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EXPLORING BUILDING'S CLIMATIC ADAPTABILITY THROUGH CRITICAL REGIONALISM: THE WORK OF FERNAND POUILLON AND EL-MINIAWY BROTHERS IN SOUTH OF ALGERIA

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Oum El-Bouaghi, 2022

To the soul of Hany El-Miniawy,

رحمه الله وجعل هذا العمل صدقة له ولنا إذا صرنا إلى ما صاروا إليه، آمين

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ABSTRACT

Both identity and climate-responsive design issues in Algeria are still a big concern. Globalisation has affected architecture through the irrational adaptation of forms and materials. The regions where the climate is severely hot-dry, e.g., south of Algeria (more than 80% of the total surface of Algeria) are harmed more. As a response to identity and climate, this thesis aims to develop design strategies toward a comfortable, climate-responsive architecture with an excellent representation of identity. The 'Critical Regionalism' approach and occupants' thermal comfort are the key assessment criterion throughout the research.

Firstly, the thesis develops a new practical evaluation method of the critical regionalism approach concluded by pioneer theorists. A simple climate analysis tool is used to analyse the climate of eight regions of Algeria to determine effective strategies according to both PMV-PPD and adaptive comfort models. A further explication of climate-responsive design parameters inspired by the vernacular architecture of the Algerian south is conducted too. Fernand Pouillon and El-Miniawy brothers, very known architects who work over Algerian territory have been presented through their biographies, thoughts, philosophies and projects. Three case studies of each one of them are selected (six cases in total) for further investigations. Thereafter, a comprehensive framework is carried out to explore their performance in both identity and climatic adaptability points of view, through several methods (polemic essay, data collection, interview, qualitative architectural analysis, survey, in-situ measurements, dynamic simulation, parametric simulation, sensitivity analysis and optimization). Different aspects of architectural design that meet the critical regionalism criteria are explored and outlined. Also, the thermal performance of the case studies is investigated and optimized using dynamic simulation. The results reveal that the case studies apply the approach and adapt to the harsh climate of the Algerian south. Finally, the original contributions of this thesis are summarized and further works are outlined.

Keywords:

'Critical Regionalism' approach – architectural identity – climate-responsive design – Fernand Pouillon – El-Miniawy brothers – hot-dry climate – south of Algeria.

RÉSUMÉ

Les questions d'identité et de conception sensible au climat en Algérie sont toujours une grande préoccupation. La mondialisation a affecté l'architecture par l'adaptation irrationnelle des formes et des matériaux. Les régions où le climat est sévère chaud-sec, par exemple le sud de l'Algérie (plus de 80% de la superficie totale de l'Algérie) sont plus touchées. En réponse à l'identité et au climat, l'objectif global de cette thèse est de développer des stratégies de conception vers une architecture confortable et sensible au climat avec une excellente représentation de l'identité. L'approche « Régionalisme critique » et le confort thermique des occupants sont le critère d'évaluation clé tout au long de la recherche.

Dans un premier temps, la thèse développe une nouvelle méthode d'évaluation pratique de l'approche du régionalisme critique conclue par des théoriciens pionniers. Un outil d'analyse climatique simple est utilisé pour analyser le climat de huit régions d'Algérie afin de déterminer des stratégies efficaces selon les modèles PMV-PPD et de confort adaptatif. Une explication supplémentaire des paramètres de conception adaptés au climat inspirés de l'architecture vernaculaire du sud algérien est également menée. Fernand Pouillon et les frères El-Miniawy, des architectes très connus qui travaillent sur le territoire algérien ont été présentés. Trois cas d'étude de chacun d'eux sont sélectionnées (six cas au total) pour des investigations ultérieures. Par la suite, un plan d'étude est réalisé à travers plusieurs méthodes (essai polémique, collecte de données, entretien, analyse architecturale qualitative, enquête, mesures in-situ, simulation dynamique, simulation paramétrique, analyse de sensibilité et optimisation). Différents aspects de la conception architecturale qui répondent aux critères de l'approche régionalisme critique sont explorés et décrits. En outre, les performances thermiques des cas d'étude sont étudiées et optimisées à l'aide de la simulation dynamique. Les résultats révèlent que les cas d'étude appliquent l'approche et adaptent le climat rigoureux du sud algérien. Enfin, les contributions originales de cette thèse sont résumées et les travaux ultérieurs sont décrits.

Mots clés :

Approche « Régionalisme critique » – identité architecturale – conception adaptée au climat – Fernand Pouillon – frères El-Miniawy – climat chaud-sec – sud Algérien.

ملخص

لا تزال قضايا الهوية والتصميم المتلائم مع المناخ في الجزائر مصدر قلق كبير. أثرت العولمة على العمارة من خلال الاستخدام اللاعقلاني للأشكال والمواد. المناطق التي يكون فيها المناخ شديد الحرارة والجفاف، كجنوب الجزائر (أكثر من 80 ٪ من إجمالي مساحة الجزائر)، هي الأكثر تضررا. استجابة للهوية والمناخ، فإن الهدف العام لهذه الأطروحة هو تطوير استراتيجيات التصميم نحو عمارة مريحة ومتلائمة مع المناخ مع تمثيل ممتاز للهوية. المنهج "الإقليمي النقدي" والراحة الحرارية للمستخدمين هي معيار التقييم الرئيسي في جميع أنحاء هذا البحث.

أولا، تطور الأطروحة طريقة تقييم عملية جديدة للمنهج الإقليمي النقدي المستخلص من المنظرين الرواد في هذا المجال. يتم استخدام أداة بسيطة لتحليل المناخ لتحليل مناخ ثماني مناطق في الجزائر من أجل تحديد الاستراتيجيات الفعالة وفقًا لكل من نموذج PMV-PPD وadaptive. كما تم إجراء شرح إضافي لمعايير التصميم المتلائمة مع المناخ المستوحاة من العمارة التقليدية (القديمة) للجنوب الجزائري. تم تقديم فرناند بويون والأخوين المنياوي من خلال سيرهم الذاتية وأفكارهم وفلسفاتهم ومشاريعهم، وهم مهندسون معماريون معروفون كانوا قد عملوا من قبل في القطر الجزائري. تم اختيار ثلاث حالات لكل منهما (ست حالات في المجموع) لدراستهم في هذا البحث. بعد ذلك، يتم تنفيذ خطة بحث شامل لاستكشاف أدائهم في كل من جانبي الهوية والتكيف المناخي، من خلال عدة طرق (مقال جدلي، جمع البيانات، مقابلة، تحليل معماري نوعي، استبيان، قياسات في الموقع، محاكاة ديناميكية، محاكاة بارامترية، تحليل الحساسية والتحسين). يتم استكشاف وتحديد الجوانب المختلفة للتصميم المعماري التي تلبي معايير "الإقليمية الحرجة". أيضا، يتم فحص الأداء الحراري لحالات الدراسة وتحسينه باستخدام المحاكاة الديناميكية. كشفت النتائج أن حالات الدراسة تطبق نهج "الإقليمية النقدية" وتتكيف مع المناخ القاسي للجنوب الجزائري. أخيرًا، تم تلخيص المساهمات الأصلية لهذه الأطروحة وتم توضيح الأعمال الأخرى المستقبلية في هذا السياق.

الكلمات الدالة:

المنهج "الإقليمي النقدي" - الهوية المعمارية - التصميم المتلائم مع المناخ - فرناند بويون - الأخوان المنياوي - المناخ الحار الجاف - جنوب الجزائر.

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NOMENCLATURE

Symbols

A_j	Opening (j) surface	m^2
e	Acceptable sample error 10% or (0.1)	
E_{max}	Maximum output values	
E_{min}	Minimum output values	
e_{vi}	Wall (i) wind exposure coefficient	
L	Body thermal load	W/m^2
M	Metabolic heat production rate	W/m^2
n	Number of measured periods	
n_p	Number of pieces	
n_s	Sample size	
p	$P=1$	
P_{oj}	Opening (j) surface air permeability	$m^3/h.m^2$
p_p	Estimated percent in the population 50% or (0.5)	
P_{pi}	Wall air permeability	m^3/h
q	Equals to (1-p_p)	
q_{res}	Total heat loss from respiration rate	W/m^2
Q_s	Flow rate by wind infiltration (winter)	m^3/h
q_{sk}	Heat loss from skin rate	W/m^2
Q_v	Specific ventilation rate	m^3/h
qv_{inf}	Flow rate by wind infiltration (summer)	m^3/h
Q_{vmax}	Maximum extract flow rate	m^3/h
Q_{vmin}	Minimum extract flow rate	m^3/h
$qvo_{inf,i}$	Opening (i) infiltration rate	$m^3/h.m^2$
Q_{vref}	Reference extract flow rate	m^3/h
S	Heat storage rate	W/m^2
$S_{ouv,i}$	Opening (i) surface	m^2
T_{comf}	Operative temperature	ºC
T_{out}	Prevailing mean outdoor air temperature	ºC
V_h	Volume of living spaces	m^3
W	Mechanical work accomplished rate	W/m^2
$\bar{y}$	Measurements' average	
y_i	Period (i) actual measurement	
$\hat{y}_i$	Period (i) simulated value	
z	Standard error (1.64) associated with the level of confidence (90%)	

Abbreviations

ACH	Air changes per hour
ASHRAE	American Society of Heating, Refrigerating and Air Conditioning Engineers
CR	Critical Regionalism

CVRMSE	Coefficient of Variation of the Root Mean Square Error
FP	Fernand Pouillon
GSA	Global sensitivity analysis
HVAC	Heating, ventilation and air-conditioning
IEA	International Energy Agency
ISO	International Organization for Standardization
LSA	Local sensitivity analysis
MB	El-Miniawy brothers
MC	Mechanically-conditioned
NMBE	Normalised Mean Bias Error
NV	Naturally ventilated
OAT	One-at-a-time
PIS	Performance index system
PMV	Predicted mean vote
PPD	Predicted percentage dissatisfied
RH	Relative humidity
SA	Sensitivity analysis
SDG	Sustainable Development Goals
SI	Sensitivity index
TMY	Typical meteorological year
TSV	Thermal sensation vote
UCLA	University of California, Los Angeles
WWR	Window to wall ratio

INTRODUCTORY CHAPTER
INTRODUCTION

A. Introduction (motivation)

To find a middle ground between 'Modernism' and 'Postmodernism', to revive vernacular but be rational and contemporary, to adapt the context and assure the particularity of region and culture, to benefit from resources and nature, to be real instead of being vulgar and out of place. The idea is not about names or titles, the main objective is the noble concept and innocent goal of reality. Anyway, the notion of 'Critical Regionalism' (CR) has been first talked about in 1981, by Alexander Tzonis[1] and Lian Lefaivre[2]. The concept came as a description of what several architects tried to do as a reaction to 'Postmodernism' and its celebrated ornaments as essential to architecture at that time (Tzonis & Lefaivre, 2003). Later on, in 1983, the theorist Kenneth Frampton[3] introduced the approach in six points that are called 'Six Points for an Architecture of Resistance, this essay criticized the 'universalization' and non-culture multiplicity. Also, mankind's ability to interpret life and create a new nucleus for civilizations. However, there is a paradox between being rooted in resources and adapting scientific, technical and political rationality to keep pace the modern civilization. Therefore, Frampton's idea was to introduce six points that can be criticized as being modern and returned to resources (Frampton, 1983). Afterwards, the same theorist spread 'Ten Points on an Architecture of Regionalism: A Provisional Polemic', which discussed in its most evident form, the main concepts that explain the approach, where he clarifies the situation that architecture suffered from because of the capitalism and lose of cultural and social values in this era. Frampton called it a 'speculative manifesto' which opens the door for extensive debate

[1] Alexander Tzonis (1937-present) is a professor at the University of Technology, Delft, Netherlands

[2] Liane Lefaivre is a professor at the University of Applied Arts in Vienna, Austria

[3] Kenneth Frampton (1930-present) is the Ware Professor at the Graduate School of Architecture and Planning, Columbia University

to find a reliable practice of architecture (Frampton, 1987). 'Region' means physically to a frontier of place that is determined by extremes of culture and nature (Canizaro, 2007), it can be shown in architecture that responds to the local quality of place, which has a relationship also to the sociocultural practice.

Other pioneer theorists have talked about the idea of regionalism in architecture: Lewis Mumford[4] in his writing 'Regionalism' in 1924; Süha Özkan[5] in his writing 'Regionalism within Modernism' in 1985; William J. R. Curtis[6] in his writing 'Authentic Regionalism' in 1986; and Alan Colquhoun[7] in his writing 'Regionalism' in 1997. The global concern about these theories is the identity in architecture with relative concerns to the nature and environment constraints in some of them as an influencing parameter.

Identity in design and singularity of place

Is the architecture a product or a building's process? … by considering both concepts, which are irrelated and reflect the architecture, the contradiction in cultural settings can be revealed. Therefore, the critique of the architecture of these values is always contributing to much understanding of 'identity in design' (Al-Masri, 1993). Architectural identity can be identified as a particular local culture which represented in form of a living landscape with the singularity of the place that accumulated over time and shows a unique perspective towards life (Nooraddin, 2012).

The notion of 'design thinking is a valid concept for discussing and understanding architecture. The Modernity issue brings the inevitability of change. Cultural identity does not mean the blind adoption of cultural artefacts, but being aligned with change and culture with synthesis and incorporation (Ali, 1989). Architecture should be influenced by regional practices, climate, local materials, craftsmanship and local building traditions (Steffen Lehmann, 2016). Architectural design that is imported from the context plays a significant role in determining design vocabulary, while the context refers to specific settings in which the building is surrounded. Therefore, it is mandatory to understand the factors that affect the 'sense of place' and 'identity' (Lambe & Dongre, 2016). Identity is a process, not a found object (Correa, 1983). Sometimes, new arrivals to regions can reshape the identity of the place

[4] Lewis Mumford (1895-1990) was an American historian, sociologist, philosopher and literary critic

[5] Süha Özkan (1945-present) is a Turkish architect, architecture critic, theorist and lecturer

[6] William J. R. Curtis (1948-present) is an architectural historian whose writings have focused on twentieth century architecture

[7] Alan Harold Colquhoun (1921-2012) was an English architect, historian, critic and teacher

by adding new elements that have following their perspective. Later on, this restructuring manner influences the building's form, plan and structure which produces a new identity in design (Heath, 2009). Identity is what a group of people recognized in a specific place and time, a set of meanings can be identified, and by changing of any of that parameters, the identity is subject to change. Anyway, resistance to forms is always strived by societies to maintain the continuity of identity (Al-Naim, 2008).

Adaptive architectural design

Since many statistics reveal that buildings consume approximately 40% of the world's total energy consumption, architects and engineers have a very important role in designing architecture that meets both energy and occupants' comfort expectations. An adaptive architecture to the climate is inevitable and well encouraged.

'Climate-responsive design' means that the outer shell and volumes' settings can respond to climate changing over seasons and shifting between day and night. Therefore, the idea is to find the appropriate choices in design to assure the 'low tech' buildings through passive strategies, which can be found most in vernacular architecture that can be taught (Lehmann, 2011).

Fernand Pouillon and El-Miniawy brothers

Fernand Pouillon (FP) (1912-1986) a French architect and El-Miniawy brothers (MB), Hany (1947-2022) and Abdel Rahman (1950-present), the two Egyptian architects have left their touch in the architectural history of Algeria. Iconic projects contribute to raising the level of consciousness of locals and architects towards different regions. FP and MB have realised many projects over the country (more than 50 projects). With more concerns to their work in the south of Algeria, this thesis explored the El-Gourara hotel in Timimoun (1968), the M'Zab hotel (1970) and El-Djanoub (1974) hotels in Ghardaïa designed by FP and Maader village in Bou-Saada, M'sila (1975-1980), 400 in El-Oued (1979) and 600 in Ouled Djellal, Biskra (1980) housing units designed by MB.

However, architects in Algeria and abroad have been affected by the international style, either by directly influencing or forced undirect influencing. The commonly used materials and forms that are spread over the world through hidden forces and policies are one of the most influencing parameters on architecture and cause its degradation in terms of regional identity and climatic adaptability. Yet, a gap between realised buildings and what identity in architecture claims is revealed. To fill this gap, this research is looking for a practical solution

H. Previous studies

Although the concept of CR is well known in global scientific theory and history, there is no similar local academic work regarding the practical implication of this concept. However, several global and local studies have been conducted on a similar topic or have the same interests and objectives in terms of regional identity and climate-responsive design. As following, there are important references and similarly conducted studies:

* Al-Masri, W.M., 1993. *Architecture and the question of identity: issues of self-representation in Islamic community centers in America* (Doctoral dissertation, Massachusetts Institute of Technology).

* Colquhoun, A., 1997. The Concept of Regionalism, postcolonial Space (s).

Curtis, W.J., 1986. Towards an authentic regionalism. In *Mimar 19: Architecture in Development*. Edited by Hasan-Uddin Khan. Singapore: Concept Media Ltd..

* Fathi, H. and Abd al-Rahman, S., 1986. *Natural energy and vernacular architecture: principles and examples with reference to hot arid climates*. University of Chicago.

* Frampton, K., 1983. Towards a Critical Regionalism: Six Points for an Architecture of Resistance. *The Anti-Aesthetic: Essays on Postmodern Culture*, pp.16-30.

* Frampton, K., 1987. Ten points on an architecture of Regionalism. *Architectural Regionalism: Collected Writings on Place, Identity, Modernity, and Tradition, edited by Vincent B Canizaro*, pp.374-85.

* Givoni, B., 1969. *Man climate and architecture*.. Oxford: Elsevier publishing Co.Ltd.

* Lefaivre, L.M. and Tzonis, A., 2003. *Critical regionalism: architecture and identity in a globalized world*. Prestel publishing.

* Maachi Maïza, M., 2002. *La composition architecturale dans l'œuvre algérienne de Fernand Pouillon, cas du Sud-ouest algérien* (Master dissertation, Centre universitaire Béchar).

* Mazouz, S., 2010. La crise identitaire dans l'architecture en Algérie.

* Nguyen, A.T., 2013. *Sustainable housing in Vietnam: Climate responsive design strategies to optimize thermal comfort* (Doctoral dissertation, Université de Liège, Liège, Belgium).

* Olgyay, V., 1963. *Design with climate - Bioclimatic approach to architectural regionalism*. New Jersey: Princeton University Press.

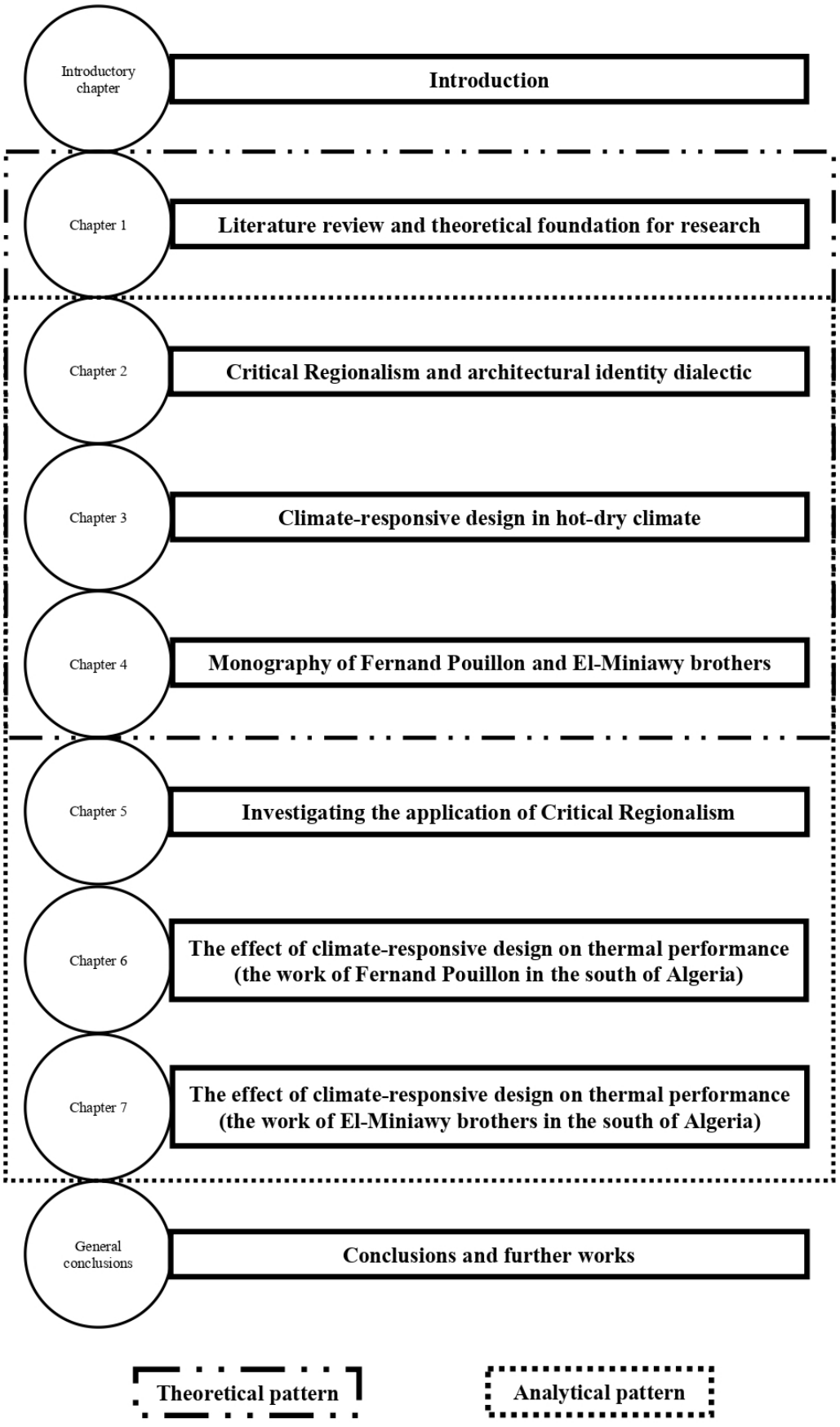


Figure I. *The structure of the thesis.*

CHAPTER ONE
LITERATURE REVIEW AND THEORETICAL FOUNDATION FOR RESEARCH

1.1. Introduction

By providing an up-to-date overview of researches advancements related to identity and globalization concerns, this chapter discusses the concept of identity and the role of modernity in the shift towards globalisation, which became a crucial study in identifying the factors that influence the concepts of change and continuity in architectural/urban identity. Also, climate-responsive architecture which is inspired by vernacular has shown growth through the development of contemporary research methods. This chapter aims to prepare a theoretical comprehension of the thesis' subject and research domain.

1.2. Literature review on identity and globalization

1.2.1. Terms and definitions

1.2.1.1. Identity

According to Watson and Bentely (2007), '*Identity is neither an easily reducible, nor a separable quality of places it is neither constant and absolute, nor is it constantly changing and variable*', the authors indicate the complexity of 'identity' and its opposition to rootlessness, it is a cohesive feeling and a binding force that enhances the sense of belonging, this force can overcome to several economical and physical issues, also can be an efficient factor to bring new investments and talents into the area.

Another definition of identity by Abel (1997), where states that identity is a process, it comes from the accumulation of civilization's culture through history, so, the identity cannot be a found object or fabricated but rather being lived and developed, it appears as a result of understanding ourselves and our environment, it is a diagnostic of our real problems that we are facing nor only a self-conscious of being having an identity as an endpoint.

Also, Aly (2011), adds that religion is the key factor in affecting the continuity of traditions and identity, whereas most suggestions in re-interpreting the traditional image are belonging to the religion itself and our understanding of its boundaries and aims.

1.2.1.2. Globalization

In opposition to the divergence, the globalization crisis suspends every meaning of identity. So, the place is where the space loses its meaning of authenticity. The postcolonial diasporas are an example of that, where the identity becomes diasporic, it is divided into several authentication spaces, neither universalized nor original. Ironically, the more globalization increases the more the areas of anti-universalized and identity heralds are increasing too, now the world is fragmented due to these two opposite parts which made globalization lose its power and ceases to constitute a universal space (Afonso, 2004). **Figures 1-1 a and b** represent the impact of globalization (or universalism) on the production of architectural identity worldwide.

(a) 

(b) 

Figure 1-1. *Pictures showing identity in architecture (a) vs. the globalization in the architecture of many countries around the world (b). Source: https://archinect.com/forum/thread/120945211/architectural-globalization-a-storm-or-a-breeze (Accessed date: November 22nd, 2017).*

1.2.1.3. The anti-humanism

When speaking about universalism, the overall redefinition of humans is being imposed. While universalism obliterates every sense of identity, thus the religious message is no longer directed towards man, but rather towards the extinction of man. Once identity becomes fragmented, cultural, aesthetic and religious expression no longer exists to present human conditions or their variations (Afonso, 2004).

1.2.1.4. Region

According to Curtis (1986), '*"Region" is at the very best a hazy notion. It may refer to the distribution of racial or ethnic groups; to common geographical or climatic features; to political boundaries de-limiting a tribe or some other federation. Rarely does it make sense to*

make a direct equation between region and nation, or between region and religion. In these circumstances it is necessary to beware of deterministic arguments that jump automatically from one region to one set of forms. The grass roots idea of culture is useful so long as it forces attention upon basic patterns of adaptation in the traditional architecture of a region (e.g., to climate) but misleading the moment that it ignores the role of exterior influences'.

1.2.1.5. Culture and tradition

'*Culture is not composed of elements which can be disassembled and re-composed: culture has to be lived. Culture is mature and sediment slowly as they become fused into the context and continuity of tradition*' (Canizaro, 2007).

According to Graburn (2000), tradition is defined as a manner of perceiving space or expressing things in a typical way. However, there is a tradition in every field, the same is for architecture too, traditional architecture can be understood as vernacular, which is architecture without a known author, there is also a tradition in every new trend in architecture that predefines the space. However, traditional sources can be culture, anthropology, memory, habits, media … etc. Leach (1997), adds that all these notions related to space are proof of considering the built architecture as a cultural ingredient that effects directly or indirectly city's theory specialists. Mihaila (2014), includes that educators should consider this very important issue of built architecture as a cultural ingredient in future cities' characters in rehabilitation, preservation, sustainable development and innovation growth.

