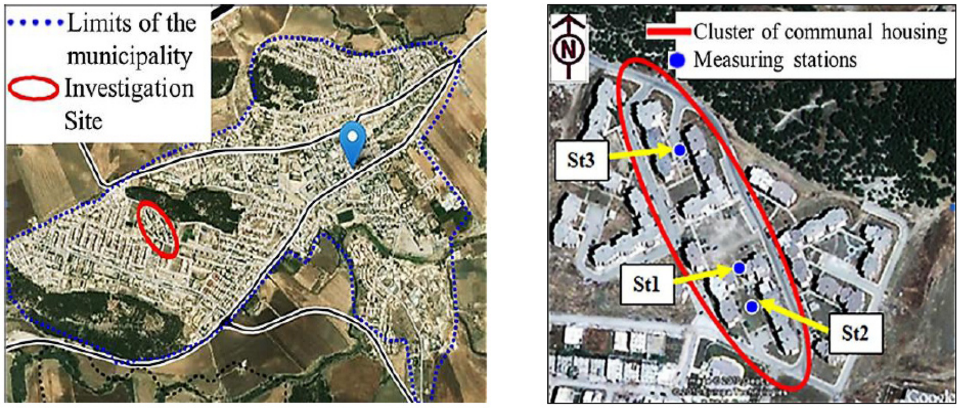


Figure 9. case study location (Source: Author, 2022)

To determine the impact of the prospect on the microclimate, we used a disto-meter to measure the distances between the buildings and their height in meters. In reality, all open spaces have been eliminated so that each station may be described by its height H and distance L. The close and direct relationship between the prospect and the SVF led us to these stations separated by buildings in order to estimate the distance between them to an accuracy of one meter. This site has an average COS of 1.86 whereas the CES is approximately 0.31. The height of the buildings is equal to RDC+5 (RDC in Algerian lexicon represents the ground floor) in terms of the number of levels. The RayMan simulation model was then fed these dimensions, enabling the calculation of the SVF represented as a percentage. Consequently, the results indicate that stations ST1, ST2, and ST3 are distinguished respectively by H/L ratios of 2.37, 1.48, and 1.78, whereas the SVF values are 0.30, 0.46, and 0.43, respectively (figure 10). Figure 11 provides more evidence that H/L ratios and SVF values are inversely related.

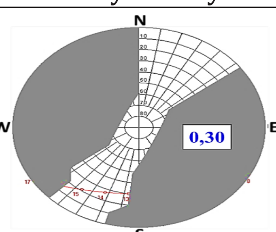
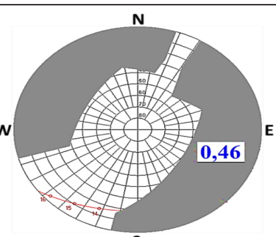
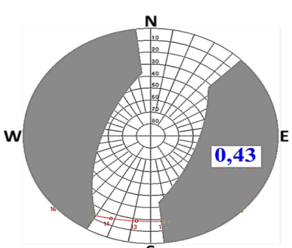
	Station	H/L	SVF (calculated by the RayMan model)	Photos
COS = 1,86 / CES = 0,31	St1	2,37		
	St2	1,48		
	St3	1,78		

Figure 10. Geometric characteristics of the three measuring stations (Author, 2022)

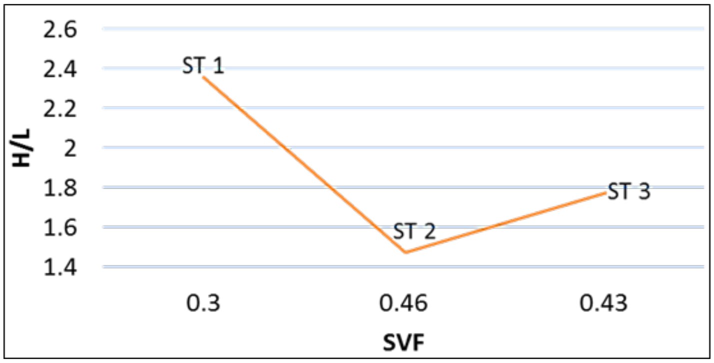


Figure 11. Variation of prospect (H/L) versus SVF at the three stations (source: Author)

Assessment of the Microclimate at the three Measuring Stations

The evaluation of the microclimate at the level of the collective housing group is another step in the investigation. At the three stations, several microclimatic data, including air temperature (T) in °C, relative air humidity (H) in percent, and wind speed (V) in meters per second, were measured (figure 10). These additional data complement the previously introduced collection of geometric and thermal metrics in our GIS.

