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Vernacular Features in Rural Housing of the Aurassien massif between Traditional Practices and Bioclimatic Aspect. Case study of Ain Zaatout (Algeria)

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Abstract. The rural habitat in the Aures region is an excellent example on vernacular and human architecture. It reflects how inhabitants of this region responded to their requirements in an ingenious way and how local builders have succeeded to respond to challenges of climate, building materials and cultural expectations despite the particularly harsh environmental conditions of the Aures. The aim of this study is to determine the strategies used in vernacular constructions to deal with the severe climatic conditions that prevail in the Aures region. Precisely, rural dwellings in Ain Zaatout village (Beni Ferah) were studied to emphasize the importance of the architectural properties of the traditional houses in terms of thermal performance and climatic adaptability. In this regard, an extensive literature review was carried out on previous studies that investigated the Aures settlements. Accordingly, a comprehensive knowledge on typical Aurassien village and various data including spatial organisation, architectural characteristics and construction materials and techniques have been gathered. Based on this background, a qualitative analysis supported by field measurements was conducted. Then, two representative houses were selected as case studies for monitoring comfort parameters in summer period. Finally, the traditional and contemporary houses were compared in terms of their thermal performance. Through this study, the most frequently used strategies and their effectiveness were derived. The results indicate that vernacular rural habitat in the Aurassien villages is creatively adapted to the environmental conditions and uses various climate responsive strategies. The study additionally reveals that vernacular constructions in the Aures are more adapted to the climate constraints and social needs than contemporary residential buildings. These results were confirmed by hydrothermal values where main indoor temperature in a traditional rural house was less than external values by 3 °C and more humidified, while in modern house indoor temperature records were more than the exterior by 1°C. Thus, vernacular climatic responsive strategies must be considered as a reference for nowadays environmental issues in rural areas. Moreover, they can be feasible for contemporary buildings and, consequently, they could contribute greatly towards improving indoor thermal comfort whilst reducing buildings energy demand.

Keywords. Vernacular architecture, bioclimatic aspects, social values, rural habitat, temperate climate, Aures (Algeria)

1. Introduction

In recent years, international energy demand (gas and electricity) has increased tremendously, particularly in the building and construction sector, which is responsible for more than a third of the world's final energy consumption [1] and nearly 40% of the total CO₂ emissions released into the atmosphere (842 million tonnes each year), with the aim of providing maximum thermal comfort for a large number of people, and consequently a change radical to the climate and the natural environment due to the phenomenon of greenhouse gases (GHG), where we have experienced a very high rate of global warming (0.18 C° since 1981 per decade) especially during the period between 2013 until to 2020 [2].

In Algeria, according to the national energy balance sheet made by "The Ministry of Energy and Mines" in 2019, the structure of final consumption remains dominated by the residential sector (households and others) with a percentage of 46.7% [3]. What is poses a great requirement to make an action plan to manage the problem of energy efficiency and thermal comfort of buildings, from the primary phases of construction, which is made a total sustainable development at the level of quality of life in buildings, as well as socio-economic development. Not only in urban areas, but also rural areas where people face harsh conditions, especially the high cost of energy used for heating and cooling, and not everyone can afford it. , which is why passive solutions are needed. Exploiting the bioclimatic potential of the site and climate in the country, by resorting to the principles of vernacular architecture opens a very wide field of solutions for current problems, especially what is concerned with the control of the energy demand to consume. According to Semahi.S the three major bioclimatic strategies that must be optimized are passive solar heating, natural ventilation and evaporative cooling [4].

One of the major and vast region containing rural space is the Aures or so called the Aurassien massif which is located between the high plains of Eastern Algeria and the Saharan borders (fig.1) , it is defined as a vast mountain range severally partitioned, cut by two deep long and parallel valleys; valley Abiod and Abdi oriented NE/SW crossed by secondary ones [5], with a Berber population named *Shaouia* installed in a group of *Dechra* which is the local name of old Aurassien villages installed on the sides of the valleys (west side of Abiod valley and on the East side of Abdi valley).