Le Corbusier[1] once said: '*... la tradition est la chaîne ininterrompue de toutes les novations et, par-delà, le témoin le plus sûr de la projection vers l'avenir*' (Weber & Yannas, 2014). '… tradition is the unbroken chain of all renewals and, beyond that, the surest witness of the projection toward the future'. As Le Corbusier said, traditions are consecutive actions through history, these actions can be analysed and interpreted to simulate and predict the future. However, architecture and cities are considered traditions too, they included two types of fabrics, physical and social (anthropological) which are reflecting and affecting each other's (the relation between physical forms and anthropological aspect of space – the duality of place/space through traditions, culture, identity and climate).

According to Weber and Yannas (2014), the global architectural community has been interested in vernacular and traditional architecture, while the earlier studies and existing

[1] Charles-Édouard Jeanneret (1887-1965), known as Le Corbusier, was a Swiss-French architect, designer, painter, urban planner, writer, and one of the pioneers of what is now regarded as modern architecture

publications have taken vernacular architecture in point of view anthropological or archaeological side, not from a climate efficiency point of view. Similarly, the studies of climate design were considering contemporary cases and modern technologies without referring to past experiences.

1.2.2. Architectural identity

The architectural identity is presented in many aspects which expresses the trail of the culture of civilizations. It is not a found object, but rather a process, an accumulation of cultures through history. Since it is a process, identity cannot be fabricated or industrialized, we build our identity by recognizing our real problems and tackling them (Correa, 1983).

So, architectural identity is supposed to take into consideration the problems that may occur before designing the space, after realising it and while using it. This complex issue can be related to these concepts: (social anthropological needs, and climate issues, for example). Therefore, while we design and use the spaces through these years and after the juxtaposition of traditions, the architectural identity has been built, not only the architectural models and elements but also the usual use of the space and the understanding of it in the unconsciousness of users and receivers. Thus, the pre-visualizing of the urban fabric is an important issue too, to control the harmonic process of these spaces all under the tent of architectural identity (Kaihoul & Sriti, 2018).

1.2.2.1. Anthropology of space

According to Hatzopoulou (2004), It is an interdisciplinary science that explores the relationship between man, space and time, by drawing on the past. It develops the present with prospects and plans for the future. More specifically, it creates an appropriate environment for the man that responds to today's needs by reviewing the particularity of space and qualitative values to improve it so that a new harmony of space can be born again. However, the anthropology of space aims to assure the preservation and continuity of social groups' identity through history, and also to create new diversities that assure multi-identities and avoid uniformity.

According to Muntañola Thornberg, the architecture of human space is affected by three factors: thoughts, history and territory (body, society and environment). Thus, identities (masks or traces) of individuals or society are composed which determine a precise place. However, the mental structure of this precise place or this identity is having a relationship between forms and concepts, between the local and global, between one's own culture and that

of others, etc., those are not a universal structure, but rather a symbolic form (Muntañola Thornberg, 2004).

In the same study, Muntañola Thornberg states that after several years of interdisciplinary dialogue, the prospective axes that define the architectural layout and design could be as follows:

- The plurality of cultures in space-time.
- Complementarity between globalization and new local identity.
- The interest in the notion of 'identity' in the modern spatial and architectural layout/design.
- The interest in the transactional dimension of the built site itself, with its hybrid nature.
- Territories of the invention.
- The deep 'dialogic' and 'fibred' structure of contemporary space, in all the basic dimensions of any culture.

1.2.2.2. Quality of space and spatial specificities

The space is not considered with its quantitative values only anymore, but rather responding to a qualitative exigence of man. The physical aspects of space are natural (water, climate, hills, mountains, etc.), while the ideological aspects of space are turning it to be a familiar place that is responding and satisfying the psychological needs of men or groups when living or visiting the places, such as (places of development civilisations, places of fighting, temples, churches, mosques, etc.). the main qualitative characteristics that influence the performance of places are their natural, cultural, political, social and religious specificities. These qualities are determining the manifestation of groups in physical places and the perception of space **(Figure 1-2)**. Thus, these specificities are distinguishing each social group with its system of values and hierarchize its members. The societies of old times present specific characters; due to the nature and typology of their foundation, ideology, economic system, religion and cultural level. On the other hand, modern societies are characterized by the banality of the way of life, which is caused by globalization, rapid technological development, mass media, tourism, etc. This banality results from uniformity in every aspect of life and becomes a non-distinguished society or group (Hatzopoulou, 2004). Therefore, architecture is not a consolidated object to confirm social science's theories, but rather an activity to revive the style or the architectural design, to settle novelty and discontinuity, differences in both urban layout and fabrics in the specific time of groups that are using it and even in the history of it, since that every period gives the space its relevance (Robin, 2004).

According to Davidson, the continuity of communities is depending on their ability to preserve their past. Societies' awareness of their past is an awareness of their continuity. However, the concern should be focused on the interpretation of the past in a way that will be able to re-establish in present and is already suitable for it and its continuity. The challenge is to eliminate the rupture resulting from the introduction of the contemporary environment; the concern also is that the past has certain values for the present (Davidson, 1998). **Figure 1-3 a and b** show two attempts from gulf countries (Qatar and Saudi Arabia) to preserve identity in public architecture projects.

(a)  (b) 

Figure 1-3. *Pictures showing a practice of presenting the identity of historical sites in Souq Waqif of Doha, Qatar (a) and the great mosque of Riyadh, Saudi Arabia (b). Source: https://foxnomad.com/2011/04/15/where-to-see-the-sights-and-struggles-of-doha-qatar/ and http://www.akdn.org/architecture/project/great-mosque (Accessed date: November 22nd, 2017).*

1.2.3. Urban identity

1.2.3.1. Cohesive fabric and environment

Since our environments are different, the logical consequence of urban fabrics also would be different in point of view of the compactness, units' form, materials, urban layout and streets. For example, the Saharan urban fabrics seem to be more compact with narrow streets and patio-built units. This urban fabric is also a result of social order needs, the hierarchy of streets from public to private shows the intimate relationship between local habitants and visitors. Public spaces for social gatherings like plazas assure the mixed use of spaces, the preservation of the landscape of the local environment to integrate the design with nature and to demonstrate agricultural spaces in those fabrics. Therefore, to clarify these crossed complex fabrics we should find the harmonic serrated wheels which touch these elements or criteria. Two urban fabrics in the south of Algeria could be noticeable examples, Ghardaïa old Ksar **(Figure 1-4 a and b)** and Ouled Djellal old Ksar **(Figure 1-5 a and b)**.

(a)  (b) 

Figure 1-4. *Aerial picture showing the old Ksar of Ghardaïa (a) and the integration of the city within topography in the angel walk (b). Source: http://cnra.dz/atlas/secteur-sauvegarde-vallee-de-loued-mzab/ and https://www.pinterest.com/pin/269723465154428305/ (Accessed date: December 22nd, 2017).*

(a)  (b) 

Figure 1-5. *Aerial picture showing the old Ksar of Ouled Djellal (a) and the grand plaza (Rahba) (b). Source: https://www.facebook.com/photo.php?fbid=217958462273187&set=pb.100021771045847.-2207520000.1526125081.&type=3&theater and http://pedagotec.e-monsite.com/album/5-ouled-djellal-la-grande-place.html (Accessed date: December 22nd, 2016).*

1.2.3.2. Anthropology of the city and the urban space

The importance of urban anthropology is coming from its necessity to the social scientists and architects in cities and urban space design. However, the question comes from the reality of urban anthropology, is it a divisible reality composed of unalterable structures and social institutions, a singular continent that can include original cultures? A bit like a mosaic, its pieces should be analysed and treated as a recognizable or alternative phenomenon in different societies by preserving historical factors, specific tools and strategies should be adapted (Delgado Ruiz, 2004). Old postal cards of Ouled Djellal **(Figure 1-6 a, b and c)** represent the importance of urban space in enhancing social interaction.

(a) 

(b) 

(c) 

Figure 1-6. *An old picture of Ouled Djellal showing 'Rahba' plaza (a) and a corner of one of its entrances (b), where the quality of urban space is revealed in the interaction for discussing and commerce, a wedding celebration in 'El-Gbour' plaza, Ouled Djellal, March 1969 (c). Source: https://www.geneanet.org/cartes-postales/view/6101394#0, https://www.geneanet.org/cartes-postales/view/6101395#0 and https://www.facebook.com/photo.php?fbid=177583032977397&set=pb.100021771045847.-2207520000.1538142285.&type=3&theater (Accessed date: December 22nd, 2016).*

1.2.3.3. Public spaces and urban practice

Healthy communities are having great public spaces that contribute to social, economic, cultural and environmental development. Also, public spaces promote the city – not only visually, but also by providing a sense of character and a forum for public activities. However, a well-designed public space encourages people's interaction, physical activity, play and local pride of place **(Figure 1-7**).

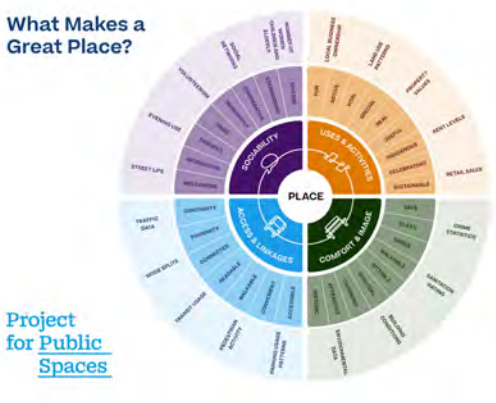


Figure 1-7. *Picture showing the four aspects that enhance the quality of public space and make a great place. Source: https://www.pps.org/article/grplacefeat (Accessed date: January 06th, 2017).*

Sustainability is based on three pillars: environmental, social and economic aspects. Thus, the environmental design is related to social exigence too, whereas the people claim that their social needs have not been satisfied. Therefore, the importance of both sustainability, environmental and social is inevitable. Consequently, the future generation, community interaction of daily activities, sustaining social justice, equity, relationships and character, etc. are concepts that we must consider too. However, a well-designed space is known for its quality value and character, continuity and enclosure, quality of the public realm, ease of movement, legibility, adaptability and diversity. The harmonic blend of these qualities combines and produces an urban space that affects its users. Therefore, the urban space is influencing and influenced by social sustainability at the same time.

According to Stathacopoulos (2004), The urban space cannot be received as a geometric pattern and the collective urban practice cannot be received as a pure ideology. However, the importance of mastering the development of urban space and what it implies is inevitable, the outdoor spaces depend on the buildings arranged and they can be lived as an urban space if it has other extremely readable features. Contradictory to the interior space which is protected as the symbol of privacy, the outer space is open to unhindered movements and free air and may include public spaces, semi-public and private. On the other hand, cities have an educational role too, it is considered a secondary institution that is produced by man, the general form of the city and its layout/design presents the various values that reinforce or weaken civilization. It can be revealed in cities with winding little streets in front of those which have wide avenues intersecting at right angles. Also, to change the urban culture, the ability of individuals to accept the variation is an important factor. Therefore, we must be careful in distinguishing between types of personalities and urban culture. However, societies are expected to be largely urban in the future. Thus, the importance of the anthropology of space comes here to change the culture in a way to be called urban through maintaining a specified type of personality for example.

1.2.3.4. Mix-use (users and cultures)

Anthropologists are always looking for the space's variation according to the different cultures of users. The oppositions that compose these categories are numerous, such as pure/impure, private/public, polite/impolite, and masculine/feminine, and the concepts of community, education or family also affect cohabitation in the same urban ensemble. Also, the question of cultures' origins is imposed. Consequently, it is not important only to debate the evolution of these cultural (or habitus) models, but rather to explore how long the processes of

evolution of these norms are long. Also, many authors state that the house is considered a conservatory of culture (a private space), while the public space is influenced by public standards. The conviviality is thus assured by organizing the urban spaces for civil purposes, the individuals and social groups cohabitation in the city. Thus, civility is built around the know-how of the spaces in the rules of suitability, it engages the relationship with others. On the other hand, the history of conviviality in urban spaces is influenced by the constitution of 'police space', the idea of imposing rules on urban space use is a little bit confusing. However, the crisis of urban spaces and disqualification of the modes of living is affected by the status of urban space itself and the rules of its use also (Bekkar, 2004).

1.2.3.5. Urban/social fabric

Due to Aly (2011), the urban space should attain the balance between urban identity, urban fabric, morphological settings, activities, manifestations held and meaning. We can express our identity either through visual abstraction or conceptual abstraction. Therefore, by assuring this identity, a conscious cohesive community would be produced, tradition must be respected beside development is the key to our existence. Therefore, we can produce identity in a developed way with contemporary technology. So, Sherine Aly recommends the followings:

- Find a land between these two extremes (tradition and modernity) in expressing identity and urban spaces to apply the community's needs for interacting in their daily life and activities.
- Think regionally, systematically and ecologically.
- Assure the all-relevant demands and exigence of the system (structuralism).
- Holism.

1.2.3.6. Culture and urban identity

Culture is a critical issue to discuss, there are many questions for culture to reconsider. Also, there is a local culture (graffiti for example) and a global culture. Thus, the local must be updated and connected to the global. Otherwise, the space would not have a meaning and cannot present an environment of quality. However, between tradition and culture, there is a need to innovate something to resuscitate and activate. Cultural inputs are referring to humanity, anthropology, architecture, art, literature but also science, activated public places and the state of local/global places. Anyway, at the city level, the cultural ingredient should be treated on a global scale, whereas the policies and strategies should consider the entire local

and regional identity through both heritage and innovative architectural heritage. The following fields should be considered: sociology, anthropology and political science towards simplifying things to establish ethics and values depending on users' options. Therefore, the connection between architecture and urban space must be settled, it is important to consult (not only architects and planners), but rather consulting other domains that are targeting the user, his decision and his civism in different levels of decision-curatorship to cultural policies-, to create currents of opinion and supporting notable initiatives concerning the quality of city architecture as a cultural ingredient (Mihaila, 2014).

According to Ibrahim, urban identity is influenced by several subjects, such as psychology, philosophy, sociology, human geography and anthropology. However, the globalization movement in the past decades brought the issue of urban identity on the agenda of architects, planners and designers to attain a sustainable urban-cultural development in the urban identity of a community. Thus, enhancing local culture and identity through emphasizing traditional buildings and vernacular architecture was an efficient practice (Ibrahim, 2016).

There are two perspectives regarding the city, one is dedicated to technical and the other is dedicated to sensory. Sensuous requirements may coincide or conflicts with other technical demands but are not separated from them. However, emotions and feelings towards an urban space are related to its technical design though, urban identity reflects people's traditions, culture, aspirations, needs, successes, failures and future.

Social identity is composed of individuals who express themselves and generate a group of internal and external attributions that defines this identity. Therefore, it is usually coming from a sense of belonging to specific categories, ethnic groups, socio-professional categories, religions, etc. However, these groups appear in form of urban identity as a substructure of social identity. Thus, through history, it was clear that urban public spaces are the bowls to incubate social identity. Whereas the plazas that are in front of civic buildings or nearby mosques, cathedrals, city halls, museums or libraries are enhancing this aspect. On the other hand, today's urban plazas or squares creation becomes a nightmare in terms of assuring identity to the whole community and enhancing the city with significant places. Thus, to design a real icon with special quality, it must be integrated within the fabric and show excellence in design to remain efficient in urban life. The most influencing factors on the urban identity are physical and natural elements, such as climate and environment. Conservation of old heritage is also encouraging identity. Also, cultural identity is in contrast to an individual's identity, while it is related to groups and social systems. Thus, the 'space' notion is an important element

to develop cultural identity, due to its function, and symbol, as space where interactions occur (t Schneider, 1998).

1.2.3.7. Islamic city character

Islamic city, is it a spontaneously found product or very careful steps to be followed during its rise process to create a special character? When you see this concept during those years and through different places around the world, you just discover that this treasure did not exist by coincidence, it is a very determined plan and all is intended and designed due to many parameters and criteria such as social urban fabric and environment. Islam is considered an urban religion, whereas it adapts the worship of its individuals in form of social gathering practice. Despite that piety is the only source of appraisal, the Islam lessons that are presented in urban settings are widely encouraged. However, since the Islam identity is imported from emphasizing the needs, functionalities and socio-economic exigencies of the community, thus the Islamic city must assure these needs through its forms, layout and urban fabric (Saoud, 2002).

The concept of an Islamic city has been always a disputed issue in the field of Middle Eastern and Islamic studies. Until the 1960s, the Islamic city was discussed amongst Orientalists and historians the real nature of it, later on, the topic has been taken up in many other academic fields (Goddard, 1999).

The urban includes (not only) what is built and concrete, but it is also buildings' landscape and activities, all together compose the town's fabric. However, the public spaces extend from streets squares and parks of a town into the buildings, which represent the town's quality and most representative value of it. Therefore, it is obvious that Middle East cities are the best example of presenting an integral building within the general fabric, and where urban neighbourhoods have traditionally organized their functions and services concerning the whole (gathered pieces order them all) (Madanipour, 1996). Architects need to find a practical approach to vitalize the tradition, by taking into consideration both, contemporary and old culture.

The term 'Islamic city' or 'medina' is inspired not only by Islam, but also it is the evolution of society's needs by referring to 'El-Maqasid of Islam'. For example, we see the basic design of the mosque with its principal elements (rectangular form, courtyard, parallel columns to Qibla, simple Mihrab, flat roof supported by palm trunks, entrances in three opposite façades to Qibla wall), those elements have evolved and reshaped through history into many types of mosques (all in refereeing to El-Maqasid); due to many cultures of Muslims

around the world and also sometimes it changed due to environmental needs and climate. In cities, also there were many developments of the shape of Islamic cities to adopt the new environments and cultures (but always saving the main principles of Islamic city and Islam reference), the same as mosques in evolution.

1.2.3.8. Islamic city's pattern

According to Saoud (2002), the layout and form of an Islamic city are influenced by many factors, such as the local environment (topography and morphology of pre-existing towns), and the socio-cultural, political, and economic structures of the newly created communities. The following features involve these factors:

- Natural laws.
- Religious and cultural beliefs.
- Design principles stemmed from government laws.
- Social principles.

Figures 1-8 a, b and c show three masterplans of old Islamic cities in different regions.

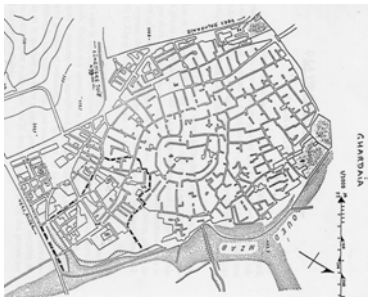
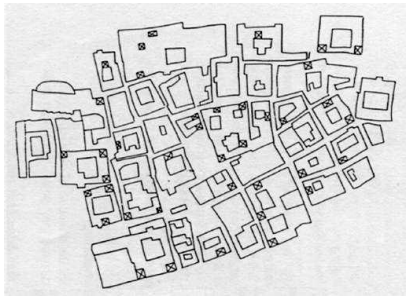
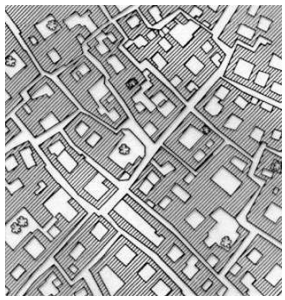
(a)  (b)  (c) 

Figure 1-8. *Masterplan showing the similarities in old Islamic city's pattern in the old Ksar of Ghardaïa (a), the old city of Dubai (the Bastakia) (b) and the old city of Kuwait (c). Source: https://www.pinterest.com/pin/523684262889829548/ and http://www.muslimheritage.com/uploads/Islamic%20City.pdf (Accessed date: October 11th, 2018).*

1.2.3.9. Islamic city's urbanism

- **The Jâmi**

Von Grunebaum (2005) gives the following description: '*The full-fledged Muslim town ... has two focal points-the Friday Mosque and the market. The Jâmi, as the spiritual center, is in general appropriately placed along the main thoroughfare or, where the plan of the town permits, at the rectangular crossing of the two main thoroughfares which is market by a spread-out square ... Next to the jâmi we find the principal government building, be it the palace of the ruler or the official residence of his deputy. The jâmi is [also] the political as well as ... the intellectual center of the town*'.

- **The markets**

'Islamic urbanism' culminates in a now famous description of how the markets were organized in a typical Muslim city. As will be seen, this description appears repeatedly in subsequent studies on the Islamic city: '*... the centre [of the city] is occupied by the Great Mosque, the old political centre, as well as the religious and intellectual centre of the city ... Near the mosque, the religious centre, we Find the furnishers of sacred items, the süq of the candle-sellers, the merchants of incense and other perfumes. Near the mosque, the intellectual centre, we find also the booksellers, the bookbinders and, near the latter, the süq of the leather merchants and the slipper (babouche) makers which also use leather. [Next comes] ... the clothing industries and the commerce in cloth, which occupy so large a place in the life of Islamic cities. The essential component is a great market [composed of] a group of markets that carry the mysterious name, Qaiçariya. The Qaiçariya ... [is] a secure place encircled by wall ... The Qaiçariya, placed not far from the Great Mosque, as in Fez or Marrakech, for example, is a vital centre of economic activity in the city. Beyond the commerce of textiles, of the jewelers, and the makers of hats (chechias), we find the makers of furniture and of kitchen utensils ... Farther out are the blacksmiths. Approaching the gates, one finds places for caravans ... then the sellers of provisions brought in from the countryside ... In the quarters of the periphery are the dyers, the tanners, and, almost outside the city, the potters*' (Abu-Lughod, 1987).

- **Road's hierarchy**

Brunschvig[3] distinctions between public and private roads, as the following quote: '*In the cities, Muslim law distinguishes a real road, [meaning a road] open at both ends (shãri, tariq nãfid), as a public path where everyone has the right to pass. A dead-end road (sikka ghayr nãfid; sikka is often replaced by zuqãq or zanqa) is considered by most authors [i.e., qaãdis] as a private way belonging in joint ownership to the residents*'. Thus, Islamic law made a clear and strict distinction between public and private roads. In addition to the definitions given above, Brunschvig demonstrates how public roads had certain restrictions and regulations on obstructions, street width, and projections/overhangs that usually did not apply to private (dead-end) roads. For example, '*the width [of a public road] should be so maintained*

[3] Robert Brunschvig (1901-1990) was a French historian, orientalist and professor at the University of Paris

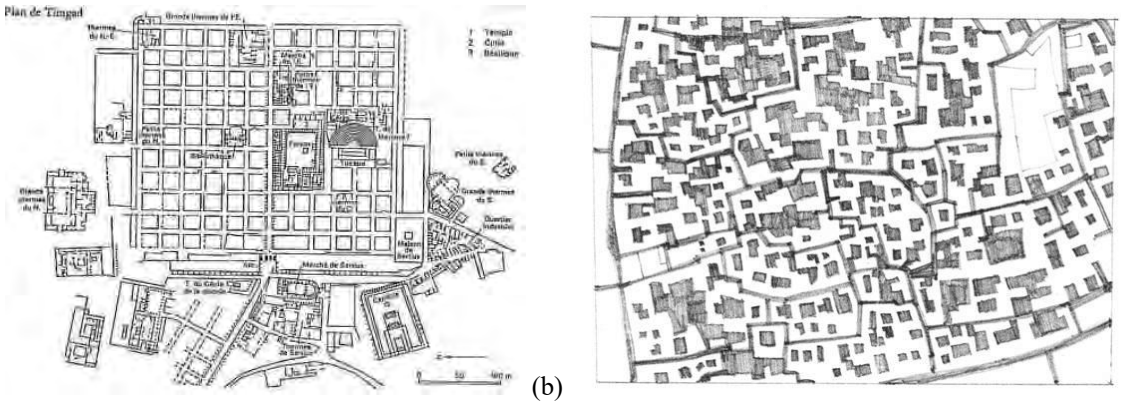
that the largest beings and objects, such as camels carrying the greatest possible loads, and carts or carriages can pass without incident' (Abu-Lughod, 1987).

- **Morphological components**

According to Saoud (2002), The scholars are divided into two groups in terms of stating the impact on Islamic city or 'Medina' layouts and patterns. Some indicate that Roman street patterns and insulae layouts had a great influence on the buildings plot and streets of Medina. On the other hand, some scholars see the Islamic city as an entity with distinctive form and characteristics such as 'the Ksour' in North Africa's old cities. Thus, the general morphological components of 'Medina' are as follows:

- The main mosque.
- Suqs.
- Citadel.
- Residential quarters.

Figure 1-9 a and b show the difference between the rational planning of a Roman city (Timgad, Algeria) and the organic urban fabric of an Islamic city (Muharraq, Bahrain).



(a) (b)

Figure 1-9. *Masterplan showing the rationality of Roman town planning of Timgad (a) and the urban fabric hierarchy of open spaces of Muharraq city. Source: https://geopolicraticus.wordpress.com/2012/05/10/addendum-on-roman-cities/ and https://www.researchgate.net/publication/322330738_The_Rehabilitation_of_the_Muharraq_Historical_Center_-_Bahrain_A_Critical_Narrative/figures?lo=1 (Accessed date: October 11th, 2018).*

1.3. Literature review on climate-responsive design

1.3.1. 'Climate-responsive design': between vernacularism and modernism

According to (Grunske, 2006), environment, climate and energy are the three fundamental areas that are applied in architectural design strategies. Consequently, different parameters are related to those fundamentals and should be respected, such as regional climate, architectural identity, saving resources and energy conservation. However, vernacular

architecture adapts the strategies through architectural concepts, local identity and energy saving, by cross-interaction between local architectural design and regional environment constraints. Similarly, in opposition to contemporary architecture, the vernacular one produced a comfortable house in terms of improving indoor conditions, reducing energy loads, respecting sustainability principles and providing valuable ideas.