During the Summer Period

The summer air temperatures at all three stations are found to be in perfect agreement with the SVF values. The temperature rises whenever the SVF rises (Table 1). This study highlights the significance of sunlight access to urban areas, which impacts both surface and air temperatures (Chahrazed, 2010). A reverse reading demonstrates that a high value of the prospect produces a cool urban island in a hot climate (Bourbia et Awbi, 2000).

Table1. summertime microclimatic and geometrical parameters of the three measuring stations

	T (°C)			H (%)			V (m/s)			H/L			SVF		
	St1	St2	St3	St1	St2	St3	St1	St2	St3	St1	St2	St3	St1	St2	St3
6h	21,7	21,4	21,5	46,3	46,5	46,0	0,0	0,0	0,0	2,37	1,48	1,78	0,30	0,46	0,43
8h	26,2	26,2	26,0	40,8	42,0	41,6	0,0	0,0	0,0						
10h	32,0	33,7	32,2	31,6	33,1	32,0	0,0	0,0	0,0						
12h	32,4	38,1	37,5	25,7	27,0	26,4	0,2	0,0	0,0						
14h	34,0	37,1	36,7	23,9	24,2	24,5	0,0	0,0	0,1						
16h	32,8	36,7	34,9	22,0	17,0	19,4	1,1	0,2	2,1						
18h	35,2	37,3	36,2	18,7	15,7	17,0	1,1	1,0	1,5						

Source: Author, 2022

Between 6 am. and 10 am., as depicted in Figure 12, the air temperatures at the three locations are remarkably similar. Until the conclusion of the day, station ST1 with the lowest SVF has a significantly lower temperature than the other two stations. At 12:00, a temperature difference of 5°C is recorded as the biggest.

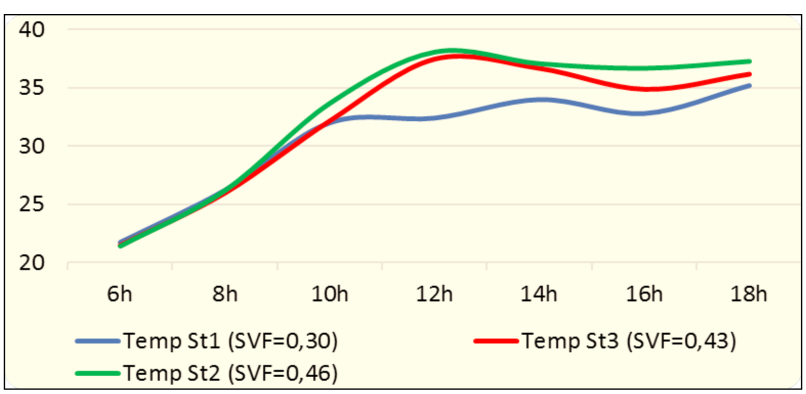


Figure 12. Differences in summertime air temperature across the three stations(Author, 2022)

Regarding the relative humidity of the air on this summer day, the declining tendency of the graph (Figure 13) may be observed throughout the day. From 6 am. to 14 pm., the values are almost the same. Beyond this, the relative humidity of the air at station ST1 with the lowest SVF (0.30) is the most significant, with a difference of 2 % from station ST3 (SVF = 0.43) and a difference of 4 % from station ST2 (SVF = 0.46). This result is comparable to the conclusion reached by Awbi and Bourbiain 2002, who demonstrated that air temperature and relative humidity in urban areas are inversely related in arid and semi-arid climates.

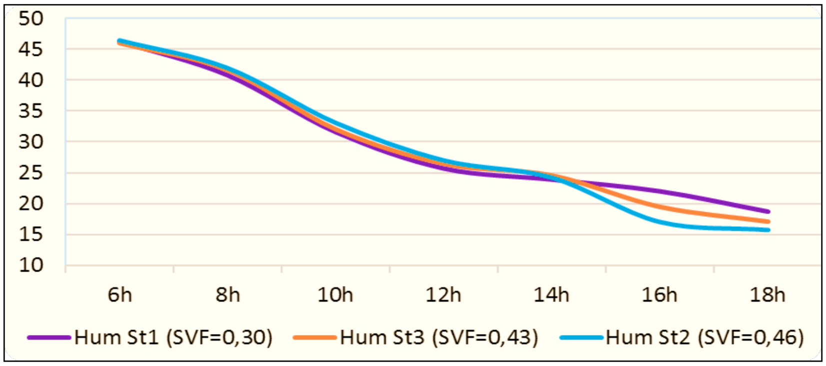


Figure 13. Differences in summer relative humidity across the three stations(Author, 2022)

During Winter Period

From 8:00 am to 12:00 pm, the winter air temperature values of the three sites are fairly near (see table 2).