The Aurassien societies could keep their name and identity and their attachment to the massif since the Roman colonization, in particular by their types of mountain settlements, translating a specific way of life. Adjali.S has classified human settlement in the Aures region on three forms according to the physical characteristics of the surrounding context [6]:

- Dispersed habitat on the Northern foothills of the Aures.
- A grouped habitat, more structured and denser, often located on ridges or at the bottom of the valley; these are the *Dechra* of the Aures massif.
- Habitat that with Saharan typology on the southern piedmont. It is defined by a group of fractions around a courtyard.

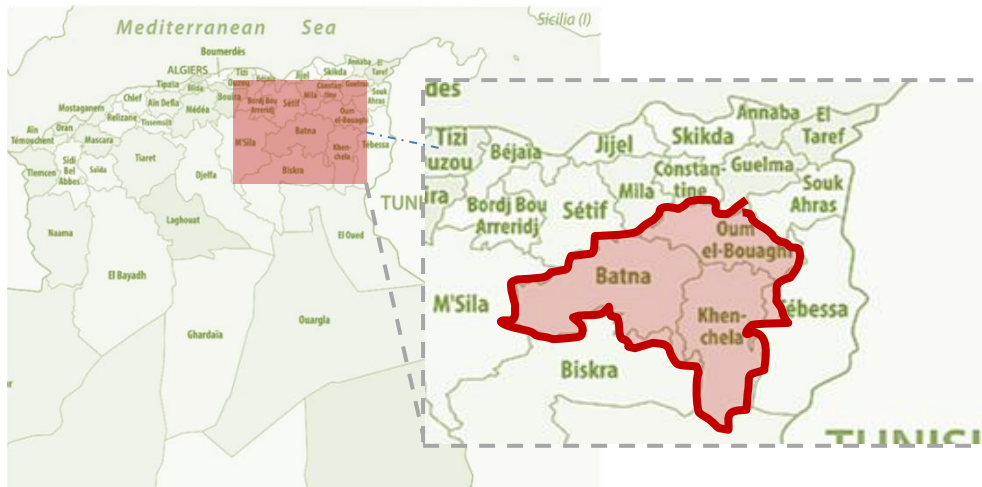


Figure 1. Aures location and borders

The rural habitat in the Aures is an excellent example of a vernacular and human architecture which reflects the way in which the man of this region has responded to his requirements, in an ingenious way based on a long knowledge of his climatological data, where we find constructions with a specific construction system based on local materials (earth, wood, etc.) and passive strategies that adapt to the context and the local temperate climate (cold winter, hot summer), reflecting his way of life at the same time.

2. Materials and Methods

The research methodology is based on two main phases the analysis of a representative case study of traditional rural habitat in the village of Ain Zaatout in the south of the massif Aures started by the general context characteristics and on-site data collection in order to figure out bioclimatic aspects, to do so set of measurements have been done during frequent visits in both winter and summer periods to examine the thermal performance of vernacular building comparing to contemporary house in extreme hot days of the summer period.

2.1 Case study Ain Zaatout (Beni Ferah) village

Beni Ferah a village which lays between the southern massif Aures and northern Ziban borders (fig.2). Its administrative name is Ain Zaatout situated on the north of wilaya of Biskra, its old core named Dechra or *Taklihth* traversed by secondary valley (Kecha) [5]., where traditional architecture is presenting a testimony on the way that ancient inhabitants treated their environment from urban to architectural scale using site potentials that fits their social requirements.