Prof. Hassan Fathi[4] reviewed in his book (Fathi & Abd al-Rahman, 1986) the applied techniques in ancient architecture in terms of design strategies, economic situation, climatic conditions, public health considerations and ancient craft skills. Thus, to meet climatic requirements, Fathi promotes climate-responsive design in hot-dry regions through passive environmental techniques that met physical, cultural and economic challenges. Therefore, to enhance the indoor microclimate for users, the buildings are designed in a way to protect indoor spaces from heat and provide adequate cooling.

According to Steele (1992), Hassan Fathi attacked 'Modernism' in all of its forms, blaming it fully for neglecting human needs and social values. Also, being responsible for destructing the long-established cultural patterns that such disregard has now encouraged under the title of 'Modernism' and 'globalization'. On the other hand, Fathi criticize also the inability of 'Modernism' to adapt both physical and environmental laws; due to its international style to all different regions (different climates, topography, culture, … etc.).

Rapoport[5] once said: '*The amazing skill shown by primitive and peasant builders in dealing with climatic problems, and their ability to use minimum resources for maximum comfort*'. According to Weber and Yannas (2014), the climate as a generative factor is still a critical issue in determining the built form, Rapoport was careful to lay aside claims of climatic determinism. Rapoport also said: '*One need not deny the importance of climate to question its determining role in the creation of built form. Examination of the extreme differences in urban pattern and house types . . . shows them to be much more related to culture than to climate*'.

The different climate aspects that affect indoor microclimate and human comfort are necessary to be aware of in different design steps. However, the architects should consider: the average, change and extremes of temperature, the temperature differences between day and night, humidity, sky conditions, incoming and outgoing radiation, rainfall and its distribution, air movement and special features such as monsoon winds, thunderstorms, sand storms and

[4] Hassan Fathi (1900-1989) was a noted Egyptian architect who pioneered appropriate technology for building in Egypt and an author for several publications

[5] Amos Rapoport (1929-present) is an architect and an author of over 200 academic publications

hurricanes. The shelter acts as the mediator between the natural environment and human beings, its task is to fulfil the comfort requirements to provide an optimum condition of liveability. However, the architect's task is to provide such conditions by using the utmost natural means, and as result, achieving a saving cost by minimizing the use of active sources as much as possible.

Vitruvius[6], once said: '*We must begin by taking note of the countries and climates; in which homes are to be built if our designs for them are to be correct. One type of house seems appropriate for Egypt, another for Spain...one still different for Rome...It is obvious that design for homes ought to conform to diversities of climate*'. What we as architects are aiming for is to take the climate-motivated, environmentally sustainable, valid ideas and practices, from both indigenous and vernacular buildings, and to incorporate them into current architecture that responds to the issues of climate (and comfort) in the design of the building.

According to Hamed (2017), the authenticity of architecture and public spaces should be preserved to create an architecture that expresses local identity, providing connected routes between places and wildlife, recreation, walking and cycling. Also, the environmental dimension of architecture can be maintained through a sustainable drainage system (using permeable and pervious paving), solar temperature moderator (through water surfaces and vegetation), source of cooling corridors (green corridors), wind shelter and wildlife habitat.

In addition, the most obvious feature that characterizes architectural style is the use of environmental and local materials, such as limestone and mud bricks sandstone in walls, marble and wood in columns, and wood taken from palm and olive trees for roofs and to cover the width of the room. Also, the construction system and structure to increase the thermal loads capacity, such as timber structure framework, double roof system, thick walls, and paint external walls with rough materials with light colours. Similarly, there are other patterns and concepts in terms of assuring the duality between environmental design and social needs (cultural background of individuals), such as small openings for privacy and to reduce high-temperature degrees in summer, a courtyard to perform as an internal family space to provide privacy and to help also the building to ventilate itself during the night, daylighting needs, natural ventilation as well and drinking water supply systems. On the other hand, contemporary architecture has produced a new adaptation of concrete material and horizontal/vertical expansion of residential quarters with sharp corners and right angles which eliminated every

[6] Vitruvius (80-70 BC) was a Roman architect and engineer during the 1st century BC

sense of identity and embodied a new character that is also critical in terms of energy efficiency. Consequently, the impact of this new tendency is increasing directly by the currently excessive approach towards village expansion and creating new ones. As a result of that, the population's needs for preserving local identity and improving lifestyle, quality of life, interaction activities, achieve sustainable management of natural resources in alleviating rural poverty are threatened to be lost. However, to achieve sustainability in architecture, the environmental impacts should be minimized, the regional identity should be maintained, make sure that local raw materials are adopted to be appeared as a key of local identity and at the same time in point of view of energy performance.

1.3.2. 'Human thermal comfort': a literature review

A moderately clothed human feels comfortable referring to three parameters: range of temperature conditions of air movement, humidity and exposure to direct sunlight. Therefore, this will be different from indoors to outdoors, from one's culture to others, from climate conditions which people adapt to different climate conditions. Also, it is important for architects not to provide a comfortable indoor environment only, but rather to create a pleasant outside space too, through Indigenous structures, vernacular architecture, and typical 'modern' 20th-century architecture.

According to Nguyen (2013), after exploring several first studies to determine the neutral comfort temperature of a man wearing standard clothing at sedentary activity and moderate humidity, the found range is from 25.5 °C to 26 °C. Thus, the range is applicable worldwide in a climate-controlled environment. Afterwhile, a huge number of empirical studies occurred worldwide using ASHRAE and Bedford 7-points thermal sensation votes (TSV) **(Table 1-1)**. The first scale of ASHRAE is more familiar and used frequently than the Bedford scale. The range of ASHRAE TSV is from +3 to -3, whereas the neutral temperature indicates zero in the scale and means a comfortable point. However, Nguyen states that the deviation of regression equations of several empirical studies revealed that most studies have the same sensitivity towards the temperature's changes and thus it is possible to predict people's thermal comfort sensation towards a certain built environment by knowing the ambient temperature. The range of neutral temperature is from 25.1 °C to 26.8 °C.

Table 1-1: *ASHRAE thermal sensation scale*

ASHRAE scale	
+3	Hot
+2	Warm
+1	Slightly warm
0	Neutral
-1	Slightly cool
-2	Cool
-3	Cold

However, to precise a comfort zone of certain people's conditions in a climate-controlled environment, the ASHRAE 55 standard (ASHRAE, 2017) has evolved over years and collects a huge database of thermal comfort studies that occurred over the world and introduced a simple graphical method that presents this comfort zone on a psychometric chart (by interpolating the two graphs of Olgyay and Givoni) (Olgyay, 1963; Givoni 1969).

Thereafter, Fanger examined a group of tropical people right after arriving in Denmark, he found that their neutral temperature is 26.2 °C, slightly different from the 25.5 °C of local people. This brings to mind the different abilities of humans in adapting to the thermal environment in long term. Therefore, a new model has been created and evolved later, which is 'the adaptive model' (Fanger, 1970).

1.3.3. Vernacular design lessons

1.3.3.1. Vernacular architectural design

As stated by Weber and Yanas, the conducted studies of vernacular buildings after the release of Rapoport's seminal book have supported his theory. However, the vernacular architecture in its built form and materiality may corroborate with climate conditions. At the same time, it is difficult to say that it fits the whole year's environmental performance. Consequently, the adapted passive strategies may show a contradiction between summer and winter, for example, the thick walls that contain small windows (a characteristic of Mediterranean vernacular) may provide an indoor microclimate that is cooler than the outdoor, these two features can serve the buildings in the hot summers in this region. On the other hand, in winter, these features prevent the indoor temperature from arise above the outdoor values (10-12 °C), which are well below the thermal comfort range and thus the building is no more free-running and forced to use active sources (non-renewable energy). The main objective today is to provide an indoor comfortable microclimate for occupants with less energy use and materials. Thus, adapting energy renewable sources in place of non-renewable ones and dispensing unsustainable processes and materials. Similarly, by knowing the building's physics and materials, wide knowledge of energy and thermal behaviour of using many materials can

be conducted through measurements and simulation studies. Thus, what vernacular architecture lessons can present and how can be inspired-from for us today?

The practical importance of vernacular architecture for architects and academics comes from two main reasons, the first one is that vernacular architecture provides a huge number of real examples which are presenting rich subjects to study in terms of applying passive strategies of environmental design that are not only the technical application but rather an integration of buildings architecture with inhabitant's lifestyle. Whilst few contemporary buildings are still applicable for such studies, most developing countries with warm climates still consider conventional mechanical solutions as inevitable. The second reason of being vernacular architecture is important comes from what Le Corbusier says about its ability to inspire architects and students. This capacity has often enhanced in developing new ideas and projects, contributing in terms of innovation rather than limitation (Weber & Yannas, 2014).

1.3.3.2. Vernacular urban layout

There is no doubt that climate has the first impact on the urban layout design in the traditional city; that's why we notice the 'compact layout' in hot and dry regions Ouled Djellal and Ghardaïa for example. The layout in these zones features three elements: narrow streets, wide open plazas and interior gardens.

According to Fathi and Abd al-Rahman (1986), when you see the general view of traditional city layout, you recognize the wide courtyards which are spread in the urban fabric and work as 'cool fresh air tanks', as seen in Marrakech, Tunis and Damascus. Therefore, this organigram is preferred from the climatic point of view to the urban layout of wide streets and orthogonal layout as seen in Washington. The work of these narrow zigzag streets is the same as the courtyards; it stacks up the cool fresh air during the night and blocks it to waste in the morning time to regulate the temperature through this fabric.

Fathi once said: '*When the full power of a human imagination is backed by the weight of a living tradition, the resulting work is far greater than any that an artist can achieve when he has no tradition to work in or when he wilfully abandons its tradition*'. According to Steele (1992), The reason that indigenous and vernacular architecture has fulfilled the traditional and artistic aspects for humans is that it responded to primarily natural forces. As Hassan Fathi once said in a lecture in Dar Al-Islam: '*If the architect does not respect the God-made environment, be commits a sin against God. The God-made environment is the landscape; the atmosphere, the flora, the fauna, and the human beings who live in this environment. In this God-made environment there is nothing that is inharmonious. If we become one with nature,*

1.5. Literature review on Critical Regionalism

According to Hartoonian (2014), through the lens of Frampton in his work 'Towards a Critical Regionalism', architects should not apply local or vernacular architecture directly without any critics, they should analyse local character and then reinterpret it to adapt contemporary exigence and rational development of science.

In her study, Radstrom (2014), regarding urban spaces, the globalization phenomenon has led to the homogenization of urban identity. This issue is increased in smaller urban spaces which do not receive much attention and are consequently being designed or managed by foreign solutions that do not enhance local identity.

Another study by Lewis (2002), always has been a conflict between two opposing forces, one force in pursuit of preserving traditional and indigenous architecture. On the other hand, a force promotes the invention of new forms using new technologies and materials, this force produces a new different architecture in terms of systemization, flexibility and interchangeability.

According to Aly (2011), identity presents the relationship between man and place. The sense of belonging reflects people's traditions, needs, ambitions, plans and prospects. This concept is almost nonexistent in contemporary architecture, whereas the lack of climate adaptability, local materials and the integration of modern technology with cultural values (the original principles of local architecture can be developed concerning new techniques and styles).

1.6. Theoretical foundation for sensitivity analysis, simulation-based optimization, vernacular-inspired architecture and energy demand

1.6.1. 'Sensitivity analysis, parametric simulation and simulation-based optimization': a literature review

1.6.1.1. Sensitivity analysis

SA has been widely used in building energy modelling and simulation domains. It seeks the model behaviour and identifies which input parameter influences the output variation. Thus, SA is a concept of different techniques of quantifying the model's output sensitivity that is caused by variability and uncertainty of the model's input parameters.

In general, SA is composed of two major groups, local sensitivity analysis (LSA) and global sensitivity analysis (GSA). There is also a screening-based method, which is considered a GSA. The philosophy of this approach is to determine the importance of parameters by exploring the least one that reduces the output variance while fixed at any evaluation and thus giving the parameters a descending order by profiting from a smaller number of evaluations. This technique shows effectiveness due to its advantages; the screening-based method can evaluate heavy models with a large number of input parameters, all in low computational cost and time (Kristensen & Petersen, 2016). Other GSA groups of variance-based methods and regression-based methods require high computational effort compared to screening-based methods.

LSA – derivative-based methods (applies a single SI measure) are applicable to determine linear models but are not sufficient for non-linear models. Also, it does not give information about the shape of parameters, and it has no quantification regarding the correlated parameters. So, it treats each parameter as uniformly distributed variations as equally as possible and determines the extreme variations and thus calculating the mean.

Morris's method applies the elementary effect as a measure to quantify the parameter sensitivity. Although it is considered partly global, it still applies the one-at-a-time (OAT) variable technique. Also, the Morris method has a limitation as it cannot determine the correlation between parameters as other GSA methods (Sobol, FAST, …etc.). Studies by (Morris, 1991; Kristensen & Petersen, 2016; Sanchez, et al., 2014), state that screening-based methods (Morris's method) has almost the same results as variance-based method (Sobol method) in ranking the parameters in building energy modelling and simulation. SA contributes to discovering neglectable parameters that can be ignored for further optimization studies. The variance-based method cannot consider the interaction effects, neither suitable for discrete variables (Tian, 2013).

A recent study by Zeferina (2021), explores the GSA (Morris and Sobol) of 14 parameters to the output of cooling demand in six climates over the world. It demonstrates that the ventilation rate is the most influential factor and that the coefficient of variation for the total peak demand is around 25% and 21% for the total annual demand. Several studies promote the vernacular architecture design parameters. According to (Hamed, 2018), there is a relationship between architectural identity and energy efficiency in buildings, whereas architectural identity shows remarkable behaviour in conserving energy and reaching users' comfort. Also, Nguyen et al. (2011) investigate the vernacular architecture and climate-responsive design in adapting to the hot-humid climate through several parameters (envelope, ventilation, … etc).

Many studies revealed that SA is a practical technique in studying building performance and it can be performed typically in early stages where it is still possible to modify parameters as much as possible (Heiselberg, et al., 2009). While (Sarrazin, Pianosi & Wagener, 2016), addressed the most critical choices in GSA: Sampling size and threshold for input parameters. As mentioned by Nguyen and Reiter (2015), choosing the SA method is belonging to the model outputs target. Morris is considered to be a reliable method with low computational effort (cost and time) and provides a global evaluation of both continuous and discrete variables.

A study by Rodriguez et al. (2013) shows the difficulty of getting information from SA since that reliable outputs require a large number of input parameters. On the other hand, the uncertainty of inputs may have an impact on the outputs. Therefore, the robustness of detailed models is widely used to obtain accurate SA results.

A study by Yu et al. (2013), demonstrates through sensitivity index (SI) and LSA in four cities in China with hot summers and cold winters the most influencing envelope parameters in the energy performance of cooling and heating seasons and found that shading coefficient and window to wall ratio (WWR) are the most influencing in the cooling season, while wall heat transfer coefficient and shape coefficient are having the remarkable impact in the heating season.

However, this study will consider the LSA method; due to the large chosen project and the number of input parameters and evaluations in six climates in Algeria of both naturally ventilated (NV) and mechanically-conditioned (MC) types.

1.6.1.2. Parametric simulation

According to Alwetaishi (2019), the parametric variation study of WWR has revealed that east and south directions are the worst and 10% is the recommended WWR in the hot region in terms of occupants' thermal comfort.

Since that thermal comfort range is addressed as a steady state in several studies (ASHRAE, 2017; Nguyen, 2013), others describe it as an adaptive behaviour that is changing proportionally from climate to others (Nguyen, Singh & Reiter, 2012). Whereas, the ASHRAE adaptive model is suitable for the NV building and PMV-PPD is more convenient with the MC building.

(Nguyen & Reiter, 2012), used parametric study and model calibration to evaluate low-cost apartment NV to achieve thermal comfort as much as possible. Also, Nguyen and Reiter (2014) investigate the passive strategies' effectiveness in achieving thermal comfort through

psychometric chart evaluation and revealed that natural ventilation and evaporative cooling are the most influential parameters in hot-humid climates.

A study by Yao et al. (2018), explores different parameters affecting thermal comfort and energy conservation through the parametric variation simulation in severe hot/cold climates of China. A study by Yang et al. (2021), investigates several design parameters affecting building-integrated photovoltaic and thermal double-skin façade, which is also influencing indoor thermal comfort and building energy efficiency through LSA and OAT in three different climate zones in Australia.

On the other hand, many studies have explored building parameters in affecting the indoor thermal environment through parametric variations, but the studies are few and do not seem to be well organized in terms of defining the most influential parameters of hotels nor well addressed towards several climate zones with the same model.

1.6.1.3. Simulation-based optimization

Ali-Toudert and Weidhaus (2017) state that there is a lack of best practices models in Algeria in terms of energy-efficient buildings. Thus, she confirmed the easiness to save energy in comparison to local inappropriate types and the possibility to dispense heating and reducing cooling remarkably.

For further studies, the parameters that show an evident impact on thermal behaviour and energy performance should be used for multi-objective optimization using genetic algorithms in current and future scenarios of climate change (Nguyen, et al., 2021; Nguyen & Reiter, 2014), since that, using many parameters in the optimization requires high computational effort beside it consumes time. So, there should be an evaluation of the parameters' sensitivity (Zeferina, 2021) in each climate and hence dividing them into categories to use the most influential ones in the optimization procedure. Whereas, the more the optimization sampling and time increased, the more the results achieve optimal solutions (Hamdy, Nguyen & Hensen, 2016). Optimization algorithm shows capability in terms of multi-objective optimization through several algorithm types (Yong, et al., 2020).

Tourism activity increasing requires a large number of hotels, whereas the thermal behaviour and energy consumption should be measured and evaluated from both points of view of NV and MC to establish benchmarking in this sector. Nguyen and Rockwood (2019) explore through a survey the energy benchmark of hotels in Vietnam and then creates a reference model to evaluate other hotel and for further labelling studies of hotels in term of energy consumption intensity.

1.6.2. 'Vernacular-inspired architecture': a literature review

As stated by (Oliver, 1997; Priya, et al., 2012), vernacular architecture is the most used in residential buildings, which is indigenous, responsive to climate constraints with maximum adaptability and refers to specific time or place. Other studies (Singh, Mahapatra & Atreya, 2007; Saleh, 1999; Dili, Naseer & Varghese, 2010) mentioned that the principles imported from vernacular architecture have been lost in modern buildings and can be used in terms of building efficiency and design better future for sustainability.

(Bodach, Lang & Hamhaber, 2014) explore the idea of climate-responsive design through the vernacular architecture of Nepal which provides a comfortable shelter that is improved over hundreds of years. Even if techniques and materials have been lost due to the modernization and globalization movement that affected the building sector. However, the study provides a qualitative review of the traditional architecture of Nepal and its adaptation to climate.

Another study sets that applying climate-responsive strategies in Sizhai village are effective solutions to adapt the summer hotness and winter coldness in extreme climates and provides a comfortable environment almost for the duration half of the year (Chi, et al., 2019).

Huang et al. (2016) show that passive design in traditional dwellings in Tibet regions is effective in improving the indoor environment in winter but does not reach the adaptive thermal comfort (between 16.4 °C and 24 °C) without active sources. However, the study constitutes that the local inhabitants are satisfied with the indoor built environment and tolerant of lower thermal comfort. A study by Priya et al. (2012) concludes, through a quantitative and qualitative method, that the vernacular architecture and passive techniques, used in the coastal region (warm-humid climate) in India, provide a comfortable thermal environment. Another study by Xu et al. (2016) carries out site measurements of six ancient timber-framed halls in northern China and concludes that indoor thermal comfort can be achieved in summer but not in winter. However, the climate-responsive design strategies used in halls still can be used in contemporary public buildings.

Alp (1991) explained qualitatively the passive strategies used in desert regions to control the harsh climate and set that architects must achieve the best possible natural climatic control, which subsequently, may be supplemented by active strategies.

Several studies (Panchabikesan, Vellaisamy & Ramalingam, 2017; Tejero-González, et al., 2016; Belarbi & Allard, 2001; Prieto, et al., 2018; Amraoui, et al., 2021; Kaihoul, et al., 2021) have been done to review the effect of passive strategies and its potential to adapt

different climate factors. According to (Ratti, Raydan & Steemers, 2003), the courtyard configuration is an environmental strategy that creates an indoor microclimate better than the street and helps interior spaces to better performance with this improved microclimate. However, the courtyard shows effectiveness in hot-dry and cold climates and does not enhance the buildings in humid climates (that is why it is not possible to find it in vernacular architecture in these regions). Xu et al. (2020) state that the thermo-physical properties of envelope materials (including glazing) can be an effective factor towards climate-responsive design and better energy performance.

The above studies have revealed the worthiness of traditional and vernacular architecture as a source of inspiration, and the importance of climate-responsive design in improving the built environment and, hence, better energy performance. However, most of these studies have investigated the passive design in temperate or hot and humid climates, and there is a lack of studies of climate-responsive design performed in severe hot-dry climates with a long period of summer (five months) (Ould-Henia, 2003) and harsh climatic conditions. The importance of rethinking the climate-responsive design inspired by traditional architecture is revealed by the fact that heritage is survived hundreds of years under severe conditions. So, it can be reinterpreted in informing modern sustainable building design.

1.6.3. Energy demand: between occupants and passive design

According to Hussaini and Majid (2014), the lack of users' awareness towards the energy efficiency practice is due to the missing information by the government, and it has no relation with attitude and influence of culture. Thus, cultural background and altitude are not influential factors for indoor efficient energy use since users are not well informed towards this issue by the government.

On the other hand, (Nguyen, Bokel & van den Dobbelsteen, 2019) demonstrate that energy consumption is not related at first to the characteristics of the indoor built environment, but it is rather related to users' financial status and occupants' behaviour. Thus, the government should consider both aspects, the design strategies for better energy performance and the development of more detailed regulations regarding the economic situation of occupants. A study by de Meester et al. (2013) investigates the relationship between buildings' insulation and occupant's behaviour and concludes that the number of inhabitants and their lifestyle reduces heating loads, and the more the building is insulated the more the occupants' lifestyle influences the heating loads too.

According to Yang et. al. (2020), the residents in the Turpan basin (hot-dry climate) can adapt to the hot climate that reaches up to 34 °C, thanks to the heavy envelope and design pattern and techniques that could improve the indoor thermal environment. Another study by Rijal (2021) sets that the passive strategies in heating the indoor thermal environment are effective in vernacular houses and show satisfaction of local inhabitants even though the internal mean comfort temperature is 10.7 °C which is lower than the thermal comfort standards. It consequently leads to decrease energy consumption. As stated in a study by Ali and Al-Hashimi (2018), the more the design assures better strategies, the more the house results in comfortable indoor spaces, where the building's envelope is the main parameter that influences the house's thermal performance. In addition, another study demonstrates that MC systems consume the largest portion of total energy in hot-dry climates, during the hot and long seasonal period of summer (Mostafaeipour, et al., 2019), while passive strategies are effectively to be used in buildings' cooling and heating (Zaniani, et al., 2018). In general, the comfort conditions for occupants stand around 22-27 °C for temperature and 40-60% for humidity (Al-Ajmi, Loveday & Hanby, 2006).

According to Steemers et al. (1998), the urban fabric typology with a courtyard is the most thermally comfortable urban configuration. A study sets that the traditional urban morphology has sufficient shading throughout the year, unlike modern one, due to the staggering volumes and aspect ratio (Ali & Al-Hashimi, 2018). Also, according to Ben-Hamouche (2008), compactness could influence the environmental performance effectively of both buildings and urban spaces.

It is necessary to be aware of the importance and effectiveness of early design decisions. Thus, research and studies are showing large impacts on the economy and environment in the pre-design stage (Luyten, 2010). In this regard, (Al-Saggaf, Nasir & Taha, 2020) explain the significant influence of adapting architectural design features in hot climates during the early stage and its contribution to high-energy performance (particularly in cooling). A study by (Singh, Mantha & Phalle, 2018) shows that climate affects the energy consumption of the residential sector in India where the warm-humid regions consume more electricity than the hot-dry ones. According to Sun (2013), the Chinese energy demand of the residential sector can be maintained effectively through energy-efficient design to meet comfort criteria, where the heating demand is the major need to be fulfilled, and the study shows the impact of fenestration on energy consumption in different climate zones. Another study sets that energy demand can be regulated through passive strategies such as envelope materials and insulation (Hamdaoui, et al., 2018).

1.6.3.1. Energy demand and simulation

Barbosa and Azar (2018) examined residential and commercial buildings in hot dry climates through building energy modelling and found that rising set point of temperatures by a few degrees affects energy consumption significantly. Thus, the occupants and facility managers can have a significant influence on consumed energy, particularly in extreme climates. According to a study by (Schnieders, Feist & Rongen, 2015), passive houses can be realized in different places in the world and in every climate. The main idea is to minimize the energy demand with high thermal comfort. Anyway, the details of each passive house must be determined through thermal dynamic simulation and corresponding design tools in which the goal can be achieved. A study carried out by Xiong et al. (2019) explores the classification of China's climatic zoning and its impact on energy demand to highlight the passive design that improves the thermal environment and energy performance (cooling and heating), through simulations with EnergyPlus. A study by Nguyen et al. (2011) carries out an in-situ survey and simulation and concludes that the traditional houses in Vietnam show adaptability to the local climate but in extreme climates, they could not achieve indoor thermal comfort. Also, another study by Nguyen and Reiter (2014) shows the importance of simulation-based optimization methods and the promising future towards buildings' efficiency.

The above studies show the usefulness of simulations and the impact of different factors that influence the thermal behaviour of the indoor environment and energy consumption, such as occupants' behaviour, climate conditions and passive strategies adaptation.

1.7. Chapter conclusion

This chapter presents the literature review and theoretical foundation for research. Thesis keywords (Critical Regionalism approach – architectural identity – climate-responsive design – Fernand Pouillon – El-Miniawy brothers – hot-dry climate – south of Algeria), were explored through intensive and updated state-of-the-art research. In section 1.1, the research domain was introduced. In section 1.2, the architectural/urban identity was presented through theory and history, and the related terms are well outlined. Section 1.3 continues by presenting the second part of the thesis which is the climate-responsive design. In section 1.4, the CR approach is well presented and theoretically explored. Section 1.5 an in-depth theoretical foundation for used tools and methods in thesis research was outlined by presenting previous studies. By analysing data, the global form of this chapter shows interesting studies and a vast domain of research throughout the thesis.