Table 2. Microclimatic and geometrical features of the three winter measurement locations

	T (°C)			H (%)			V (m/s)			H/L			SVF		
	St1	**St2**	**St3**	**St1**	**St2**	**St3**	**St1**	**St2**	**St3**	**St1**	**St2**	**St3**	**St1**	**St2**	**St3**
8h	10,5	10,5	10,4	67,3	65,0	6,1	0,0	0,7	0,2						
10h	12,6	12,4	12,0	65,0	62,8	65,0	0,0	1,5	0,2						
12h	14,5	14,7	14,3	63,5	59,2	61,5	0,0	0,0	0,0	2,37	1,48	1,78	0,30	0,46	0,43
14h	16,5	18,2	16,7	52,5	51,5	54,0	0,0	0,0	0,0						
16h	12,5	13,8	13,6	49,2	47,5	45,0	0,0	0,0	0,0						

Source: Author, 2022

However, beginning at noon, the air temperature at station ST2 begins to diverge from the other two sites (ST1 and ST3) by 1.5°C and becomes progressively more significant until 4:00 p.m. (figure14). This finding is due to the fact that station ST2 (Figure 10) is clearly exposed to solar radiation throughout the day when the winter sun reaches its highest point in the sky. This access to the sun is facilitated by a large opening to the sky and enhanced by the absence of potential environmental obstructions on the south side. However, this conclusion contradicts the findings of our previous research on the site of Coudiatin the city-center of Constantine, which demonstrated that a big SVF in warm regions makes cold winter winds more accessible, hence lowering the air temperature (Boucheriba et Bourbia, 2011). This is not the case with the ST2 station in Ain Smara due to the presence of environmental masks that shield this location from cold northeast and northwest winds.

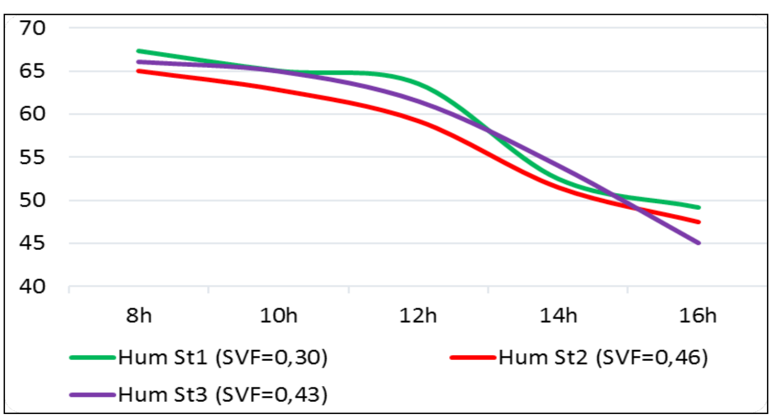


Figure 14. Differences in winter air temperature across the three stations(Author, 2022)

During the winter, the relative humidity of the air is greatest at the beginning of the day and decreases throughout the day. Nonetheless, it is observed that the relative humidity of the air at the station ST2 with the most significant SVF (0.46), during the longest period of the day, is significantly lower than the relative humidity of the air at the two other stations (ST1 and ST3) with SVFs of approximately 0.30 and 0.43, respectively (figure 15). This is because station ST2 is well exposed to winter sunlight during the winter solstice when the sun is at its highest point.

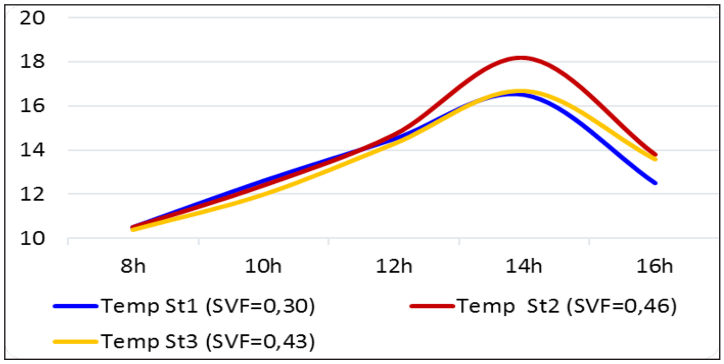


Figure 15. Variation in winter relative humidity across the three stations (Author, 2022).

Identifying a Morphoclimatic Density Indicator in Relation to H, L, SVF, COS and CES

Given that we began our research by noting that the COS and the CES are two closely related urban density indicators according to the applicable urban regulations, we recall that the COS (indicator of vertical density) has a greater impact on an urban microclimate than does the CES. On the basis of this premise and the fact that the COS (like the CES) is a hypothetical term devoid of units, we chose to link it to a real and quantifiable geometric parameter, which was represented by the prospect (H/L). This has a demonstrable effect on the management of urban microclimate and effects the SVF directly (figure 16).