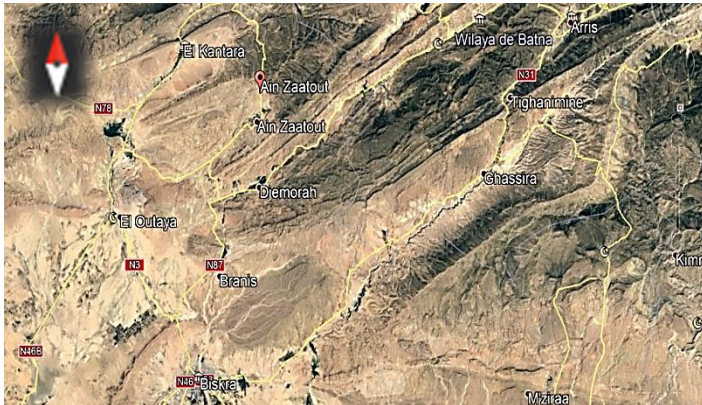


Figure 2. Ain Zaatout situation [7]

2.2 The special structure of the Dechra

The special organization of the Dechra refers to an interaction of environmental, socio-cultural, economic and climatic, even symbolic factors where local inhabitants have chosen high hills to build their shelter (fig.3), not only for defensive reasons but also in order to save lands for agriculture which is their main activity besides of grazing, they used local materials in the process of building, given the configuration of the site and the mountainous nature of the region they intuitively created specific features to deal with the difficult climate conditions.



Figure 3. The hill of the old Dechra

2.3 Traditional local habitation

The most common spatial organisation of the house is made on two levels (fig.4), contains several functions, where the first is reserved for the animals and the storage of wood; *Thasekkift*, *Zerdab*, *Bit nou loum*, *Thazekka*, and the second is reserved for the family activities and the storage of agricultural goods; *bit n'Ilmes* which is generally centralising the house and distribute to the rest space, *rooms*, *tghorfet* (fig.5), even terraces are commonly accessible and reserved for the activities of drying agricultural goods.



Figure 4. View on a vernacular house showing the frontage and the entrance



- | | | |
|---------------------|-----------------|-----------------------|
| 1- L'bit
n'llmes | 5- Zerdab | 9- Exterior
Skifa |
| 2- L'bit | 6- Tghorf
et | 10- Entrance |
| 3- Tghorfet | 7- Tghorf
et | 11- Zerdab |
| 4- L'bit | 8- Tharfift | 12- Zerdab |
| | | 13- Tghorfet
Skifa |
| | | 14- L'bit
stah |
| | | 15- stah |
| | | 16- stah |

Figure 5. Plans of a typical vernacular house in the village [5].

2.4 Contemporary settlements in the village

In recent years new habitat housing typology has emerged in the village (self-construction) with new special organisation adding new spaces regarding the current social and economic situation of inhabitants where concrete is taking place of local building materials.

Unlike the traditional habitat all spaces in contemporary house are arranged in the first floor, in linear plan distributed by a corridor in addition of new spaces like the living room and garage (fig.6).



Figure 6. Rural housing transformation in the village

2.5 Climatic conditions

The climate of the region can be defined as arid and continental (cold in winter, very hot in summer) with quiet rare rainfalls [8].

The coldest month is January (6.2°C) while the hottest month is July (26.9°C) (fig.7)