CHAPTER TWO
CRITICAL REGIONALISM AND ARCHITECTURAL IDENTITY DIALECTIC

2.1. Introduction and study background

The 'identity' or 'search for meaning', considers the particular context in which each architectural/urban project has evolved. As well as the unique social, economic, environmental and technical factors to which respond. The reveal of meaning is guaranteed by the appropriate and creative utilization of available resources in meeting functional and cultural needs, as well as the higher potential in each project to set a standard for the future. This chapter attempts to classify the various approaches towards answering the problem of regional architectural identity through the lens of selected pioneer theorists achieving to developing the theory of CR.

By exploring several essays and theories regarding this subject, this chapter aims to thoroughly identify the aspects that have been successfully clarified by other theorists and problems that need to be studied, especially those related to the CR approach. On this basis, the developed theory of this research will be outlined to investigate case studies in the upcoming chapters.

2.2. Critical Regionalism polemic between Neo-Avant-Gardists and Neo-Historicists

2.2.1. An overview of the subject

Paul Ricœur[1] once said: '*How to become modern and to return to sources; how to revive an old, dormant civilization and take part in universal civilization*' (Frampton, 1983).

[1] Jean Paul Gustave Ricœur (1913-2005) was a French philosopher best known for combining phenomenological description with hermeneutics

2.6. Critical Regionalism; between theory and practice

The upcoming section presents selected projects (post World War II and contemporary) that are practising the theory of CR theory and being explored through the seven points of CR **(Table 2-3)**. The texts are resumed and coloured to facilitate collecting them into a table, the texts are brought from (Lefaivre & Tzonis, 2003; Aga Khan Award for Architecture, 1977).

2.6.1. Pioneer classics and contemporary Critical Regionalism (post World War II)

2.6.1.1. Oscar Niemeyer (Dance Hall, Pampulha, Belo Horizonte, Minas Gerais, Brazil 1942)

- Niemeyer was addicted to organic and sinuous contours that are inspired by nature. (V)

- The Dance Hall was an expression of the regionalist approach in Brazilian culture. (III)

- 'The Samba', the quintessential Brazilian dance seems to be swaying gently with the project. (III)

- The Dance Hall of Niemeyer become the most celebrated hallmark of all Brazilian architecture to follow 'the sensual rippling curve'. (III)

- The restaurant façade and the low wall under the curve of the canopy are clad with local tiles typical of the Portuguese colonial architecture of Brazil. (I)

See **Figure 2-10 a, b and c**.

(a)  (b) 

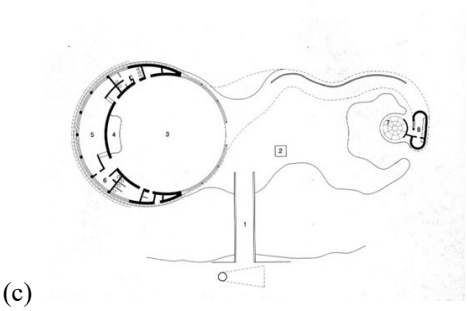
(c) 

Figure 2-10. *Oscar Niemeyer (Dance Hall, Brazil 1942). Source: https://www.archdaily.com.br/br/01-23011/pampulha-beleza-pioneira-e-intimista-de-niemeyer-paul-clemence and https://eutopics.wordpress.com/2012/12/08/brasilidade-architecture-and-modernity-oscar-niemeyer-in-pampulha-belo-horizonte-minas-gerais-brasil-1942-43/ (Accessed date: November 26th, 2021).*

2.6.1.5. Ricardo Porro (School of Plastic Arts, Havana, Cuba 1961-65)

- The used materials were brick and tiled Catalan vaulting; in reaction to the dominant American International Style and contrast to other communist countries. (II)

- Porro's project for plastic arts school was an exercise of '*Cubanidad*', a synthesis of Spanish colonial and Afro-Cuban forms. The building was inspired by a woman's body, the curved outlines in passageways and the cupolas which expressions of the erotic aspect of traditional Cuban culture. (III)

- The curves are integrated harmonically with the tropical natural context. (V)

See **Figure 2-14 a, b, c and d**.

(a)  (b) 

(c)  (d) 

Figure 2-14. *Ricardo Porro (School of Plastic Arts, Cuba 1961-65). Source: https://www.archdaily.com/427268/ad-classics-the-national-art-schools-of-cuba-ricardo-porro-vittorio-garatti-robert-gattardi (Accessed date: November 27th, 2021).*

2.6.1.6. Moshe Safdie (Hebrew Union College, Jerusalem, Palestine 1976-88)

- The building is clad in local, rough-hewn and golden Jerusalem limestone. The stone arcades and sunscreens are in contrast with the reinforced concrete frames of the individual buildings. (I)

- The overall overview of Hebrew Union College is well integrated with the city of Jerusalem. (VI)

2.6.1.8. Berger + Parkkinen (The Nordic Embassies, Berlin, Germany 1995-99)

- The curving wall of a polycentric cluster of embassies is made of oxidized copper louvres, which is in contrast with the bombastic glass and steel gigantism is very familiar in Berlin at that time. (I)

- The project's purpose is counter-institutional, the complex is open to the public and well-integrated with the site. (VI)

- The project is a real application of the regionalism approach, while the six buildings of embassies are expressing the unity of Nordic countries and at the same time, each building expresses its national individuality. (III)

- The initial form was inspired by the site boundary, then developed by creating unity and defining 'critical urban mass'. Consequently, the final form has presented six masses and a void. The void brought a sense of cultural unit and calls for communication. At the same time, stands for individual decisions. (VI)

- The copper band is referring to the Scandinavian landscape and made a dialogue with the site (Tiergarten park). (I)

- The project of Nordic embassies become rapidly a landmark on the map of Berlin. (III)

- The deep metaphoric idea of the embassies' wall, brings to mind the famous 'Berlin Wall' which was steadfast for over three decades and then fell in 1989. This a reminder that walls bring together rather than divide, have openings rather than closure only and create a strong sense of place and community. (III)

- Each embassy of the complex has a unique identity and is in harmony with other embassies (by using the same materials), which expresses the relationship between Nordic countries to each other. (III)

See **Figure 2-17 a, b, c and d**.

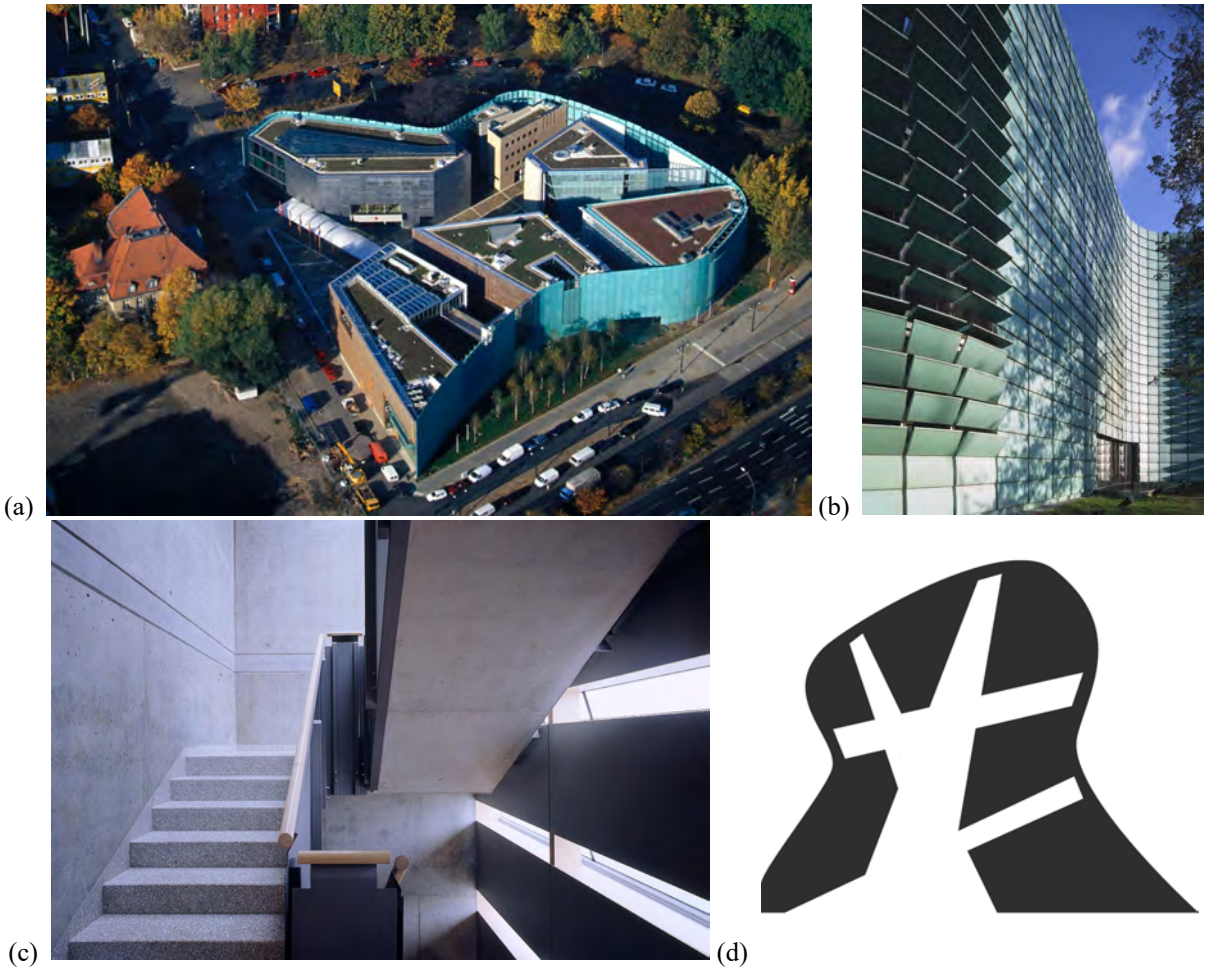


Figure 2-17. *Berger + Parkkinen (The Nordic Embassies, Germany 1995-99). Source: https://berger-parkkinen.com/en/nordic-embassies/ (Accessed date: November 27th, 2021).*

2.6.1.9. Jacques Ferrier and Jean-François Irissou (Siège Sociale de Total énergie La Tour-de-Salvagny, Lyon, France 1998-99)

- The three buildings' structures (two for the company and one for the founder's house) are borrowed from functional agricultural buildings, which are spreading in the rural region. Thus, the useful vernacular form was the source of inspiration; due to its functionality. (I)

- Ferrier considers that the beauty of architecture depends on things seen daily rather than icons of architectural culture. Therefore, he always searches for useful structures that last for years and already have a place in society. (III)

- Ferrier did not consider any architectural correctness of the structure and form and he integrated his project with the rural landscape harmoniously. (I)

- The two company buildings with the house are having the same simple typology as the local industrial farm buildings. All are well-planned in a meticulously functional layout. (III)

- Benninger has implied several traditional concepts such as ‘wadas’, a traditional courtyard house in the region. Each group of students have their courtyard for social and spatial purposes. The cluster of ‘wadas’ or buildings composes the concept of a village or the entire college with a vast network of crossing paths, which enhances the interaction between students and creates potential points for meeting and gathering. (I)

- The consequence zones of the complex of gardens, passages, stepped platforms, atria or orchards are having an identity of their own, controlled chaos that enhances the sense of place and integration within the site’s topography. (VI)

See **Figure 2-19 a, b, c and d**.

(a)  (b) 

(c)  (d) 

Figure 2-19. *Christopher Benninger (The Mahindra United World College, India 1997-2000). Source: https://archello.com/es/story/6713/attachments/photos-videos (Accessed date: November 28th, 2021).*

2.6.1.11. José Antonio Martínez Lapeña & Elías Torres Tur (La Granja Escalator, Toledo, Spain 1997-2000)

- The La Granja Escalator seeks for reducing defacing topography and at the same time maximise access. (VI)

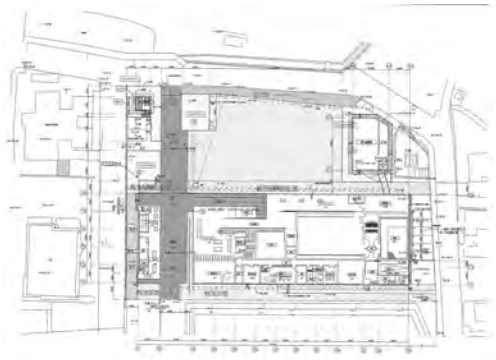
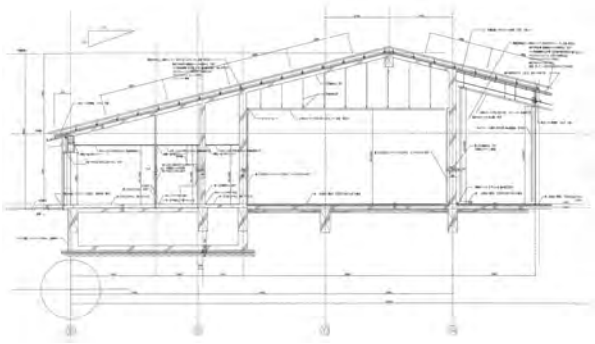
(c)  (d) 

Figure 2-22. *Kengo Kuma (Hiroshige Ando Museum, Japan 1998-2000). Source: https://www.archiweb.cz/en/b/muzeum-malire-ando-hiroshige-nakagawa-machi-bato-hiroshige-museum-of-art (Accessed date: November 28th, 2021).*

2.6.1.14. Leslie Elkins and James Turrell (Live Oak Friends Meeting Hall, Houston, Texas, USA 1995-2001)

- The 'Quakers' or 'Religious Society of Friends is a movement that believes in the ability of each human being to experience and access the light within or see 'that of God in everyone. The project revolves around this idea. (III)

- Elkins and Turrell installed an aperture (one-meter square) in the ceiling centre and the seating was placed around the aperture in form of a meeting circle or square, they called it the 'Skyspace'. (VII)

- The key parameter is the light which is considered analogous to the almighty (according to Quakers' belief). (III)

- In every change in the sky, the opening allows the onlookers to sense the mediation between man's place in the universe and connect heaven and earth. At nightfall, another technique is adapted by Turrell which is a segment of the roof with an artificial neon-light installation that spread a heavenly blue hue in the space. (VII)

- The project is a mix of the traditional architecture of Houston with work of art. The grey wooden typical with a low-pitched roof house is adapted with the innovative idea of 'Sky space'. (I)

- The project's purpose is to reinforce community ties between Quakers, and by adapting the vernacular architecture, this project attracts many non-Quakers to visit and inspire from. (III)

See **Figure 2-23 a, b, c and d**.

Figure 2-23. *Leslie Elkins and James Turrell (Live Oak Friends Meeting Hall, USA 1995-2001). Source: https://sah-archipedia.org/buildings/TX-01-HN123, https://foursquare.com/v/live-oak-friends-meeting-house/4c784942748cb713b59f3668 and https://www.facebook.com/archinerds/photos/one-accord-live-oak-friends/1046591755505512 (Accessed date: November 28th, 2021).*

2.6.1.15. MVRDV (Hageneiland, Ypenburg, The Netherlands 1997-2001)

- The housing project 'MVRDV' is in contrast with typical housing in terms of extending the façade material up onto the roof, or contrary by extending the roof's material down onto the walls. Also, the sizes are not uniform and are separated by equally diverse proportions. This break-down the monotonous typical housing project and transform it into a varied one. (II)

- The interior plan of units is free with concentrating services' space in one zone. (II)

- The project eliminates cars from entry to the urban island, thus the zones are fully exploited in gardens, play areas and grassy paths. The resulting spaces enhance the pleasure of private space due to the ecological, quieter surroundings and cleaner-air design. (VI)

- The project is dedicated to the reuse of an abandoned railway path (35 kilometres) from the 1920s and 30s, in an integrated approach with the agricultural and natural landscape. (III)

- As the architect said: '*The old railway line cut into the landscape like a wound, imposing its own laws in accordance with the need of the machine age.*'. This type of old engineering work defaces the landscape alongside with traditional rural buildings. (VI)

- The project regenerates the circuit into a bicycle, skating, jogging track or trekking trail following natural reserved space to reawaken the connection with nature. (V)

- The project appreciates the traces of industrial archaeology that is considered second nature to the site. Thus, the history of social and economic forces could be an influencing element in the design and could benefit from it. (II)

See **Figure 2-26 a, b, c and d**.

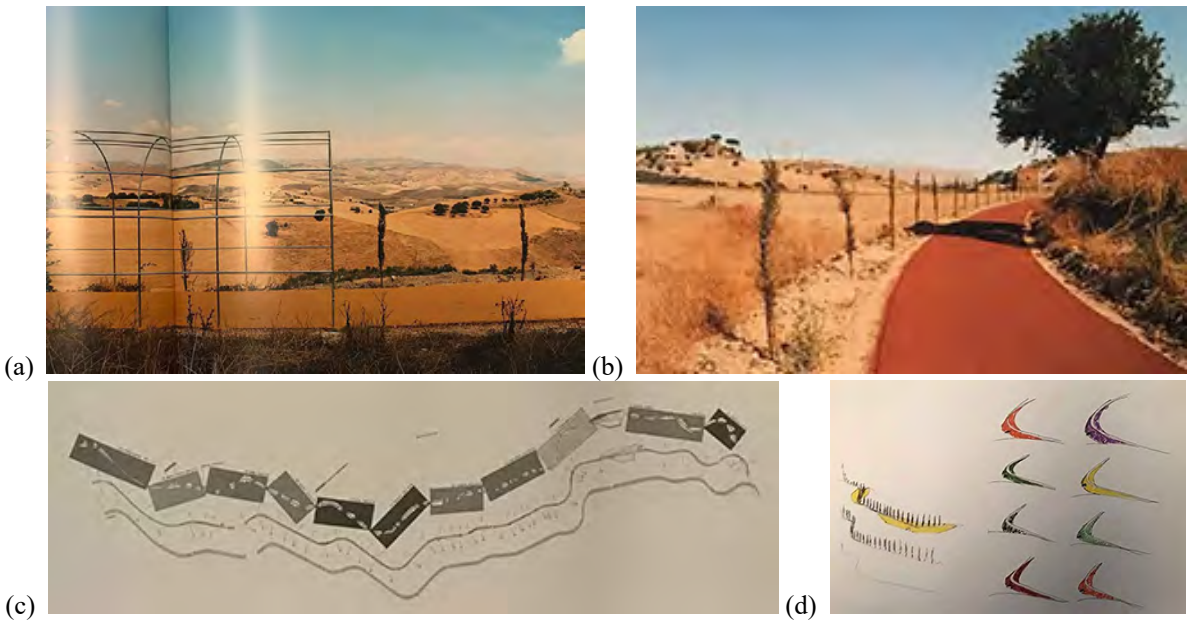


Figure 2-26. *NavarraOfficeWalkArchitecture (Strip Park between Caltagirone and Piazza Armenia, Italy 2001). Source: (Lefaivre & Tzonis, 2003).*

2.6.1.18. foreign office architects (Yokohama International Port Terminal, Yokohama, Japan 1995-2002)

- The main idea in Yokohama International Port Terminal is belonging to the Metabolist movement (which was raised in Japan in the 1960s) and its main philosophy is that architecture should look like 'flow charts'. The project is a floating port and park with a mix of civic facilities for public use in integration with both, the port and the urban site. (III)

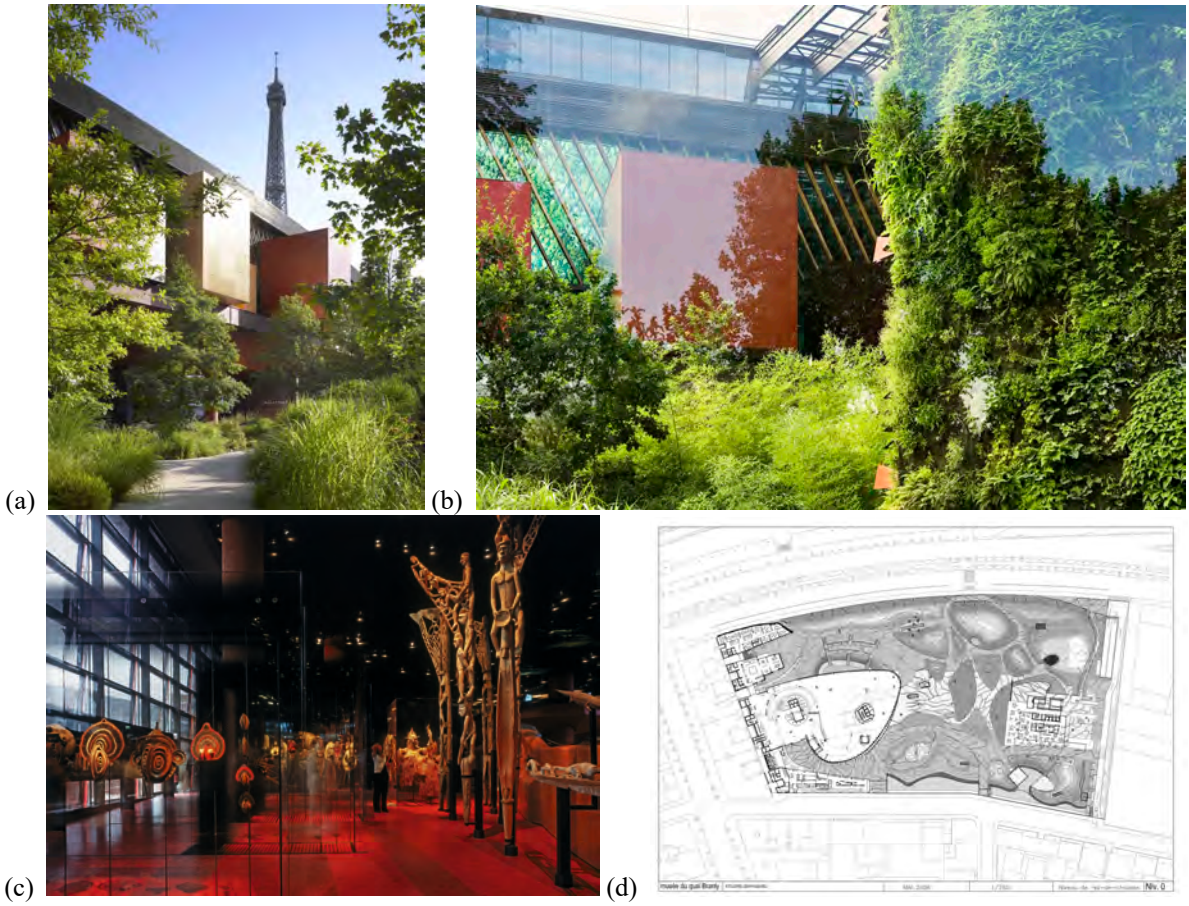


Figure 2-29. *Ateliers Jean Nouvel (Museum on Quai Branly, France, since 1999). Source: https://www.archdaily.com/914842/musee-du-quai-branly-ateliers-jean-nouvel (Accessed date: November 29th, 2021).*

2.6.1.21. Dick Van Gameren and Bjarne Mastenbroek (Royal Embassy of the Netherlands, Addis Ababa, Ethiopia 2005)

- The Project is located on the outskirts of Addis Ababa city enclosed with a eucalyptus grove and stands against the urban sprawl. As if alerting the city to the need to preserve nature and the beauty of getting integrated with it. (III)

- The main objective of the architects is to preserve and respect the topography of the surrounding landscape (maintain existing contours while keeping wildlife and vegetation undisturbed) and enhance the Genius Loci with a metaphoric touch of Dutch water landscape on the roof. (V) (VI)

- The brutal concrete was used and the pigmented colour is red-ochre (which reflects the Ethiopian earth) and is the same in walls, floors and ceilings. (I)

- The rock-hewn vernacular architecture of Ethiopia was the source of inspiration for this project by creating a cave-like space indoors. At the same time, adapting another source of

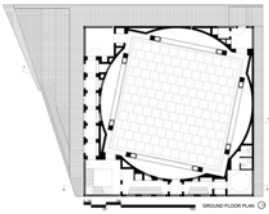
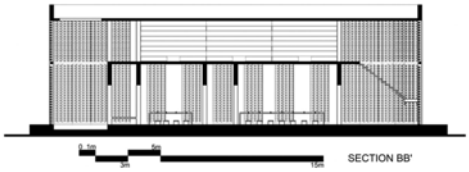
(c)  (d) 

Figure 2-32. *Marina Tabassum (Bait Ur Rouf Mosque, Bangladesh 2005-06). Source: https://www.metalocus.es/en/news/bait-ur-rouf-mosque-marina-tabassum# (Accessed date: November 29th, 2021).*

2.6.1.24. Kashef Mahboob Chowdhury/Urbana (Friendship Centre, Gaibandha, Bangladesh 2008-10)

- The project is inspired by the third century BC oldest urban archaeological site of Mahasthangahr, which is found in Bangladesh and is not far from the Friendship Centre. (I)

- The used materials are local hand-made bricks which also survived in the region and were brought from the monastic aesthetic of the earliest ruins of the Mahasthangahr site. The structure is based on reinforced concrete, finishes are in timber and stone. (I) (II)

- The project promotes natural ventilation and cooling through its layout conception design of courtyards and pools, and by details of ventilated structures with green roofs, doors and windows. (VI)

- The complex is built directly on the lowland (the site is protected by an embankment with a water run-off pumping facility), and it reflects Genius Loci of the agricultural area by merging with the environment through the project's roofscape, and as an echo of the remained memory of the Manhattan archaeological ruins. (V)

- The sense of space is enhanced by the tactile and architectonic concept of used materials and structure, by the luxury of light and shadows, by the joy of movement and discovery in the bare, by the spirit and essentialist gathering of space as a refuge for some poorest population. (VII)

- The social aspect of Friendship Centre is promoted by its beautiful impacts on so many lives and brings vitality to people to meet and interact in the centre. (VII)

- The functional aspect of the centre's spaces is flexible and brings the individuality of each one into consideration while integrated with others. For example, the mosque inside the centre is rotated to obtain the '*Qibla*' direction and hence differs from the orthogonal layout of the project. (III)

- The green covers on the roofs promotes thermal insulation and absorb rainwater in a such tropical climate. (VI)

CHAPTER THREE
CLIMATE-RESPONSIVE DESIGN IN HOT-DRY CLIMATE

3.1. Introduction and background of the study

This chapter provides an overview of the climate-responsive design aspect of CR. Thus, exploring related sides of this subject in terms of the bioclimatic approach in architecture, thermal comfort in the built environment, climate analysis and passive strategies in hot-dry climates. This chapter aims to hierarchically identify the effectiveness of climate-responsive design in the hot-dry region of Algerian's south.