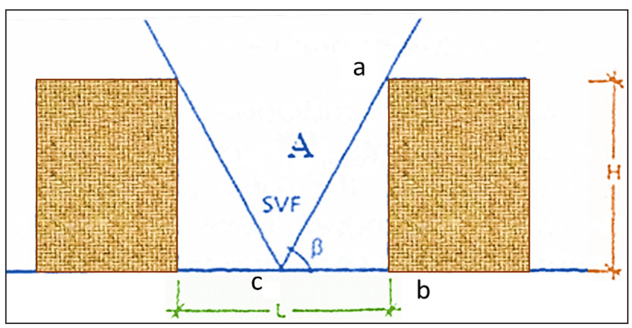


Figure 16. Illustration of the geometrical characteristics of an urban site (Author, 2022)

We then proceeded to a mixture of mathematical formulas that allowed us to deduce the empirical link that can unite these geometric parameters.Consequently, this formula, which relates to the development of a morphoclimatic density indicator, is actually intended for the application of a regulatory tool that enables the computation of the SVF using the COS and CES. The valuation of the SVF as opposed to the prospect is based on the fact that it is the most exploited in the research focused on the urban microclimate, which includes modeling and numerical simulations of the sunlight, ventilation, and the exterior thermal comfort experienced by the users. This reality makes it feasible to identify solutions for the improvement of urban microclimates by adjusting certain parameters to affect others. In conclusion, the following is a summary of the outcome:

Beginning with the previously stated equation, which states:

COS = CES * n

Where "n" is the number of levels of a single construction (e.g., a construction with a groundfloor plus two floors would have three levels).

It was determined that:

COS = CES * H/h

Where: "H" represents the height of a single structure in meters

"h" represents the height of a single level in meters

On the other hand, we have the following equation:

$SVF = \cos\beta SVF = \cos\beta$ **...[23]**

Given that: $l =$ L/2,

Where: h represents the average floor height and A represents the hypotenuse of triangle abc.

Consequently, we shall have the Pythagorean geometric equation indicating that:

$\boldsymbol{H^2 + l^2 = A^2}$..........................(**Equation 1)**

Thisimpliesthat:

$A = (H^2 + l^2)^{1/2}$,

and given that:

$SVF = \cos\beta$

thenwe get:

$SVF = \frac{L}{2*\sqrt{H^2+l^2}}$..........................**(Equation 2)**

Having previously identified the limits of L and H for outdoor thermal comfort, we can additionally define the limit of SVF using equation n°2. Knowing that :

$$H = \frac{COS * h}{CES}$$

Thus, we will have:

$\boldsymbol{SVF} = \frac{L}{2*\sqrt{\frac{COS*h^2}{CES^2}+l^2}}$ ....**(Equation 3)**

Consequently, equation n°3 contains two unknowns, namely the COS and the CES; if the SVF is known, it is straightforward to determine the value of the COS by setting the CES. We have now been able to establish an empirical relationship between the SVF and the two density indicators COS and CES (Equation 4) on the one hand, and the geometric characteristics of the built environment, namely H (building height) and L (street width) on the other (equation 3). Moreover, specialists in the field of urban climatology are aware of the SVF's influence on the thermal ambience of outdoor places (Oke, 1982) as well as on thermal comfort, making it the morphoclimatic indicator of population density par excellence. Therefore, the SVF may integrate urban morphology with the climatic and environmental performance of urban forms.

CONCLUSIONS

The selection of the COS and CES is in fact based on a number of factors unrelated to environmental considerations or the potential landscape quality. The urban act adheres to several conditions necessitated by the reality of the land, such as the value of the property, the right of ownership, the morphological limits, and the needs of a continuously expanding urban population. This study concludes that there is no correlation between COS and CES and microclimatic fluctuations, particularly air temperature. Due to this, we have focused our considerations on the search for microclimate-altering parameters at our study site. Consequently, the goal was to assign these two indices aspects that were quantifiable and more manageable. It was believed that the prospect (H/L) was the only means of achieving this objective. This index based on accurate geometric characteristics permits access to many simulation models and the calculation of the SVF, which establishes the relationship between the morphological and climatic aspect. We were able to confirm the proportionality between H/L and SVF.

A lower SVF makes it possible to cool the air in the summer in a semi-arid area. Its impact in winter is mostly determined by the orientation of the roadway or urban space in relation to the sun's path and the direction of the wind. Since COS and CES are the focus of our research, it is essential to note that for the first time we have established a clear and direct empirical relationship between all indicators: H/L, COS, CES, and SVF. The uniqueness of this discovery is demonstrated by the link created between the SVF and the two indicators of urban density in Algeria (COS and CES), which gives it the label of a readily applicable new “morphoclimatic indicator” at the level of urban climatic regulation. The other additional value that reinforces the output of this research is the specificity of the typology of communal housing, whose idea of COS and CES has frequently been confusing, and which gains a new technique of evaluation and control as a result of this research.

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