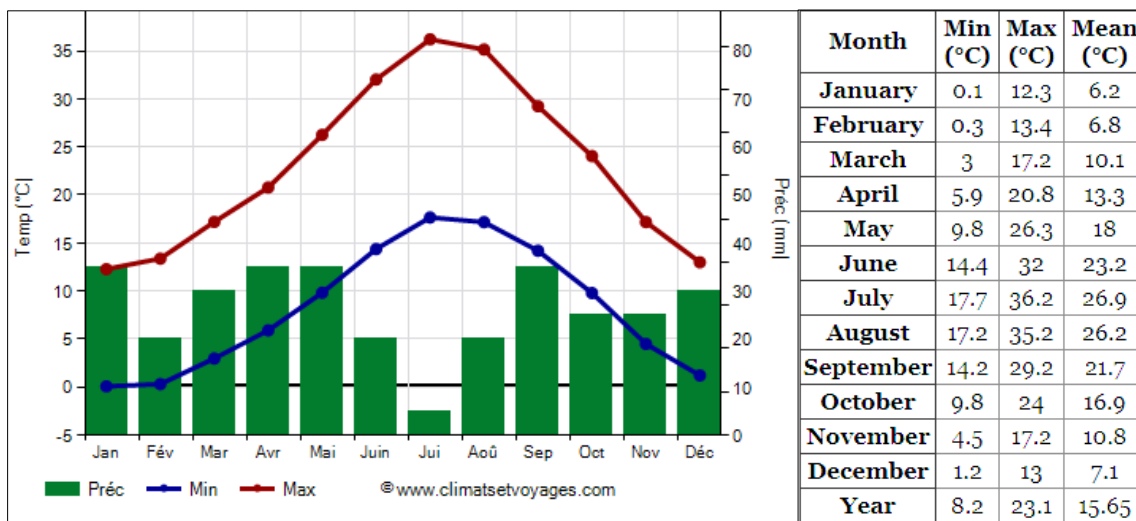


Figure 7. Precipitations and temperature graphs [8].

2.6 Bioclimatic and social aspects in vernacular habitat

By referring to a relevant literature and given the design and constructive characteristics of the Aurassien vernacular architecture, a qualitative investigation was carried out to assess the thermal performance deriving from constructive choice, architectural components and specific design features implemented by the inhabitants to cope with the harsh climate conditions. In this regard, to extract the most relevant passive design strategies used in the Aures region, the two representative houses, as well as, the related vernacular settlements have been examined. The passive design strategies that have been identified are summarised in **Error! Reference source not found.**

Table 1. Analysis of vernacular features between bioclimatic aspects and social values.

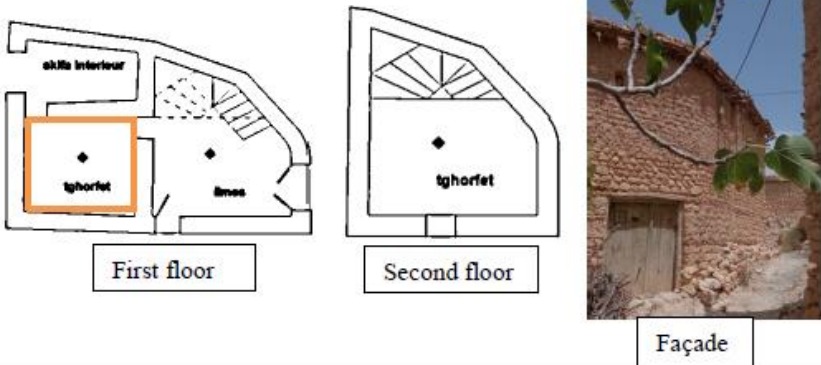

Bioclimatic aspect	Vernacular design strategies implemented	Social values
<p>Urban morphology Semi buried houses inside the village are built one next to the other in a linear way following the hill's curves which forms a compact tissue.</p>	<p>Compactness of master plan Mountainous organization with interspersed semi-buried habitats separated by narrow lanes profiting thermal inertia of the ground which plays a natural thermo-regulator also formed as a fortress for reasons of protections against climatic constraints and seasonal winds in winter and summer.</p>	<p>The cohesion between families and defensive strategy. Social structure of the Aurassien societies is based on the family as an important unit; each house contains more than one family.</p>
<p>Landscape potentials -The total integration of vernacular settlements into the context using rocky curves as a basement. - Source of local construction materials (earth, stone and wood).</p>	<p>The use of sustainable resources to respond to human needs with minimum costs and no carbonic footprint on the environment</p>	<p>Saving agriculture grounds and vegetation along with waterways nearby</p>
<p>Orientations Basically vernacular houses are built giving their back to the hill so the orientation of the main façade is NE/ SW In the other cliff side houses are facing the SW orientation</p>	<p>Heating and cooling strategy In winter: using solar gaining captured during the day and stocks it inside. In summer: protect from overheated southern façade. Controlling ventilation rate in both seasons taking advantage of following hill curves and narrow passages.</p>	<p>Tsamerth Exterior local where women gather in sunny days to do deferent activities like Milling various grains and Drying some vegetables.</p>
<p>Built form and spaces -The two storey house implanted perpendicularly to the ground, -Compact envelope with small openings. -hierarchic of transition spaces from the public then semi-public to private: Exterior Skifa -> interior skifa (entrance skifa) -></p>	<p>Thermal transition Due to the presence of the Skifa which is distribution temperature degrees are remarkably increase or decrease according to the outer one. Thermal inertia of the envelope helps to keep the heat or the freshness into the house Internal nomadism: a concept that describes the use of house spaces in time whether daily or seasonal looking for comfort according</p>	<p>The house is a social and economic unit, within which the disposition of the numerous spaces is intimately related to the structure of the family and the way it lives. The Skifa in the traditional architecture has a social role as place of gathering when it is in the exterior, and to preserve the intimacy of the house.</p>