The issue of environmental and climate constraints is the most efficient factor in architectural progress and product. While you adapt your needs and assure the functions of space at the same time you are affected by environmental data (climate for example). The Saharan regions are also part of the whole world's geography, in Algeria, it covers more than 80% of its surface (around 2 million km^2). Mario Botta[1] once said: '*Architecture is the constant fight between man and nature, the fight to overwhelm nature, to possess it. The first act of architecture is to put a stone on the ground. That act transforms a condition of nature into a condition of culture; it's a holy act.*' (Kaihoul & Sriti, 2019). Throughout history, we see this interaction between man, nature and culture, this complicated relationship shapes our life into social urban fabrics and architecture. Therefore, Architectural heritage is the most witness and expressive art and science to human beings' history book.

So, the complexity of an architecture is related to several factors (human, time and place). The human with his complicated needs, social fabric and cultural background. The time with its new fashion, scientific inventions and new tendencies and fashion. The place with its conditions like environment, topography and climate. Therefore, studying all these factors and analysing their data is mandatory to achieve the appropriate architecture for each region. FP

[1] Mario Botta (1943-present) is a Swiss architect

and MB's starting ideas in their work in the south of Algeria, which we will study in upcoming chapters.

3.1.1. Climate-responsive design aspect in 'Critical Regionalism'

According to the previous chapter, the climate-responsive design could be an effective alternative to point six. Besides its idea about considering topography and environment in design, point six promotes the climatic performance of buildings. The CR design should be adaptable and sensitive to the climate. Lewis Mumford claims the sustainable and ecological aspect to achieving the balance between man and nature is '*renewing the air, tempering the heat of the sun, reducing glare and strain, …*'. Kenneth Frampton mentioned that the building should be sensitive to climatological conditions and clarified that nature is not only topography and site but also climate and light. Thus, the building should be adapted to the climate and hence decreases energy consumption of services (e.g., MC systems and artificial light). William Curtis declares very clearly, that climate-responsive design is an essential approach to identifying each region's typology in architecture and it has always been the catalyst for the spread of architectural heritage, especially in extreme climates, '*The point in general is clear enough: the regionalist needs to seek out basic values and types well-suited to locale and to climate, …*'.

Therefore, to understand the climate-responsive design, we should explore several related concepts as follows:

3.2. The bioclimatic approach in architecture

3.2.1. An overview of the approach

'*The features of the physical environment are blanketed by a vast ocean of air, whose tide carry climatic elements to all parts of the earth and are in turn modulated by them. Climate not only plays a great part in the composition of soils, but strongly affects the character of plants and animals in different regions and – most important from our point of view – man's energy.*' (Olgyay, 1963).

Olgyay states that the human body's flexibility and capacity for adaptation are relatively low compared to those of animals, who can adapt to several extreme scenarios of climates. He says on this behalf: '*The bear, in cold weather, can reduce his metabolism through slumber, The bat can survive a change of its body temperature of 60 degrees. The elephant can cool its blood by moving its honeycombed ear … In the hostile territory of the desert many animals*

reverse their life rhythm, live by night, and tuck away underground at dawn. Some rabbit breeds place their burrows with efficient foresight in relation to water and wind.'.

Olgyay mentioned the ability of several animals in adapting to the climate, not by their bodies, but rather providing an adaptable habit in buildings. The varied patterns and forms could be a good example and a source of inspiration for the integration with natural forces. He says in this regard for birds' case: '*The open nest secures insulating qualities; the hanging nest utilizes the tensile strength of fibres, or grasses, and, pendulum-like, avoids the wind forces. The nest which is massively built from clay and straw prevents the intrusion of the direct sun and rain by its steep entrance. The vertical mud and straw nest are similar to apartment dwellings, where each opening is an individual nest comprised of two chambers. The first serves as an entrance foyer, the second an egg laying and hatching area. This very special form successfully avoids the nearly vertical sun rays, and minimizes the effect of precipitation.*'.

Huntington states limited conditions in which man could highest development in terms of physical, mental energy and moral character, as follows:

- The average temperature ranges from 40 °F in winter to 70 °F in summer.
- Frequent storms and winds enhance RH, and rains in all seasons.
- A cyclonic storm (not a harmful one) changes moderately the temperature during seasons.

Olgyay states that treating climate as a primary factor is justifiable only if the thermal built environment is considered the most influencing parameter in architectural design. For example, in the Eskimo igloo, where is the need for compact shelter with a minimum of surface exposure is inevitable. The low hemispherical form deflects the winds and benefits from the insulation value of the snow surrounding it.

Thus, Olgyay explored basic building forms used by the North American Indians in various regions and he found that those people show a remarkable ability to adapt their dwellings to the climate. A very awareness towards solving the climate problems among the craftsmen and vernacular architecture.

3.2.2. Climate zones

3.2.2.1. Olgyay classification

Victor Olgyay[2] has divided the climate zones into four areas as follows:

[2] Victor Olgyay (1910-1970) was an architect, city planner, and early researcher in the field of Bioclimatic design

find in this zone the following characteristics of materials: '*timber skeletons, wood construction, branches, woven sticks, lath, thatch, and verdure*'.

- **The second category** is the cold northern forest and mountain regions (from the north-western U.S. through Scandinavia and to the Himalayas). The houses are in heavy timber with beam construction. The roofs have low-pitched shingles or wooden roofs that use dry snow as insulation.
- **The third category** is west Africa and the Andes, where the walls are adobe covered with a thatched roof. Some several nomadic tribes live in tents of felt or skins.
- **The fourth category** is Mauretania, Gobi and Mexico, where the walls are more important than roofs in terms of protection against exterior conditions and '*the walls are built of stone, dried or baked clays supporting a flat roof of earth*'.
- **The fifth category** is the southern part of the line 45° N in Europe and 30° N in America (Mediterranean, Latin America and Chinese regions). The walls are the principal element of the house and are built of bricks or stone covered with slightly slopping roofs of semi-cylindrical tile.
- **The sixth category** is the northern part of the line 45° N in Europe and 30° N in America. Some stone construction beside many other '*timber constructions with the panels filled with mud, bricks or rough stone, or even paper*'. The roofs are tall and have an angle of 45° and are covered with thatch or shingles.

Other determinants' elements according to Dollfus:

- **Solid vs. void:** The proportions of solid surfaces and openings are influenced by: popular psychology, climate and materials. In extreme climates (hot or cold), the openings are relatively small.
- **Roof:** The roof's shape is the most determinant element of regional house type. The flat roof is used in hot zones, the vaulted roof is found in dry areas, the inclined or pitched roof is adapted to temperate climates with dry summers and the houses with a higher roof are found in wet temperate and cooler regions. Vaults and domes are generally found in hot-arid regions with clear skies. The rounded form reduces the surface's exposure to solar radiation and promotes cooling by wind, and hence night cooling.

3.2.3. Bioclimatic architecture and climate-responsive design

Remarkably, several architectural features are corresponding to certain climatic conditions. Thus, the same solutions are spreading over the world with the same climate zone,

D. Housing forms: Buildings' shapes could be an effective parameter in controlling the built thermal environment. Thus, forms should be determined according to their ability to provide a preferable thermal behaviour.

E. Air movements: The winds in winter should be intercepted while the cooling breezes in summer should be utilized. The indoor air changes per hour (ACH) and movements should be further calculated to maintain thermal comfort and hygiene exigences. The internal flow pattern could be determined by location, arrangement and openings' size.

F. Indoor temperature balance: Building envelope is the main mediator element that controls the indoor thermal environment. Thus, the time-lag and insulation characteristics of used materials should be carefully studied and investigated. The general rule is minimizing heat loss in winter and heat gain in summer.

4) **Architectural Application** is the architectural expression of previous analysing steps of climate, biological and technological aspects. The building should carefully bring the balance between different elements to provide an acceptable built environment passively.

However, the climate-responsive design strategies are the direct practical application of the bioclimatic approach. Therefore, climate-responsive design principles should be adopted as a starting step for the building's design and towards achieving sustainable architecture.

3.2.3.1. The bioclimatic chart

It seems that climate-responsive design principles are found firstly in vernacular architecture over the world. Thus, the first pioneer academic work in this regard is the publication of Olgyay (1963). Olgyay invented the bioclimatic chart **(Figure 3-1)** as a tool to analyse the different climates of the U.S. and hence he developed design architectural principles for each climate zone. The main contribution of Olgyay is that he interpolated the climate, biological and technological aspects to provide a comfortable thermal environment.

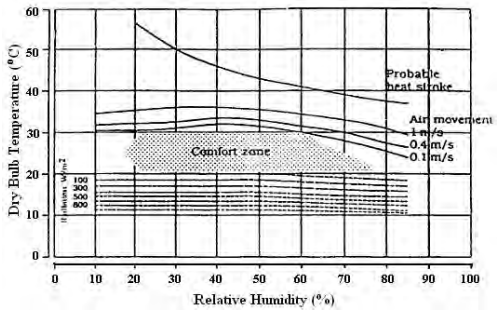


Figure 3-1. *The building bioclimatic chart of Olgyay in 1963. Source: https://www.researchgate.net/publication/253649467_Development_of_bioclimatic_chart_for_passive_building_design_in_Muscat-Oman (Accessed date: November 13th, 2021).*

3.3.2. Human thermoregulation and balance mechanism

The natural temperature of the human body is around 37 °C. The physiological reactions occur to maintain and to regulate the body to be in this average (i.e., the temperature in rest case is around 36.8 °C and it rises to 37.9 °C when doing extra effort like jogging up). (ASHRAE, 2009). The main responsible element for controlling organ temperature is the hypothalamus. It receives thermal information from sensors in blood and skin (Hensel, 1981). The mechanism of regulating human temperature is occurred by blood flow to the skin to diffuse it to the environment when the internal temperature is above the average. While in the case of heat loss, the mechanism takes the reverse way to produce supplemental metabolic heat.

Balance equation:

The exchanges between the human body and environment (gain and loss) are caused by: evaporation, radiation, convection and conduction. The mechanism of balance is presented in the following equation:

$$M - W = q_{sk} + q_{res} + S \qquad (3.1)$$

Where:

M is the rate of metabolic he x at production, W/m^2

W is the rate of mechanical work accomplished, W/m^2

q_{sk} is the rate of heat loss from the skin, W/m^2

$q_{res}$is the total rate of heat loss from respiration, W/m^2

S is the rate of heat storage, W/m^2

According to (ASHRAE, 2009), M is neglected by assuming that the person is in normal conditions and he/she is not doing any effort. With this equation, a person could have thermal comfort satisfaction when the range is between ± 1.7 °C to ± 2.5 °C around the comfort temperature. Otherwise, the unbalance of this equation (heat gain or loss) would bring a discomfort sensation in the human body.

3.3.3. Comfort models

There are several ways in determining thermal comforts, like ASHRAE 55 standard and two-node models. In this study, we will explore the ASHRAE 55 standard methods and models for calculating thermal comfort zone. ASHRAE 55 standard contains two main comfort calculation approaches. The first one is the 'Graphical Method' or 'Normative Graphical Method', as renamed in the 2020 version. This method is familiar to most people and uses limited metabolic rates between 1.0 and 1.3 met and clothing insulation I_{cl} between 0.5 and 1.0 clo of a representative occupant with average air speed 0.2 m/s and limited humidity ratio

certain activity is a function of the thermal load of the body and thus, achieving the resulted equation by using the regression method of experimental studies in the U.S and Denmark and interpolating equations of TSV with thermal loads L to introduce a final equation of PMV-PPD.

However, the PMV index could predict the thermal sensation of a group of persons through the sensation scale. It would be more practical to know how many persons are satisfied and who are not satisfied with the relevant indoor environment. To comply with ASHRAE 55 standard, the predicted percentage of dissatisfied should respect the vote range, PPD ≤ 10% when persons vote PMV in the range from -5 to +5 including 0 or in ASHRAE scale from -1 to +1 including 0 **(Figure 3-2)**. Note that even though the PMV is at the optimal neutral point (0), the PPD still have 5% unsatisfied.

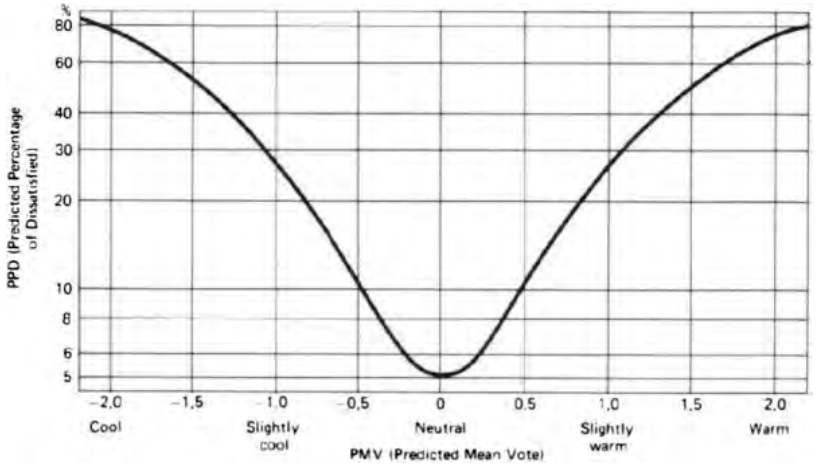


Figure 3-2. *The relationship between PPD and PMV. Source: https://www.researchgate.net/publication/259393547_A_comparison_of_suit_dresses_and_summer_clothes_in_the_terms_of_thermal_comfort (Accessed date: November 13th, 2021).*

The PMV-PPD model is well-recommended internationally by several standards (CIBSE; ASHRAE 55) and it has proved effective in MC buildings and NV buildings in temperate climates. On the other hand, in hot regions, the model shows significant bias and hence a new model for the respective climate is required. An adaptive model has been developed to predict NV buildings.

3.3.3.2. Adaptive model

As clarified previously, The PMV-PPD model is applicable in MC spaces and shows inconsistency with NV spaces, especially in extreme climates. According to (Nicol & Humphreys, 2002), the changes that occurred in several studies that obtained discrepancies in results depending on the change of receptor and his/her behaviour have emerged a new simple comfort theory 'the adaptive model'. The philosophy of this theory is based on the ability of

- Direct evaporative cooling.
- Natural ventilation cooling.
- Fan-forced ventilation cooling.
- Internal heat gain.
- Passive solar heating.
- Wind protection outdoors.
- Humidification only.
- Dehumidification only.
- Cooling (active sources).
- Heating (active sources).

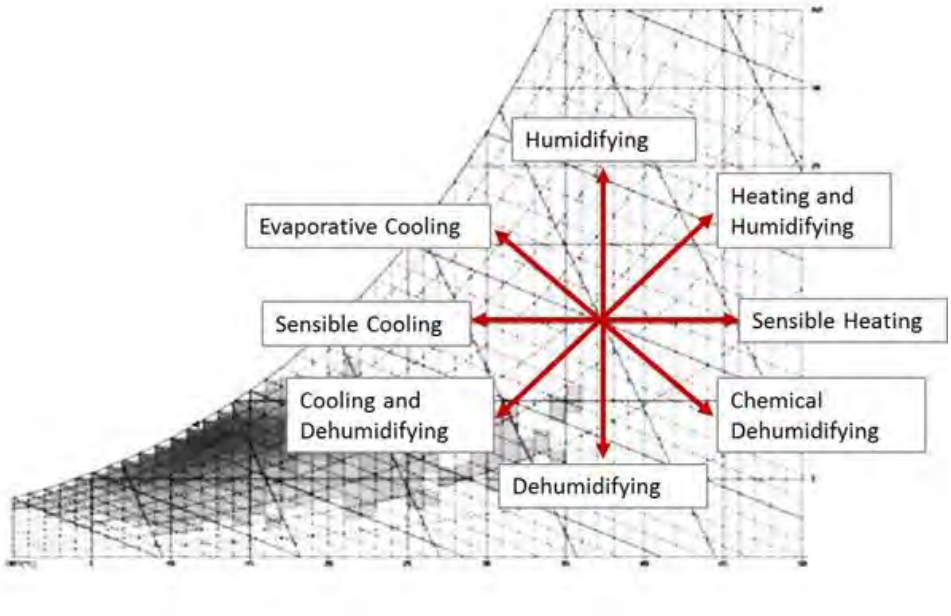


Figure 3-10. *Psychometric chart and extended passive strategies zones. Source: sustainabilityworkshop.venturewell.org/node/1195 (Accessed date: February 9th, 2022).*

A TMY file provides a single year of hourly data that is derived from a longer period (usually 30 years). In this study the 8760 hours of TMY are obtained from the most recent period (2004-2018), many locations and data could be found in (Climate.OneBuilding.Org) and in other sources. Thereafter, the hourly data can be extracted, managed and organized. The data is plotted in form of a scattered cloud which represents each hour by its temperature and humidity, the tool determines whether the data is plotted inside or outside the comfort zone of each strategy and according to comfort models calculations. Yet, by inserting TMY climate files, hourly data of each city was carried out in form of statistics of comfortable and discomfortable periods **(Figure 3-11)** and hence could be represented in charts.

CHAPTER FOUR
MONOGRAPHY OF FERNAND POUILLON AND EL-MINIAWY BROTHERS

4.1. Introduction

This chapter provides an overview of the scope of research, FP and MB monography and case studies. Thus, both architects are explored through their thoughts, concepts, philosophy, social studies, construction materials and morphology, along with selected case studies in the south of Algeria. This chapter aims to provide a comprehensive qualitative and analytical study of two pioneer architects who worked in Algeria during the 20th decade (specifically their work in the south of Algeria).

Table 4-1 resumes the monography of both architects. The general form of this chapter's upcoming section will be in the form of questions and answers to selected bullets of discussion created by the author. For the case of FP, the information and data are collected from: (Maachi Maïza, 2002; Zineddine, 2019; Pouillon, 1968; Dubord, 1986; Gruet, et al., 2013; Lamraoui & Boussoualim, 2012; Picard, 1994; Deluz, 1988; Mazouz, 2010; Ratouis, 2017; Roy, 1977; Merzelkad, 2011; Lucan, 2003; Bonillo, 2001; Pouillon, 2011; Maachi Maïza, 2008; Pouillon, 1964; Barazzetta, 2001). For the case of MB, the references are: (Noweir, 1983; Abada, 2000; Rached, 2010; El-Miniawy, 2019).

(plazas, streets, perspectives, hierarchy of spaces) that simulate the character of old cities. Also, preserving the landscape view and topography of the site creates a strong relationship with the environment and provides the space with a view towards nature. This approach in my projects enhances Algeria's folklore and creates immortal architecture. Therefore, the idea of ambience in architecture was fundamental to my projects. I represent cultural aspects and identity whether in colonized or independent Algeria of both coastal or desert, and this influences the process of my design in every stage. While preserving historical vocabulary in my designs, I am also being updated with construction techniques and engineering.

For me, rationalism is using simple forms, cohesive order, hierarchy in public spaces, the articulation between different scales and the sensitivity of created space. I have refused Modernism in its global aspect as a unified international style and lack of sensitivity. Architecture is not a plastic object nor a machine of living, but rather a rational process that prioritizes essential aspects of construction, such as operations time, costs and quality no matter what the used approach or materials.

I preserve the old construction and heritage to reuse it for other functions. For example, the M'Zab hotel (named also Rosthémide hotel) **(Figure 4-3)** is built above the ruins of a French prison (the underground is still preserved and contains dungeons). I extract the function and meaning of traditional ornamental patterns to create original rational forms.

Figure 4-3. *M'Zab hotel (ex. Rosthémide hotel), Algeria. Source: https://mapio.net/wiki/Q4819474-en/ (Accessed date: March 12th, 2022).*

I believe that beautiful and honest architecture could be the justice of genius, simple talent or conscientious and sensitive work. First comes, the meaning of construction, second, is the notion of beauty and sensitivity, thirdly, the product of the composition, materials and

When I was invited for the first time to Algiers, it was acceptable to find such filthy slums to the French presence reputation. Among the other projects in the same environment and period, mine were the most relevant and homogeneous with Muslim society. The details of the façades, the proportions, and the identical symbols reflect both, traditional Mediterranean character and Muslim social housing character. This is very clear in my awareness towards the public spaces' layout and urban design (plazas, spaces' hierarchy, perspectives, … etc.). Also, I do care about providing the users with beautiful views towards the surrounding environment, which causes a very clear integration between my projects and landscape. The large ensembles that I have created in my work were just creating other spaces that are relating to the natural environment and at the same time provide a homogeneous quality of architectural and urban spaces (this was not familiar at that period).

My projects are characterized by: integration with natural/urban sites, equilibrium masses with harmonious proportions, noble and sustainable materials, sculpture in façades, artistic ceramic work and landscapes. Abstracted archetypes without frills (creating contemporary forms by interpreting the old ones of different contexts, regions and climates). Rationalism in every aspect, such as simple functional forms, reduces materials costs and time. I do not use new materials always, but rather find the most efficient or rational means of implementing old materials, such as stone and rammed earth.

I am very aware of the interaction between morphology and its function, and between urban space quality and the aesthetic quality of construction. Stone, a material that crosses over time and resists, is, without a doubt, the preferred construction material. I am expressing architecture through simple geometries and materials. The constructive elements and morphology of my work are influenced by physical, geographical, social and cultural contexts. Before designing the project, I visited the context and then tried to fully understand it to create the optimal morphology, daylighting and orientation.

The social context is very important, I should do architecture as an Arab now the sense of belonging makes feelings and spaces more sensitive to tourists and visitors. The ideologies and practices should be respected and formed as architecture. My work in Algeria for example adapts and reflects each region's identity and transforms the idea of a hotel (in its international term) into a series of Oriental-inspired tales (Islamic identity from East to West).

I found a middle ground between old and new, architectural marriages between contemporary and archaeological elements. For example, the image of El-Mekter hotel from Alhambra palace, the image of El-Gourara hotel from an ancient temple, the façade of El-Rym

- **Morphology (volumetry)**

The hotel is composed of a closed monoblock (two parallel wings of simple rectangular style), with a ground floor and two upper floors. The symmetric form of the hotel is preserved 100% (the main transverse axis divides the hotel into two parts centred by the lobby and two main patios, one is dedicated to a swimming pool and the other is a garden). The equilibrium of masses is born of rigorous harmonious proportions. The external façade is composed of visible towers, which bring to mind the sense of fortified Ksar.

- **Façades and orientation**

The hotel contains three accessible façades, the principal northern façade contains the public entrance which is remarked by a tower and a large arch, which provide a central point of spreading circulation towards the hotel's main spaces. The southern façade (staff's entrance), and western and eastern façades face the desertic mountains. The façades contain Islamic arches and pierced curved-surface shapes in terraces (M'Zab architecture) to protect the rooms from direct sun rays while providing daylighting. The openings in exterior façades are reduced to the minimum (in the southern façade) while preserving the horizontal and vertical shading through passages, massive walls and roofs.

- **Plans and structure**

The hotel's plan is linear-symmetric and is composed of a ground floor and two upper floors (the two patios are the main productive element and centre point). The rooms spread through the three levels and have terraces to the patios and exterior. The hotel has six senior suites, four junior suites, a restaurant with 200 seats, a lounge bar, a terrace, a swimming pool and an internal garden. The used structure is shells of lightly reinforced concrete in the foundation, the stone, the double wall of hollow concrete blocks separated by an air gap in massive load-bearing walls (thickness achieves to 0.6 m in several walls) and the hollow concrete blocks in roofs.

- **Materials and colours**

The dominant colour of the region is the natural colour of desertic-rocky mountains. The used material in masonry is stone and hollow concrete blocks and covered by lime-sand render - a regular texture - (either on the wall or roof). The internal floors are covered by traditional carpets to add dynamic movement to the space.

4.5.3. El-Djanoub hotel - 600 beds (1974) in Ghardaïa, Algeria

This wonderful hotel is one of FP's masterpieces in the south of Algeria (the historical city of Ghardaïa). In 1974, under the supervision of the ministry of tourism FP started his work

patios and exterior. The rooms are relatively having big surfaces. The hotel has a restaurant, a swimming pool, a conference room, a lounge and nine internal gardens. The used structure is: shells of lightly reinforced concrete in the foundation, the double wall of hollow concrete blocks and separated by an air gap in massive load-bearing walls (thickness achieves to 0.6 m in several walls) and the hollow concrete blocks in roofs.

- **Materials and colours**

The dominant colour of the region is the natural colour of desertic-rocky mountains. The used material in masonry is stone and hollow concrete blocks and covered by lime-sand render - a regular texture - (either on the wall or roof). The internal floors are covered by traditional carpets to add dynamic movement to the space.

4.6. El-Miniawy brothers work in the south of Algeria

Most of MB's work is urban planning villages and residential units. In the south of Algeria, MB realized several rural villages, housing units and schools. Therefore, the author selects the following projects to represent a reliable sample of MB work in the south of Algeria. **Table 4-5** resumes the selected case studies analysis.

(e) 

Figure 4-15. *Maader village in Bou-Saada, Algeria 1975-1980 (a), (b), (c), (d) and (e). Source: https://www.archnet.org/sites/231 (Accessed date: March 19th, 2022).*

- **Situation (location, accessibility, nature/urban, sun path and wind)**

The village is located to the northeast of Bou-Saada (12 km far from the city centre). The project is linked by mechanical streets from all four sides (the terrain's form is rectangular), and the main northern-west side leads to the Bou-Saada. The context is 100% rural (semi-urban) with a view towards the surrounding farms. The village's main axis is oriented towards the northwest - southern east. The monsoon winds are northern west (cold wind) and southern east (hot wind).

- **Integration with the site (topography and landscape)**

The hotel is well-integrated within its rural-natural environment through form, colour and implementation. The relatively flat land is treated skilfully by MB through a square-unit form of buildings and urban spaces (alleys and urban patios) that follow the terrain's general form. The project's housing and public facilities have views towards the created interior-urban spaces in the village's big terrain.

- **Morphology (volumetry)**

The village is composed of a closed multiblock (several blocks of simple square style covered by vaults and domes), with a ground floor only. The village has a relatively symmetric axis (the blocks are gathered around the centre of the village which contains a mosque and other facilities). The equilibrium of masses is born of rigorous harmonious proportions. There are two private courtyards for each housing unit and a central patio (a meeting place for women) in each block which presents a group of four housing units, which brings to mind the sense of traditional Islamic hierarchy.

- **Façades and orientation**

The village contains four accessible façades, the principal eastern façade contains the main entrance from the principal street which is remarked by a mosque and public facilities which provide a central point of spreading circulation towards housing units and urban spaces through alleys. The southern, western and northern façades face the surrounding streets and

CHAPTER FIVE
INVESTIGATING THE APPLICATION OF CRITICAL REGIONALISM

5.1. Introduction

In this chapter, the CR points proposed by the author are explored through data collection of FP and MB quotes (in the case of FP) and interviews (in the case of MB). Thereafter, the chosen case studies in the south of Algeria were analysed each by each to look for the applicability of the CR approach. subsequently, a survey of 69 architects was performed to investigate the CR approach application in case studies. The results and discussion are presented in a subsequent section.

5.2. Qualitative analysis pattern

5.2.1. Seven points of Critical Regionalism proposed by the author

To facilitate the comprehension of the CR concept, the author has concluded the approach from pioneer theorists who talk about it, into seven points under the form of recommendation (Do and Do not do). In the upcoming section, a qualitative analysis was performed through data collection (quotes and interviews) of FP and MB ideas about the seven points of CR proposed by the author. Thereafter, each case study of their work was explored through the lens of the seven points of CR through architectural analysis and illustrations. Subsequently, a quantitative study of the sum of 69 architects' surveys using a standardized questionnaire was adapted for an in-depth investigation of the applicability of the CR approach in selected case studies.

5.4.2. Selected projects of El-Miniawy brothers' analysis

A qualitative approach was performed in this section to analyse selected case studies through architectural documents and illustrations. **Tables 5-6, 5-7 and 5-8** present the application of CR to the work of MB in the south of Algeria (Maader village, 400 housing units and 600 housing units) and respected illustration.

Figure 5-2. *The projects of case studies. Source: https://twitter.com/algeria3new/status/1474421486597386243, https://www.fernandpouillon.com/mzabarchp.html and https://www.archnet.org/sites/231 (Accessed date: April 13th, 2022).*

CHAPTER SIX

THE EFFECT OF CLIMATE-RESPONSIVE DESIGN ON THERMAL PERFORMANCE (THE WORK OF FERNAND POUILLON IN THE SOUTH OF ALGERIA)

6.1. Introduction

6.1.1. Study background

In this chapter, the effect of FP's work's climate-responsive design is explored. First, a literature review on the subject was performed to establish a theoretical foundation for the research. Subsequently, a qualitative study was carried out through data collection of selected case studies, besides in-situ measurements and dynamic simulation. Thereafter, thermal performance assessments and SA were implemented to investigate design parameters and climate zones. Consequently, an optimization of the model has occurred to compare the base case and optimized case within different climate zones. The results and discussion are presented in a subsequent section.

The evaluation of design parameters corresponding with thermal behaviour is considered an essential aspect in the retrofit development of existing and new buildings. A good investigation of each strategy could be a helpful tool for further work on energy and cost performance. It could be a basis of energy policies and benchmarking that benefit both public and private sectors (Nguyen & Rockwood, 2019).

The mechanically conditioned (MC) and naturally ventilated (NV) spaces are seeming to be important in terms of determining the type of used comfort models. ASHRAE Standard 55-2004 proposes two main approaches in terms of analysing comfort. One is the predicted mean vote and predicted percentage of dissatisfaction (PMV-PPD) model, the other one is the adaptive model. Whereas the ASHRAE adaptive model is suitable for NV buildings and PMV-PPD is more convenient with MC buildings (ASHRAE, 2017).

Software dynamic simulation witnesses fast development in terms of the prediction of future scenarios, climate change, technology development, urbanization, … etc. Therefore, the parametric variations of models must be addressed well with their sensitivity and uncertainty to establish a benchmark or boundary of building performance. Besides other aspects, the contemporary practice of dynamic simulation tools worldwide is devoted to quantifying annual thermal comfort hours, energy demand, life cycle assessment and cost. Uncertainty and sensitivity, both techniques could explore the model's influencing parameters and assure robustness. Also, give a global overview of the model and deduct the sensible parameters. Thus, reducing iterations and a lot of extra work while preserving most of the variance (Nguyen & Reiter, 2015).

In Algeria, the building sector (residential and tertiary) consumes 43% of the total Algerian energy consumption (34% is dedicated to the residential sector and 9% to the tertiary sector). Furthermore, 41% and 43% of the total energy consumption of the tertiary sector is devoted to electricity and natural gas respectively. 3.5% of this sector's consumption is addressed to hotel buildings ("L'Agence Nationale pour la Promotion et la Rationalisation de l'Utilisation de l'Énergie - APRUE -", 2017).

Likewise in Algeria, the number of hotels is increasing over the country; due to the government's orientation towards tourism. However, the complexity of hotel buildings investigation comes from their diversity in sizes, locations and types. Several studies investigate models through several parameters such as insulation, Window-to-wall ratio (WWR), ventilation, airtightness, … etc, but there is a lack of hotel building measurements in Algeria regarding thermal behaviour and energy performance. However, NV and MC types both need to be investigated more.

Very recent studies have explored hostel buildings and houses in different climates, through surveys and in situ measurements in terms of adaptive comfort model and NV buildings (Faheem, Bhandari & Tadepalli, 2022; Safarova, et al., 2022; Yao, et al., 2022; Larriva, Mendes & Forcada, 2022). Another study has addressed the PMV-PPD comfort model through meta-analysis and surveys (Niza & Broday, 2022).

Therefore, this chapter aims to examine the sensitivity of thermal performance (discomfort hours over the year in NV and MC) in a large hotel building using the LSA method (with SI). More specifically, this chapter examines the implications of different types of climates in Algeria to the uncertainty in these different outputs results and the sensitivity of the different parameters for each result. Moreover, this study investigates the difference between the effects of NV and MC analysis for adapting to the climate. Also, this study would be helpful

6.2. Climate-responsive design and the case studies (El-Gourara, M'Zab and El-Djanoub hotels)

6.2.1. Qualitative presentation of the climate-responsive design of case studies

The upcoming section presents the qualitative presentation of the climate-responsive design of case studies El-Gourara, M'Zab and El-Djanoub hotels **(Table 6-1)**:

et de Recherches Intégrées du Bâtiment - CNERIB -", 2011) to be used in different simulation steps. ACHs for envelope's infiltration are 0.1177 **(Equation 6.1)** and 0.055 **(Equations 6.2 and 6.3)** for summer and winter respectively. While the ACH for air renewal of natural ventilation (minimum air renewal exigence of indoor space) is 0.1 **(Equation 6.4)** and 0.6 **(Equations 6.5 and 6.6)** for summer and winter respectively. These rates are influencing thermal gain or loss of indoor air, by dividing (Q) over (V), whereas V is the building's volume equal to 44120.5.6 m^3. The following equations are used in determining ACH values:

Infiltration (summer)

$$qv_{inf} = \sum \left(qvo_{inf,i} \times S_{ouv,i}\right) \quad \left[\frac{m^3}{h}\right] \qquad (6.1)$$

Whereas: qv_{inf} is the flow rate by wind infiltration (taking into account only the openings located in walls facing the winds), $qvo_{inf,i}$ is the opening (i) infiltration rate (for windows ($qvo_{inf,i} = 14.5$ $m^3/h.m^2$) and for doors ($qvo_{inf,i} = 4.5$ $m^3/h.m^2$), $S_{ouv,i}$ is the opening (i) surface (m^2).

Infiltration (winter)

$$Q_s = \sum \left(P_{pi} \times e_{vi}\right) \quad \left[\frac{m^3}{h}\right] \qquad (6.2)$$

$$P_{pi} = \sum \left(P_{oj} \times A_j\right) \quad \left[\frac{m^3}{h}\right] \quad when \quad (\Delta P = 1P_a) \qquad (6.3)$$

Whereas: Q_s is the flow rate by wind infiltration (considering all envelope's openings), P_{pi} is the wall (i) air permeability (m^3/h), e_{vi} is the wall (i) wind exposure coefficient ($e_{vi} = 2.3$) which is calculated based on opening's height from the ground and region's environmental conditions (near the sea, mountains, rural environment, urban environment, etc.), P_{oj} is the opening (j) surface air permeability (for windows ($P_{oj} = 4$) and for doors ($P_{oj} = 6$) ($m^3/h.m^2$)), A_j is the opening (j) surface (m^2).

Air renewal (summer)

$$Q_v = \sum \left(Q_{vmin} \times n_p\right) \quad \left[\frac{m^3}{h}\right] \qquad (6.4)$$

Whereas: Q_v is the specific ventilation rate, Q_{vmin} is the minimum extract flow rate (for rooms of less than three occupants ($Q_{vmin} = 30$) and for bathrooms ($Q_{vmin} = 15$) (m^3/h)), n_p is the number of pieces.

Air renewal (winter)

The model is considered calibrated when NMBE is less than ±10% and CVRMSE is less than 30%.

$$NMBE = \frac{\sum_{i=1}^{n}(y_i - \hat{y}_i)}{(n-p)\cdot \bar{y}} \cdot 100 \qquad (6.7)$$

$$CVRMSE = \frac{\sqrt{\frac{\sum_{i=1}^{n}(y_i - \hat{y}_i)^2}{(n-p)}}}{\bar{y}} \cdot 100 \qquad (6.8)$$

whereas y_i is the actual measurement for period i, $\hat{y}_i$ is the simulated value for period i, $\bar{y}$ is the average measurement, n is the number of measured periods and p = 1.

In this study, the calibration was done by inserting the model's parameters inputs and running them, so the matched results were reached between the simulated and actual measurements. The measured parameters are thermal ones; so, by calibrating these parameters with the simulated model, the discomfort hours can be predicted as well (unavailable data).

The calibration was carried out for the period of measurements. The difference between the model's prediction and actual measured values resulted, for temperature, in absolute NMBE of 9.04% and -1.09% and in a CVRMSE of 13.95% and 5.2% for outside and room points respectively. For the RH, the NMBE value was -4.57% the and CVRMSE value was 23.39% for the room point. There are few critical peaks in RH calibration results; it is because of its sensitivity, that there is a kind of underestimation in measurement values. Despite that, the trends of measured and simulated parameters follow suit each other with almost similar behaviour and it is demonstrated through the calibration equations. The resulting values are below the acceptable ASHRAE 14-2002 (ASHRAE, 2002) rate of ±10% and 30% for the NMBE and CVRMSE coefficients respectively. **Figures 6-31 a and b** illustrate the described validation results.

CHAPTER SEVEN

THE EFFECT OF CLIMATE-RESPONSIVE DESIGN ON THERMAL PERFORMANCE (THE WORK OF EL-MINIAWY BROTHERS IN THE SOUTH OF ALGERIA)

7.1. Introduction

7.1.1. Study background

In this chapter, the effect of the climate-responsive design of the work of MB is explored. First, a literature review on the subject was performed to establish a theoretical foundation for the research. Subsequently, a qualitative study was carried out through data collection of selected case studies, besides in-situ measurements and dynamic simulation. Thereafter, a thermal performance assessment was implemented to explore the effect of passive design on energy demand. subsequently, a parametric variation of the model has occurred to compare the application of passive design on energy demand (cooling and heating loads). The results and discussion are presented in a subsequent section.

As a very recent statistics, in the US, the electric power sector constitutes 37% of the total energy, while buildings consume 7% of the total electricity use. Similarly, electricity covers 60% of the building's energy consumption, while natural gas the 32%. The used energy for space cooling and heating in the residential sector is 30% of total energy consumption and in the commercial sector, the percentage is 15% ("U.S. Energy Information Administration - EIA -", 2020).

In EU countries, the building sector is responsible for 40-45% of the total energy consumption (Balaras, et al., 2007; Fayaz & Kari, 2009; Cao, Dai & Liu, 2016). The International Energy Agency (IEA) declared that the buildings and buildings construction sectors combined are consuming over 30% of the total world's energy ("International Energy Agency - IEA -.", 2020). Likewise, in Algeria, the building sector (residential and tertiary) consumes 43% of the total Algerian energy consumption. Furthermore, 30% and 31% of total

Algerian energy are dedicated to electricity and natural gas respectively, whilst housing is considered the first consumer sector and consumes 43% and 60% of total Algerian electricity and natural gas consumption respectively ("L'Agence Nationale pour la Promotion et la Rationalisation de l'Utilisation de l'Énergie - APRUE -", 2017).

While the world is suffering from climate change, which is caused by CO_2 emissions the most, according to the Annual Energy Outlook U.S, electricity by fossil fuels was the most sector that increased CO_2 emission during the last thirty years ("U.S. Energy Information Administration - EIA -", 2020). Consequently, International Energy Agency states that the building sector is responsible for nearly 40% of total CO_2 emissions. Similarly, energy-related CO_2 emissions from buildings are caused by fossil fuel use rising due to growing cooling and heating building demand and lack of energy-efficiency policies and insufficient investment in sustainable buildings ("International Energy Agency - IEA -.", 2020). Therefore, the climate change issue has led to an alarming situation which alludes to mandatory sustainable building design (Attia & Gobin, 2020).

Therefore, climate-responsive design is one of the dedicated concepts and strategies that deal with global warming issues (Ibiyeye, Mohd & Zalina, 2015). According to Lehmann (2011), a climate-responsive design is a building's design which is compatible with the location's specific climate and conditions. (Rijal, Humphreys & Nicol, 2017) set that a climate-responsive design is when a building establishes thermal comfort for occupants and, at the same time, reduces energy use. Due to Nguyen and Reiter (2014), architects play an important role in creating an appropriate built environment through climate-responsive shelter and hence creating a comfortable indoor space without using modern independent and active systems. The first step to designing an energy-efficient building is to adapt to the climate through passive strategies (Olgyay, 1963; Lechner, 2014; Prieto, et al., 2018).

Consequently, the climate-responsive design is an integration of building within their particular climate through passive strategies (before using active solutions), and hence to achieve the indoor thermal appropriate conditions which lead to less energy demand and, as result, less CO_2 emissions to reduce global warming.

Regarding the case study, southern the part of Algeria is a region with a severe hot-dry climate with its cultural characteristics, and the climate-responsive design, inspired by traditional architecture, has specific attributes that reflect the climatic and cultural features. However, the traditional passive solutions in the south of Algeria have not been well documented, nor the traditional architecture nor the vernacular-inspired ones. Also, there is a lacking of quantitative measurements and energy demand studies, which become inevitable

due to the frequent electricity power cuts in summer (lack of adequate energy sources). Because of the increase in energy consumption, the government reduced the cost of electricity and gas bills by 65% in southern provinces to support citizens to cope with severe climate conditions ("La Commission de Régulation de l'Electricité et du Gaz (CREG)"). On the other hand, the rich heritage of traditional architecture and passive solutions which survived in severe climates must be explored and evaluated to highlight sustainable design in future. While this heritage is getting disappearing due to the diffusion of more energy-intensive and standardized architecture, it is inevitable to promote the such adaptation of climate-responsive design features and its positive impact on thermal and energy performance in future projects.

The main purposes of this study were:

1) To identify the climate-responsive design features applied in the chosen case study (MB Maader village, 400 and 600 housing in Bou-Saada, El-Oued and Ouled Djellal respectively), which are typical housing inspired by the traditional local architecture of the south of Algeria.
2) To investigate the effectiveness of climate-responsive design in controlling the indoor thermal environment through psychometric chart (ASHRAE 55) and dynamic simulations.
3) To reveal the energy demand (cooling and heating) evaluations of applying and not-applying climate-responsive design through parametric variations of several scenarios.

7.1.2. Methods

This chapter begins with a general overview of the study. The analysis of the topography and climate of the studied area follows the introductive part. Then the features of climate-responsive strategies and design, imported from local traditional architecture and adopted in MB Maader village, 400 and 600 housing, are defined.

Afterwards, the study method includes psychometric chart evaluation, field measurements and dynamic simulation, with the analysis of the results. The field measurements were taken to evaluate the indoor thermal environment during the hottest period of the year (end of July and beginning of August). Thus, the simulation was carried out after the models' calibration to investigate the thermal behaviour of the 'applying\not-applying' climate-responsive design. Hence, the work analyses the cooling and heating energy demands according to the thermal conditions and energy loads fixed by Algerian Technical Regulation Document (DTR C3-T) ("Centre National d'Études et de Recherches Intégrées du Bâtiment - CNERIB -", 2011). Consequently, a parametric analysis is adopted to compare different

7.2. Climate-responsive design and the case studies (Maader village, 400 and 600 housing units)

7.2.1. Qualitative presentation of the climate-responsive design of case studies

The upcoming section presents the qualitative presentation of the climate-responsive design of case studies of Maader village, 400 and 600 housing units **(Table 7-1)**:

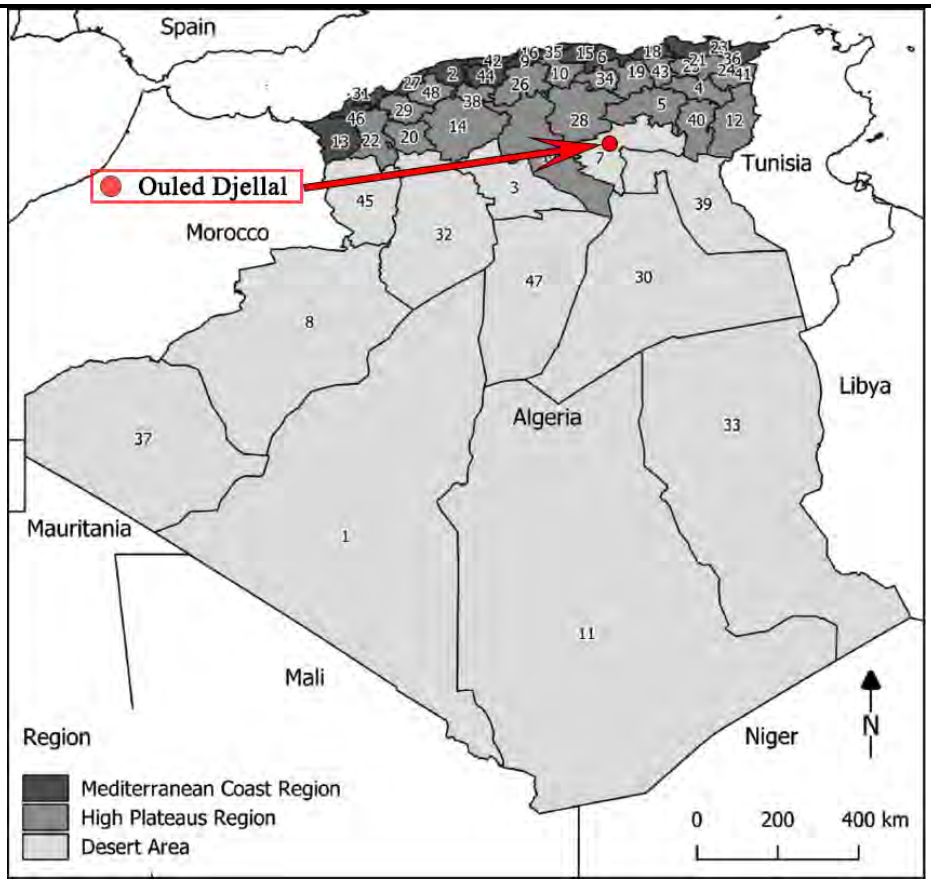
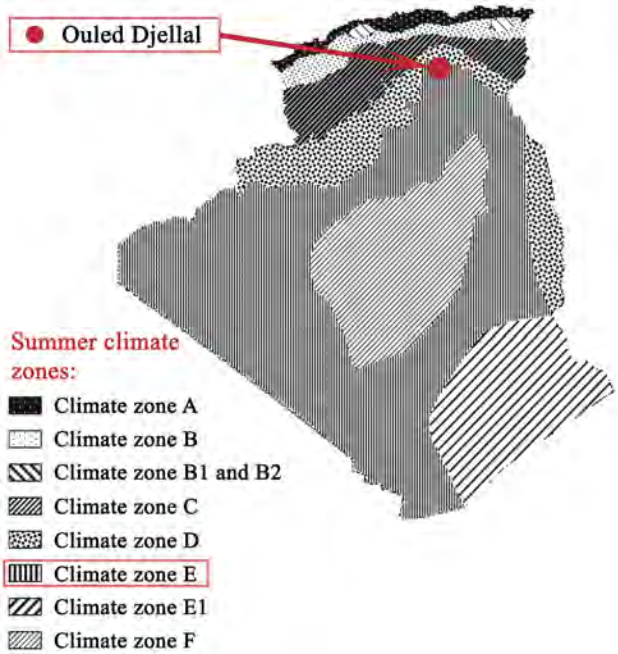
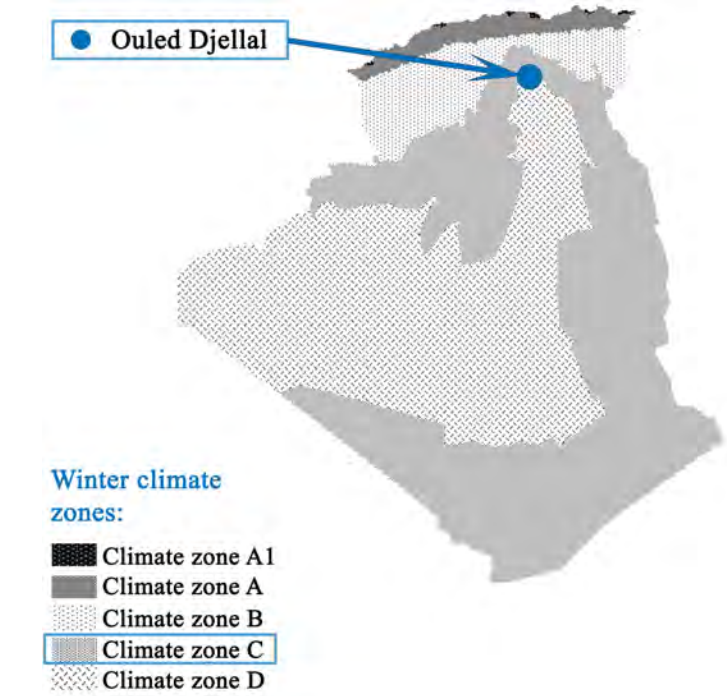


Figure 7-22. *Map showing the three major regions of Algeria and the 48 provinces. Source: (Li, et al., 2018).*



(a)



(b)

Figure 7-23. *Summer (a) and winter (b) climate zones classification of Algeria. Source: ("Centre National d'Études et de Recherches Intégrées du Bâtiment - CNERIB -", 2011).*

7.4.2. Ouled Djellal

Ouled Djellal is located 400 kilometres southeast of Algiers. It is an old Islamic city characterized by a rich heritage, compact layout, narrow streets, alleys, the grand Plaza and a great mosque in the centre. The predominant ethnicity is Arab and hence the language is Arabic; the society is constituted of conservative traditions and privacy. It is bounded by Doucen on the north, Lioua and El-Oued province on the east, Besbes and El-Oued province on the south and Sidi Khaled on the west. Ouled Djellal lies between 34.32° and 34.50° north latitude and 4.94° and 5.27° east longitude with 210 m altitudes. The general geological formation of the district is a mountainous desert. Oued Djedi is the principal valley, while the historical kernel of Ouled Djellal is located on the northern side of Oued Djedi. The city extends towards the north. The district is famous for palms, which cover the southern, eastern and western strips of the city. The myth says that the first kernel of Ouled Djellal was in the southern side of Oued Djedi, but the blessed man named Sidi M'tair threw his stick and he said it has to change direction and build in the northern side of Oued Djedi. However, the city afterwards developed as we see it today and the southern strip of palms benefits from the valley and protects the city from east-southern monsoon sandstorms (Harzallah, 2013). Since its constitution, Ouled Djellal with its oasis nature, adults and males worked in farming and especially the palms. Also, the grand plaza was a 'Souq' for commercial convoys.

The climate is hot-dry based on the climate zones of Algeria by (DTR C3-T) ("Centre National d'Études et de Recherches Intégrées du Bâtiment - CNERIB -", 2011), where 'C' is the winter climate zone (1 °C is the outdoor basic temperature) and 'E' is the summer climate zone **(Figure 7-23 a and b)**. The main monsoon is the cold north-west monsoon (December to April), and the second one is the hot south-east monsoon (June to October), followed by sandstorms from desert called 'khamasieen' from mid-March to mid-May (Archnet, 2001). Ouled Djellal has been experiencing a hot climate in summer and cold winter. Summers (May to September) are hot with the temperature hovering around 15-43 °C (the desert regions in Algeria are characterized by cold nights, especially in early summer's nights; this explains the expansion of the temperature range). Winters (November to February) are cold with temperatures in a range of 4-20 °C. Rainfall is rare and almost non-existent throughout the year. The presence of high-temperature degrees in the long summer (five months) causes thermal discomfort. The monthly normal climate of Ouled Djellal is given in **Table 5-6**. Temperature varies from 4 °C to 43 °C and RH varies from 25% to 57% **(Figure 7-24)**. Wind velocity ranges from 2.9 m/s to 4.4 m/s and sunshine hours per day vary from 6.2 h to 11.8 h **(Figure 7-25)**.

Table 7-5: *The monthly normal climate of Ouled Djellal. Source: (Meteonorm)*

S. No.	Station	January	February	March	April	May	June	July	August	September	October	November	December
1	Average maximum temperature (°C)	15.3	17.5	21.5	24.8	31.3	38.4	42.2	40.9	34.3	28.1	20	18.6
2	Average minimum temperature (°C)	4.7	5	8.3	12.5	15	22.6	25	25.1	22.1	16.7	9.4	7.7
3	Average mean temperature (°C)	9.9	11.3	14.8	18.4	23.2	30.5	33.6	33	28.2	22.1	14.7	13.4
4	Average relative humidity (%)	55	43	41	48	43	25	26	31	46	46	57	54
5	Average wind velocity (m/s)	4.4	3.9	3.5	3.7	4	4	3.6	2.9	2.9	3.1	3.4	3.8
6	Average sunshine hour per day (h)	6.7	7.6	7.9	9	10	10.9	11.8	11	9.7	8.1	7.2	6.2
7	Total rain fall (mm)	1	5	16	22	17	4	1	10	18	7	11	4

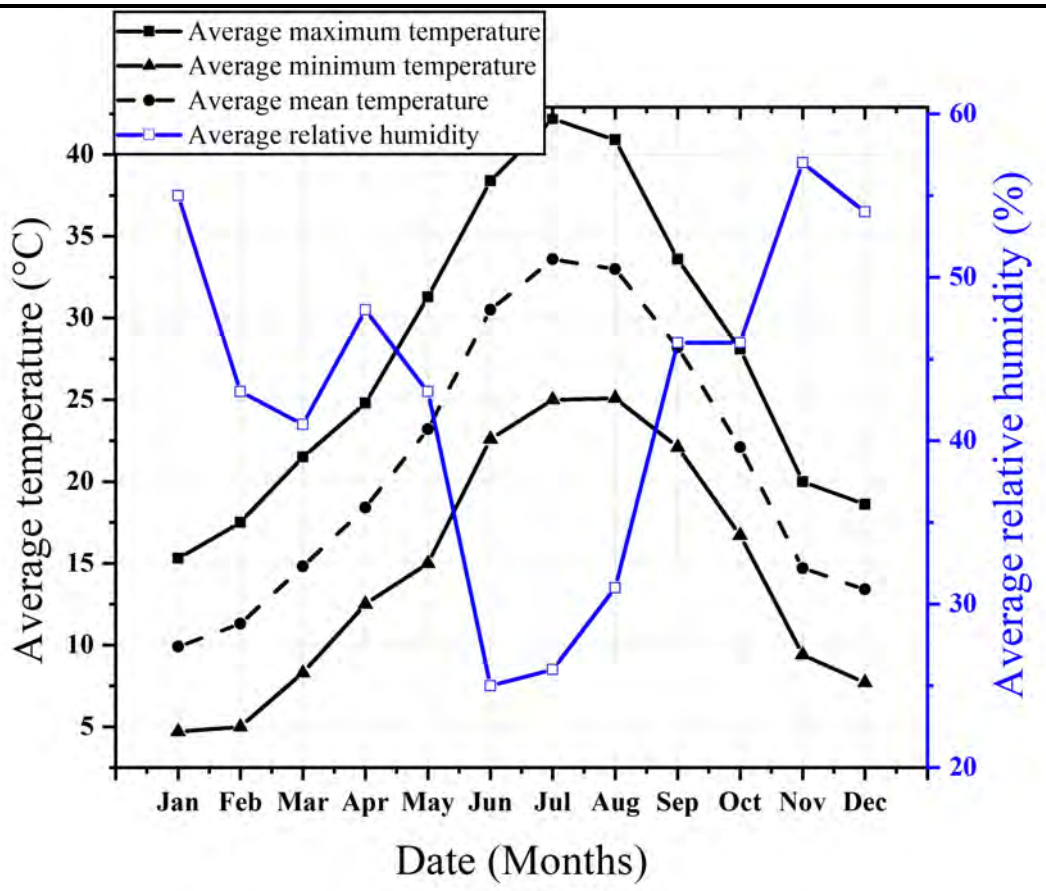


Fig. 7-24. *Ouled Djellal average temperatures and RH during the year.*

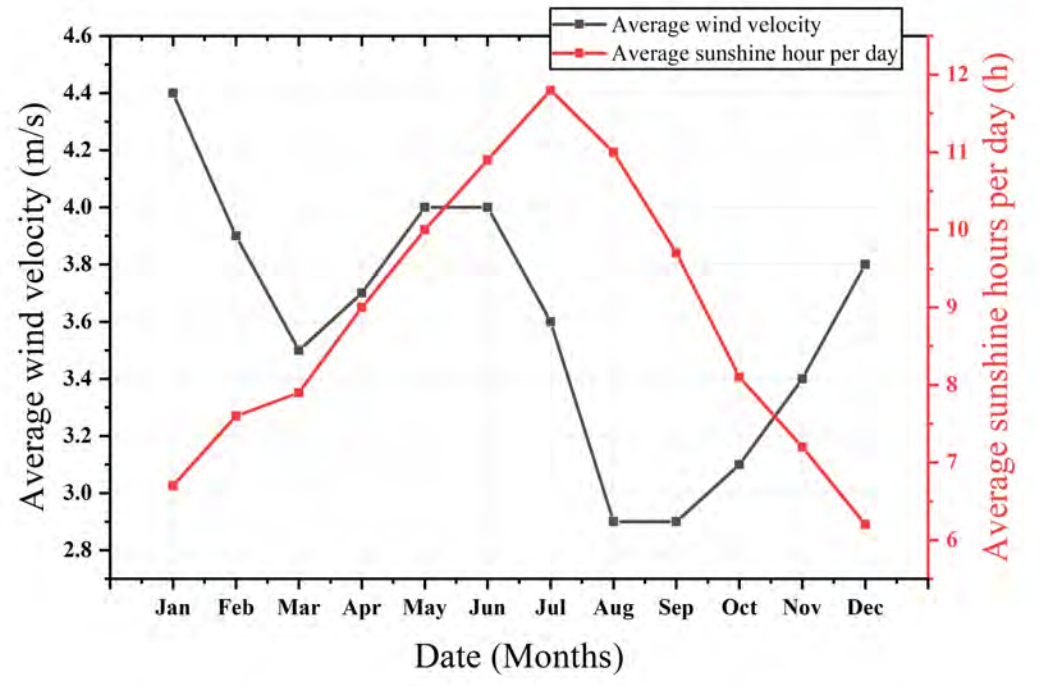


Figure 7-25. *Ouled Djellal average wind velocity and sunshine hours per day during the year.*

7.4.2.1. Ouled Djellal: 200 units housing project, by\ El-Miniawy brothers

In the period between 1988-1993, the housing project was completed. MB and the local authority collaborated over ten years of design and construction studies development, with a clear aim to provide a built environment that is sensitive to the climate and traditions. After many social studies and reinterpretation of local heritage, the 200 units housing project has been enhanced through a contemporary manner, local techniques and a strong awareness of regional identity. The site's topography was uniformly composed of sloping sand (slopes from east to west with a variance of 2.5 to 3 m) and the context was urban (Archnet, 2001). The concerned studied building type is semi-collective housing which is representative of 20% of the residential sector in Ouled Djellal. The other houses are collective (20%) and individual (60%) ("Directorate of Reconstruction, Architecture and Construction in Biskra", 2008).

7.4.3. Psychometric chart

The percentage of passive strategies' contribution in achieving comfort is defined in the bioclimatic psychometric chart according to ASHRAE standard 55-2004 since the main idea is to explore discomfort hours over the year to effectively benefit from reducing cooling and heating loads through passive strategies. The used method is the simplified graphical approach that uses the psychometric chart to represent the thermal comfort zone of an identified occupant along with relevant strategies for evaluating the space as an MC space, through the PMV-PPD model. Thus, the criteria were set as Climate Consultant 6.0 precise (0.5 clo for summer and 1.0 clo for winter, 1.1 met, winter lower operative temperature 20.3 °C, winter upper operative temperature 24.3°C, summer upper operative temperature 26.7, air speed < 0.2 m/s, RH < 84.6% and PMV = 90%). Consequently, the Climate consultant V. 6.0 (build 13) tool (Climate Consultant) was adopted by inserting the climate data input of Ouled Djellal **(Figure 7-26)**. According to Semahi et al. (2019), the three major strategies of bioclimatic design are: 'passive solar heating', 'natural ventilation and 'direct evaporative cooling'. They are the most effective passive strategies in Algeria. Thus, by applying these three major strategies in psychometric chart estimation of climate files, it was possible to achieve the results of discomfort hours in collective housing in Algeria throughout the year. The following strategies related to the psychometric chart are adopted in the case study to achieve comfortable conditions passively. It was found that:

1) 'Sun shading of windows' contributes with ~ 19.1%,
2) 'High thermal mass night flushed' contributes with ~ 11%,
3) 'Natural ventilation cooling' contributes with ~ 6%,

4) 'Internal heat gain' contributes with ~ 26%,
5) 'Passive solar direct gain low mass' contributes with ~ 8.5%.

Therefore, the total comfort hours using relevant strategies are 5337 h out of 8760 h, which presents a percentage of 60.9%, while the comfort hours of the specific region without applying any strategies is 1832 h (20.9%). The psychometric chart also shows that comfort conditions can be achieved passively to the limit of 79.4% with 6954 hours per year. Anyway, this approach is supposed to reduce discomfort hours to 3423 h (39.1%) and hence minimize cooling demand to 22.4% and heating loads to 16.7% of the total year's hours.

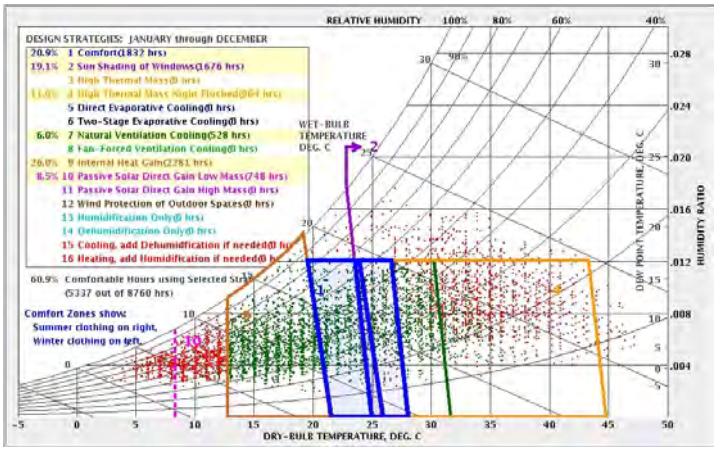


Figure 7-26. *Ouled Djellal psychometric chart and relevant adapted strategies in the case study. Source: (Climate Consultant).*

Please note that the adaptive model has been tested to evaluate the comfort zone too, but it has not had a clear influence in adapting to the harsh hot-dry climate of Ouled Djellal: the discomfort hours over the year are still limited to 61.8% when applying case study existing strategies, while the simplified PMV-PPD model only shows 60.9% achievable. Moreover, a limit of 76.6% is verified by applying all passive strategies, while the simplified PMV-PPD shows 79.4%. This is because the adaptive model could be applicable when the prevailing mean outdoor air temperature is in the range between 10 °C and 33.5 °C, while the temperatures in these hot regions are exceeding this boundary in hot summer's time. Therefore, the authors only consider the PMV-PPD model in this study.

7.4.4. Measurements and dynamic simulations

7.4.4.1. Field measurements

To investigate the thermal performance of climate-responsive design and thus the energy demand for cooling and heating, field measurements were conducted by using Testo® 480 (Testo-480, 1957) to provide detailed information of indoor thermal environment and to

calibrate simulation models and predict energy demand in longer period (see sections 6.3 and 6.3.1). The measured spaces **(Figure 7-15 a)** were on the ground floor and in different locations: the bedroom is oriented towards the east with a window to the exterior, while the living room is opened to the infernal patio and oriented to the north. Inhabitants and several appliances occupied both of them.

7.4.4.2. Dynamic simulation

EnergyPlus/DesignBuilder is used in this study. The case study was modelled as a multi-zonal design, which contributes to more reliability and completeness of the model and its thermal response to determined parameters.

- **Simulation process**

The simulation process consisted of the following steps:

- **The climate data**

Ouled Djellal meteorological data are used: they contained the hourly data of temperature, humidity, global solar radiation, diffuse solar radiation, cloud cover, dry bulb temperature, wind speed and wind direction. Thus, in the analysis of energy loads for cooling and heating, the software uses a reference year to make the simulation: this reference year is the average value of several years (2004-2018) (Climate.OneBuilding.Org). Similarly, a .epw file that contains detailed information about the weather for the 8760 hours of the year was imported. The temperature degrees vary from 4 °C to 43 °C in Ouled Djellal.

- **The model of the case study**

600 units housing project, by\ MB in Ouled Djellal: the modelled building contains two blocks, each of them has eight units, four units in each storey. **Figures 7-15 a and b** represent the two floors' plans. The unit is composed of a living room, a kitchen, a hall, two bedrooms, a bathroom, a toilet and two patios. The windows are located in each attic space, opened either to the exterior or interior patios (semi-open spaces). The unit has a surface area of 112 m^2, and each block has a floor surface area of 438 m^2. Each unit is modelled with multi zones (seven zones in total) **(Figure 7-27 a and b)**. Windows are opened at night if the indoor temperature is higher than 22 °C, allowing for night flushing ventilation. Please note that wind towers are not investigated through simulation nor in measurements because they have been suspended from users due to technical and cultural perception issues. Also, the 'internal heat gains' input is represented in occupants and no appliances were included. The lighting was applied automatically due to minimum software requirements for lighting.

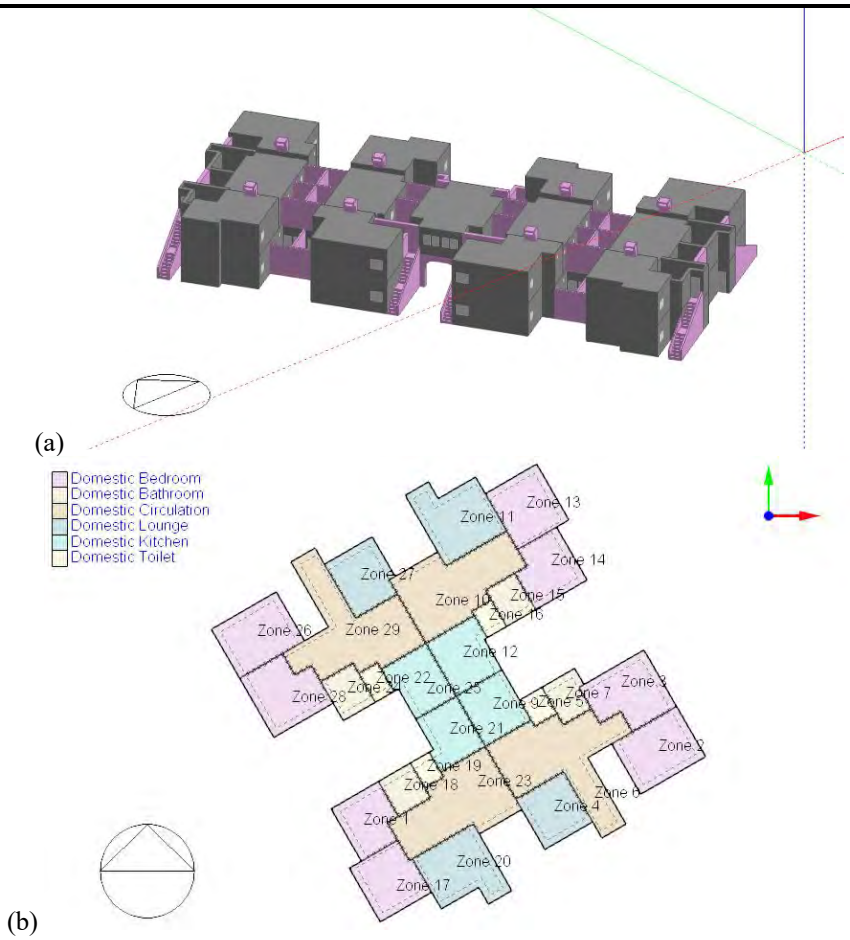


Figure 7-27. *Case study model, where (a) presents the studied building and (b) presents ground floor plans (four units in a storey).*

- **Thermal characteristics**

Table 7-6 presents the thermal conductivity, density and specific heat capacity characteristics of the envelope's materials. Also, the standard internal gains of occupants were defined (the appliances are excluded). The thermal characteristics of materials are imported from the (DTR C3-T), except for the main material of walls (lime-sand stone), which its sample has been tested technically to obtain the necessary results **(Figure 7-28)**. Consequently, ACH is calculated according to (DTR C3-T) equations for summer and winter infiltration and air renewal ("Centre National d'Études et de Recherches Intégrées du Bâtiment - CNERIB -", 2011) to be used in different simulation steps. ACH for envelope's infiltration is 0.1619 **(Equation 7.1)** and 0.251 **(Equations 7.2 and 7.3)** for summer and winter respectively, while the ACH for air renewal of natural ventilation (minimum air renewal exigence of indoor space) is 0.6 **(Equations 7.4 and 7.5)** for all the season. These rates are influencing thermal gain or loss of indoor air, by dividing (Q) over (V), whereas V is the building's volume equal to 3519.6 m^3. The following equations are used in determining ACH values:

Infiltration (summer)

$$qv_{inf} = \sum \left(qvo_{inf,i} \times S_{ouv,i}\right) \quad \left[\frac{m^3}{h}\right] \qquad (7.1)$$

Whereas: qv_{inf} is the flow rate by wind infiltration (taking into account only the openings located in walls facing the winds), $qvo_{inf,i}$ is the opening (i) infiltration rate (for windows ($qvo_{inf,i} = 14.5$ m³/h.m²) and for doors ($qvo_{inf,i} = 4.5$ m³/h.m²), $S_{ouv,i}$ is the opening (i) surface (m²).

Infiltration (winter)

$$Q_s = \sum \left(P_{pi} \times e_{vi}\right) \quad \left[\frac{m^3}{h}\right] \qquad (7.2)$$

$$P_{pi} = \sum (P_{oj} \times A_j) \quad \left[\frac{m^3}{h}\right] \quad when \quad (\Delta P = 1P_a) \qquad (7.3)$$

Whereas: Q_s is the flow rate by wind infiltration (considering all envelope's openings), P_{pi} is the wall (i) air permeability (m³/h), e_{vi} is the wall (i) wind exposure coefficient ($e_{vi} = 2.71$) which is calculated based on opening's height from the ground and region's environmental conditions (near the sea, mountains, rural environment, urban environment, etc.), P_{oj} is the opening (j) surface air permeability (for windows ($P_{oj} = 4$) and for doors ($P_{oj} = 6$) (m³/h.m²)), A_j is the opening (j) surface (m²).

Air renewal (all season)

$$Q_v = Max\left[0.6 \times V_h, Q_{vréf}\right] \quad \left[\frac{m^3}{h}\right] \qquad (7.4)$$

$$Q_{vréf} = \frac{5Q_{vmin} + Q_{vmax}}{6} \quad \left[\frac{m^3}{h}\right] \qquad (7.5)$$

Whereas: Q_v is the specific ventilation rate, V_h is the apartment volume (living spaces) (m³), $Q_{vréf}$ is the reference extract flow, Q_{vmin} is the minimum extract flow ($Q_{vmin} = 75$) (m³/h), Q_{vmax} is the maximum extract flow ($Q_{vmax} = 150$) (m³/h).

- **Occupancy schedule**

According to statistics of the urban planning and development directorate ("Directorate of Reconstruction, Architecture and Construction in Biskra". 2008), the average number of persons per household is 6.52. Similarly, the density rates are 0.2, 0.3, 0.35, 0.2, 0.3 and 0.5 (persons per m^2) for bedroom, circulation (hall), lounge, kitchen, bathroom and toilet respectively. The occupancy schedule is presented in **(Figure 7-29)**, where the rates differ from 0 (which indicates the non-occupied space) to 1 (which indicates the full occupancy of relevant space with relevant density). The occupancy schedule was determined based on a walkthrough visit and performed observation and interviews regarding occupants' behaviour in using cooling and heating systems. However, the occupants' behaviour is considered constant in the study (a fixed occupancy profile for all the proposed scenarios) and, thus, the behaviour of the building regarding the passive strategies in specific climates was counted and simulated. Therefore, the considered variable is only the design itself (for each scenario one passive strategy is changed and the others are unchanged).

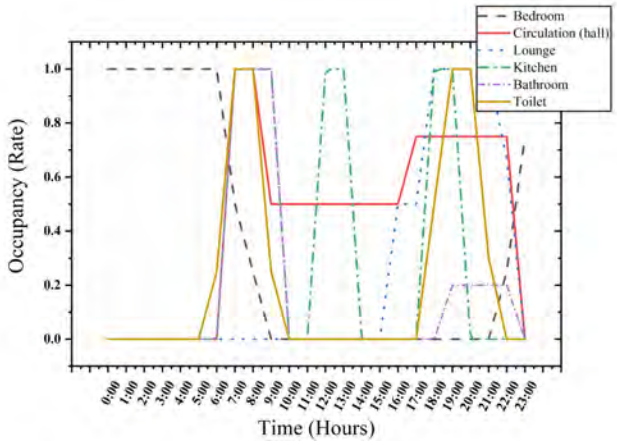


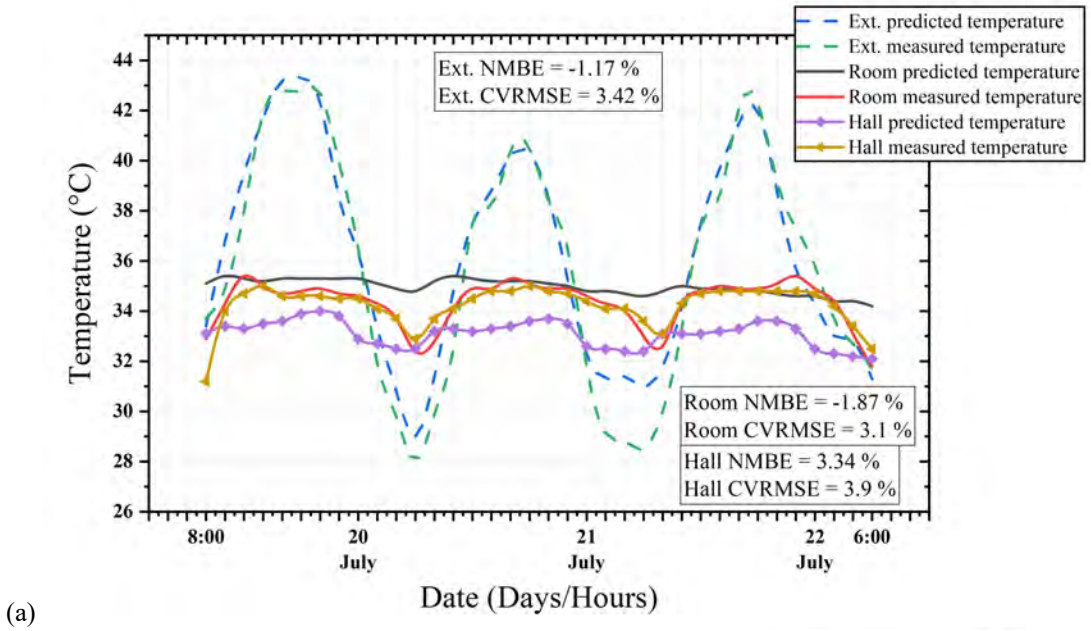
Figure 7-29. *Occupancy schedule.*

7.4.4.3. Model's validation

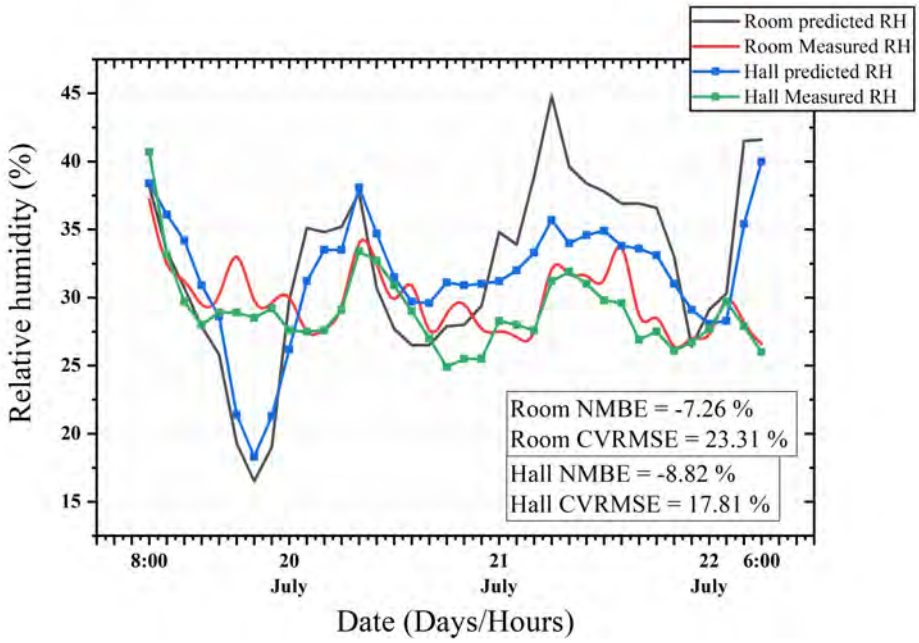
The model validation is an essential step to ensure that it is effective in describing the energy performance and thermal behaviour for periods longer than the monitored days. However, two equations can be handled, NMBE **(Equation 6.7)** and CVRMSE **(Equation 6.8)** (see section 4.4.4.3 for more details).

The calibration was carried out for the period of measurements. The difference between the model's prediction and actual measured values resulted, for temperature, in absolute NMBE of -1.17%, -1.87% and 3.34% and a CVRMSE of 3.42%, 3.1% and 3.9% for outside, room and hall point respectively. For the RH, NMBE values were -7.26% and -8.82% and CVRMSE

values were 23.31% and 17.81% for room and hall points respectively. There are few critical peaks in RH calibration results; it is because of its sensitivity, that there is a kind of underestimation in measurement values. Despite that, the trends of measured and simulated parameters follow suit each other with almost similar behaviour and it is demonstrated through the calibration equations. The resulting values are below the acceptable ASHRAE 14-2002 (ASHRAE, 2002) rate of ± 10% and 30% for the NMBE and CVRMSE coefficients respectively. **Figures 7-30 a and b** illustrate the described validation results.



(a)

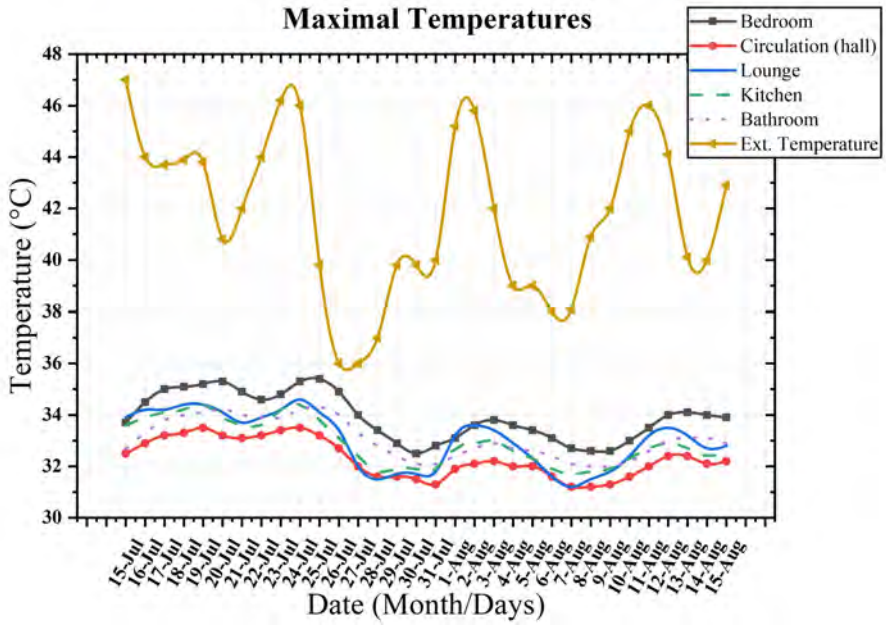


(b)

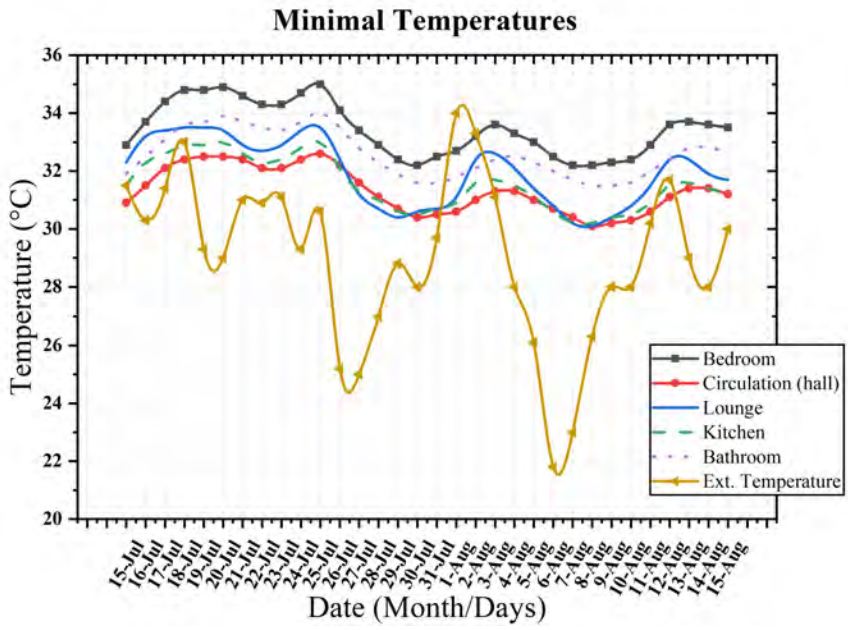
Figure 7-30. *Validation results, where (a) indicates temperature values and (b) presents RH values.*

7.4.4.4. Thermal behaviour (without HVAC)

After validating the simulation model, the thermal behaviour has been explored during the whole year. The results of the typical hottest month in summer (30 days from mid. July to mid. August) are presented in **Figures 7-31 a and b**. Temperature degrees are fluctuating between 31.2 °C and 35.4 °C while the external degrees are achieving 47 °C. Consequently, the used strategies by MB promote activity spaces with better conditions: hall spaces beside the kitchen show the best adaptability to the external hotness condition, bedroom shows less adaptability compared to other spaces; due to the direct exposition to the exterior (east façade).



(a)



(b)

Figure 7-31. *Typical hottest month, where (a) indicates maximal temperature values and (b) minimal temperature values.*

However, simulation results of the whole year (according to ASHRAE 55 PMV-PPD model) show that discomfort hours, in which the building indoor environment does not achieve thermal comfort conditions, are about 3524 h (40.2% of the simulated hours). The summer's discomfort hours are about 1840 h (21%) and the winter ones are about 1684 (19%) of the whole year's hours. The psychometric chart (ASHRAE 55 PMV-PPD model) shows almost matching results along with simulation (by EnergyPlus), in which the discomfort hours percentages are estimated at 39.1% and 40.2% respectively where the building needs extra passive and active sources for cooling and heating. However, the psychometric chart shows that the limit of the maximum discomfort hours with passive strategies is about 20.6% in a year. Similarly, the psychometric chart indicates that discomfort hours percentage can be reduced from ~ 39.1% to ~ 20.6% passively with 'Two Stage Evaporative Cooling' and 'passive solar direct gain high mass'. **Table 7-7** describes estimated comfort and discomfort hours through the year obtained by psychometric chart and the ones obtained by software model's simulation, whereas the regression between the two tools indicates a strong correlation with a Pearson correlation coefficient (R) of 0.9913 and regression coefficient (R^2) of 0.9828 **(Figure 7-32)**. Therefore, the obtained results of the simulation are confirming the psychometric chart estimation of comfort and discomfort hours that can be achieved passively.

Table 7-7: *Comfort and discomfort hours of psychometric and simulation estimation*

Estimation tool (through a single year – 8760 hours)	Comfort (h)			Discomfort (h)		
	Summer	Winter	Total	Summer	Winter	Total
Psychometric chart*	2386 (27.2%)	2951 (33.7%)	5337 (60.9%)	1962 (22.4%)	1461 (16.7%)	3423 (39.1%)
Simulation**	2540 (29%)	2696 (30.8%)	5236 (59.8%)	1840 (21%)	1684 (19.2%)	3524 (40.2%)

*By/ Climate Consultant tool V 6.0 (build 13)
**By/ DesignBuilder Version 4.8.0.068

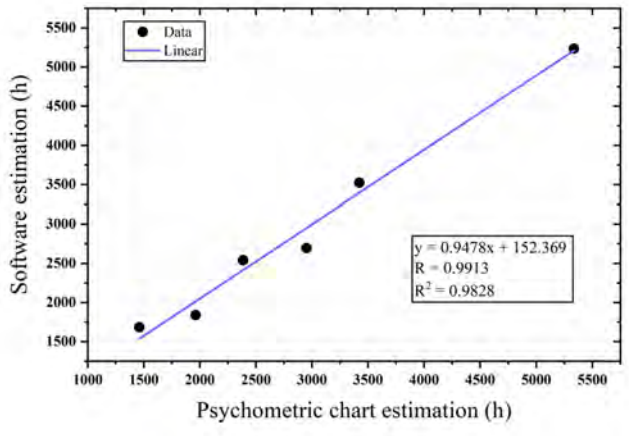


Figure 7-32. *Linear regression of comfort and discomfort hours obtained from Psychometric chart and software model's simulation over the year.*

7.4.5. The parametric variations

The schedule for cooling and heating operation is presented in **Figure 7-33 a and b**, where the values differ from 0 to 1 (0 indicates the non-heated/non-cooled action, 0.5 indicates the temperature set-back point and 1 indicates the temperature set-point), while 16 °C is the set-back point for winter (Attia & Gobin, 2020). Yet, to ensure that PMV does not decrease under 80%, heating, ventilation and air-conditioning (HVAC) set points used in the dynamic simulation of this study were put in as recommended by CNERIB and DTR C3-T. The temperatures are 21°C for winter (1.0 clo, 1.1 met, 0.2 m/s and 50% RH) and 27 °C for summer (0.5 clo, 1.1 met, 0.2 m/s and 50% RH) ("Centre National d'Études et de Recherches Intégrées du Bâtiment - CNERIB -", 2011).

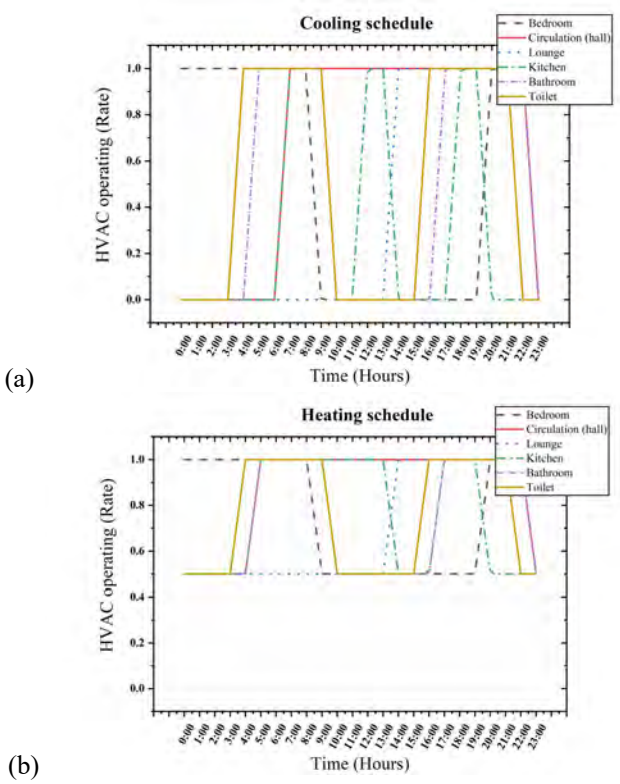


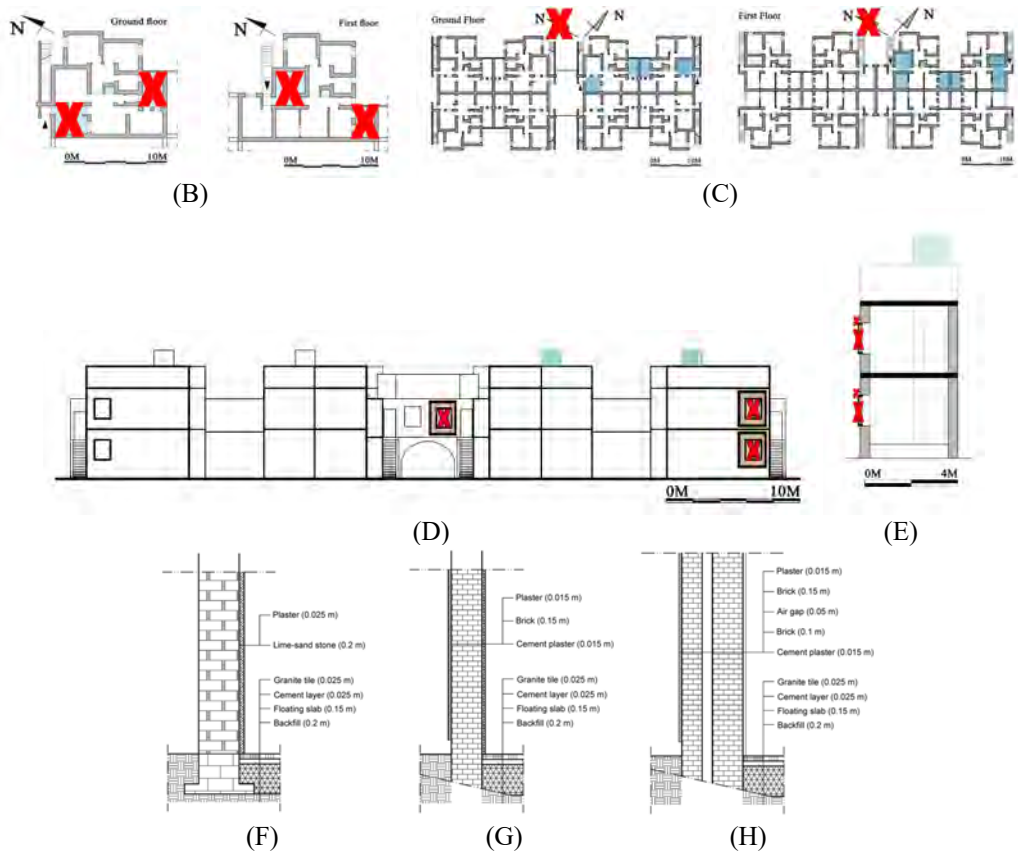
Figure 7-33. *The cooling and heating scale of HVAC operating hours, where (a) presents the cooling scale and (b) presents the heating scale.*

The study presented in this paper aims at comparing the influence of several strategies related to climate-responsive design, which are the presence of a patio, the used envelope's materials, wall thickness, orientation, WWR and shading. These factors and their variations are presented below. Eight scenarios have been analysed.

The first scenario (A), or the reference case, coincides with the actual settings of the case study without any intervention and hence to obtain the cooling and heating demand. The second scenario (B) proposes the 'patio' absence. The third one (C) proposes a change of

orientation (east-west instead of north-south). The fourth scenario (D) adopts a WWR equal to 40%, instead of (< 20%). The fifth case (E) has no shading system in windows. The sixth one (F) varies the envelope's walls, whereas the newly proposed wall has the half of thickness (20 cm) of the original one (40 cm). The seventh scenario (G) varies the envelope's material and thickness, whereas the proposed wall is made by 'bricks' with 15 cm thickness and the last case (H) proposes the change of envelope's material and thickness, where the proposed wall is a 'brick double-wall' (15 cm and 10 cm) with an air gap of 5 cm (30 cm in total). **Table 7-8** describes the different parametric scenarios and their characteristics.

Table 7-8: *Different parametric scenarios and characteristics*

Scenario	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
Characteristics	Actual design -With patios -Orientation (north-south) -WWR < 20% -With a shading system in windows -Lime-sand stone wall (40 cm) U = 1.489 W/m^2K	No-patio	Orientation east-west	WWR = 40%	No-shading system in windows	Half-thickness (20 cm) U = 2.191 W/m^2K	Brick wall (15 cm) U = 1.865 W/m^2K	Brick double-wall (30 cm) U = 1.106 W/m^2K
Illustration								

(B) (C) (D) (E) (F) (G) (H)

*U = Transmittance (W/m^2K)

'Red sign' in every illustration presents each design's variable that has been removed or changed, while (F), (G) and (H) scenarios are presenting the envelope's proposals

7.5. The effect of applying and not applying the passive design on energy demand

The results are presented in the following subparagraphs divided into two parts, regarding 'applying' and 'not applying' passive design:

7.5.1. Results of energy demand by applying passive design (actual building reference case)

MB adopted several passive strategies to obtain a climate-responsive design to achieve maximum thermal comfort hours and hence reduce cooling and heating demands as much as possible, where the cooling and heating loads are the sums of heat losses through the envelope, natural ventilation, lighting, occupation and solar gains through windows. However, after simulation of the actual design, the first scenario (A) consumes ~ 22880 kWh for cooling loads and ~ 43556 kWh for heating loads which indicates the rate of 10.43 kWh/m^2 and 19.87 kWh/m^2 for cooling and heating respectively.

7.5.2. Results of energy demand without applying passive design (parametric analysis)

The results of the other analysed scenarios are described in **Table 7-9** and **Figure 7-34**. Case (B) without the patio indicates increasing in heating loads of 45234 kWh with 3.85% more than what the actual design consumes for heating; this is because the covered patio prevents walls to receive direct solar gain, while the cooling consumes 22031 kWh with 3.72% less than what the actual design consumes for cooling. This is due to decreasing walls' contact with the exterior. Case (C) has no real evidence impact: it consumes 22675 kWh (0.9% less than the actual design A) and 42851 kWh for cooling and heating (1.62% less than the actual design A). Since the simulated building in total has a symmetric organisation, so the apartments may have contact with the exterior in more than two façades, further investigation is necessary to review orientation influence in residential building units and several blocks. Case (D) with WWR=40% shows an increase in cooling loads and it consumes 26471 kWh (15.96% more than the actual design); on the contrary, in winter it has a decrease in heating loads and consumes 42534 kWh (2.35% less than actual design). This is a critical issue that needs to find a compromise between summer and winter strategies in terms of solar gains through windows. Case (E) demonstrates the impact of the no-shading design that causes an increase in cooling loads (23189 kWh) with 1.35% more than the actual design, while the heating is convergent (43545 kWh) with 0.03% less compared to the actual design. This is because shading is

effective in summer more than in winter in terms of thermal behaviour. Scenario (F) demonstrates the effectiveness of thermal mass in the actual design: the envelope half-thickness design shows increasing in cooling loads, which are equal to 27812 kWh (21.55% more than the actual design), and in heating loads, equal to 52577 kWh (23% more than the actual design); this is due to the increase in thermal transfer between outside and inside. The thermal conductivity causes high thermal drain towards the interior (in summer) and thermal loss towards the exterior (in winter). It can be concluded that thermal mass efficiency has almost the same impact in terms of percentage between summer and winter. Case (G) shows the result of the envelope's brick wall design: the cooling and heating loads increase compared to the actual design with 25986 kWh and 50292 kWh respectively (13.75% and 15.46% more than what the actual design consumes for cooling and heating respectively). This scenario shows a common technique that is used in Algeria: brick walls cause increases in both, cooling and heating loads, due to the thermal mass and increased thermal conductivity. Thus, it should be avoided.

Table 7-9: *Results of cooling and heating demand of different scenarios*

Scenario	(A) Actual design	(B) No-patio	(C) Orientation east-west	(D) WWR = 40%	(E) No-shading system in windows	(F) Half thickness (20 cm)	(G) Brick wall (15 cm)	(H) Brick double-wall (30 cm)
Cooling demand (kWh)	22880	22031	22675	26471	23189	27812	25986	22229
Heating demand (kWh)	43556	45234	42851	42534	43545	52577	50292	37008

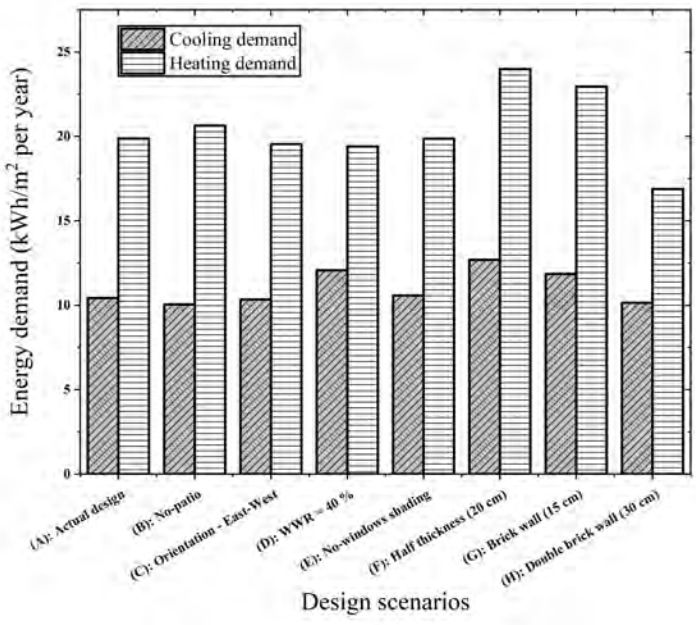


Figure 7-34. *The energy demand of cooling and heating of different design variables.*

Finally, variable (H) of double-wall brick shows noticeable effective performance for heating loads (37008 kWh) and the cooling loads are almost the same (22229 kWh) with 15.04% and 2.85% less, compared to the actual design demand for heating and cooling, respectively. This scenario is considered a passive solution because of the high thermal mass proprieties of the wall. It could be improved by adding an insulation layer instead of an air gap between two bricks layer or replacing it with Lime-sand stone.

7.6. Discussion and implications

This paper evaluates the annual space cooling and heating demand of typical housing in Ouled Djellal (hot-dry climate) after exploring passive strategies applied by the climate-responsive design of MB. The main conclusion is that adapting passive strategies through climate-responsive design can be effective in a harsh hot climate to reduce discomfort hours and hence to minimize cooling and heating demand as much as possible. Anyway, the compromise between summer and winter needs is also a critical point in the design that must be controlled through passive solutions (for example, the solar radiation must be controlled by shading in the summertime to avoid extra gains).

The adaptation of passive strategies in MB housing indicates effectiveness through cooling and heating demand simulation: the actual design (A) demonstrates effective behaviour during the year in terms of SA of studied passive strategies (if we exclude the (H) scenario with a double brick wall which is considered as a passive strategy too). However, the method of the parametric variation revealed the importance of several parameters in influencing cooling and heating demand. The overall comparison between these results and psychometric chart prediction percentages shows interesting considerations. The most influencing parameter (according to simulation) is the thermal mass of the envelope, which is assumed to contribute 11% of comfort hours over the year (according to the psychometric chart). While the parametric variation does not reveal a significant contribution of solar shading on cooling and heating loads, which is assumed to contribute 19.1% according to the psychometric chart. Further investigations should be carried out in terms of SA and uncertainty.

A further comparison of the results of MB housing in Ouled Djellal can be done with other contemporary houses, which perform the most common typology in Algeria. For this reason, a calibrated model in Biskra province (in the same region of Ouled Djellal) according to Semahi et al. (2019) was considered. It was estimated that this building consumes about 75.3 kWh/m^2 for 38% of summer's discomfort hours throughout the year. In comparison, MB housing consumes 10.4 kWh/m^2 for 21% of summer's discomfort hours. In addition, the

GENERAL CONCLUSIONS
CONCLUSIONS AND FURTHER WORKS

The last part of this thesis summarizes the main original contributions and outlines recommendations for designing an architecture that expresses identity and is a climate-responsive one in the south of Algeria through the lens of CR. Furthermore, this part mentions possible future works on the same concern of this research.

I. Original contributions of the thesis

1. Developing a practical framework of the 'Critical Regionalism' theory

In looking for identity in a placeless and globalised world. The CR theory is well known in the academic works and literature of architecture worldwide. Although the theory could not fulfil the practical expectations in the field of architecture, it draws overall guidelines of the philosophy and could not be measured quantitatively. This study tried to develop the theory and extend it from one or two theorists who first talked about it to six pioneer theorists with a wider comprehension of the theory. Thereafter, the seven points of the approach were extracted and presented as instructions. These points are used then for further evaluation subjectively and quantitatively. This method has several advantages: (1) the approach is comprehensive for all relevant theories and critics on the subject, (2) it can be useful in measuring how much the project is considered as a critical regionalist one (7/7 rating score) and (3) easy to understand and to apply by architects and critics.

2. Analysing the eight climate zones of Algeria through both PMV-PPD and adaptive comfort models

This thesis presents a comprehensive climate analysis of the eight climate zones of Algeria according to both PMV-PPD and adaptive comfort models using a simple climate analysis tool (climate consultant). The results are brought following TMY files of the eight cities (of the period 2004-2018). This technique has several features, such as (1) providing a resumed potential of the weather over Algeria, (2) it is considered a simple and easy tool to be

used by architects to design a climate-responsive architecture, (3) the comparative study of both comfort models could be useful for designers to go forward for either NV or MC buildings and (4) the detailed impact of several strategies could be very important in every designing stage (prior or post occupant level), either by architects or users.

3. Exploring the case studies according to the seven points of 'Critical Regionalism' proposed by the author (qualitatively and quantitatively)

The present work successfully investigated the case studies and scope of research through the proposed framework and method to explore their CR aspect. The innovative approach reveals several facts about the work of FP and MB in the south of Algeria. The projects were investigated in detail qualitatively (through data collection of writings and interviews). The subjective description of each case is then validated quantitatively (through a standardized survey for Algerian architects). The results showed a relative discrepancy between cases (as ordered as follows from the most critical regionalist case to the lowest): (1) El-Gourara hotel in Timimoun, (2) Maader village in Bou-Saada, (3) 600 housing units in Ouled Djellal (4) M'Zab hotel in Ghardaïa, (5) 400 housing units in El-Oued and (6) El-Djanoub hotel in Ghardaïa. This study could be useful for further evaluations of other buildings in terms of applying the CR approach and introducing a calculation method for this purpose.

4. In-depth investigation of the case studies' climate responsiveness (qualitatively and quantitatively)

As mentioned by point number six of the CR approach that architecture should consider the climate effect. This study explored case studies' climate responsiveness qualitatively (through data collection and illustrations of passive strategies and respected design). Thereafter, the projects were explored quantitatively (through in-situ measurements and software dynamic simulation). The results showed the excellence of case studies in applying different passive strategies. M'Zab hotel in Ghardaïa was simulated and thus investigated following SA of 13 design parameters (for both PMV-PPD and adaptive models). It is well noticed that space density, ventilation rate, infiltration and ventilation schedule are the most influencing parameters on discomfort hours for the PMV-PPD model. on the other hand, ventilation rate, WWR, lighting and space density are the most influencing parameters on discomfort hours for the adaptive model. 600 housing units in Ouled Djellal showed exceptional performance in terms of energy demand (cooling and heating loads). However, the in-depth investigated cases (M'Zab hotel and 600 housing units) are considered reference cases

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فيا ملبسي النّعمى الّتي جلّ قدرها

لقد أخلقت تلك الثّياب فجدّد!

أبو فراس الحمداني