<p>staires -> Tarfifth (distribution space) -> Lbit nilmes (hall or the space where the fire place is usually occupied by the oldest member in the family whom is grandparents) rooms or tghorfet</p>		
<p>Materiality and construction The traditional house in the Auras region is made of stone, earth and wood, three local materials, extraction area is always nearby. Wall thickness is 65 cm to 70 cm</p>	<p>Ecological and high energy performance materials</p>	<p>Touiza is the act of helping each other in building the house from the phase of extraction to the final one.</p>

2.7 Thermal behavior comparison between traditional and contemporary residential buildings

To evaluate the difference in thermal response between vernacular and contemporary houses, two residential buildings were chosen as case studies which are the property of the family *Nezel*. Table 2 gives a description of each house typology and its architectural characteristics. The measuring locations for both houses are also indicated respectively in the plans (**Error! Reference source not found.**).

Table 2. Description of the vernacular and contemporary dwellings.

Description	Plans, Façade and location of the measurement points
<p>Traditional habitat built on two levels with typical Aurassien order; skifa, ilmes, tghorfet in the first floor and room, terrace in the second one. -The main façade is headed to SW</p>	
<p>Contemporary habitat built on one level with accessible terrace planned to be another floor. Spaces are: living room, hall, three rooms, kitchen, garage, and veranda. -The main façade is headed to SW</p>	

2.8 Data collection

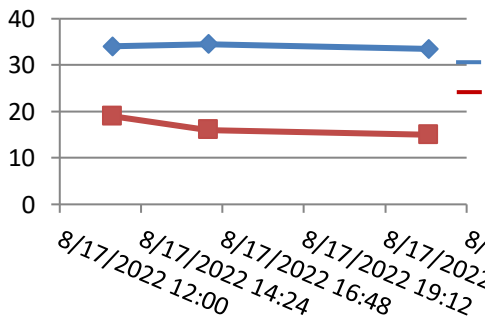
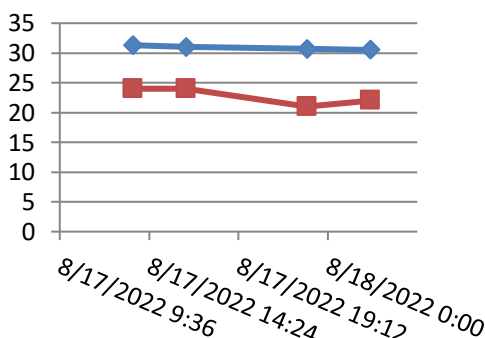
In order to have an accurate assessment of the climate responsive design strategies used in the Aures region, an on-site measurement's campaign was carried out. The environmental parameters considered for the thermal performance analysis were indoor air temperature, relative humidity and the outdoor air temperature. The hygro-thermal recorders were performed into the two houses chosen as case studies. The setting-room were monitored in each house by using a thermo-hygrometer sensor "Testo 480" with a precision of $\pm 0.2^{\circ}\text{C}$ to $\pm 0.5^{\circ}\text{C}$ and a Data logger (model HP3001) with an accuracy of $\pm 1^{\circ}\text{C}$.

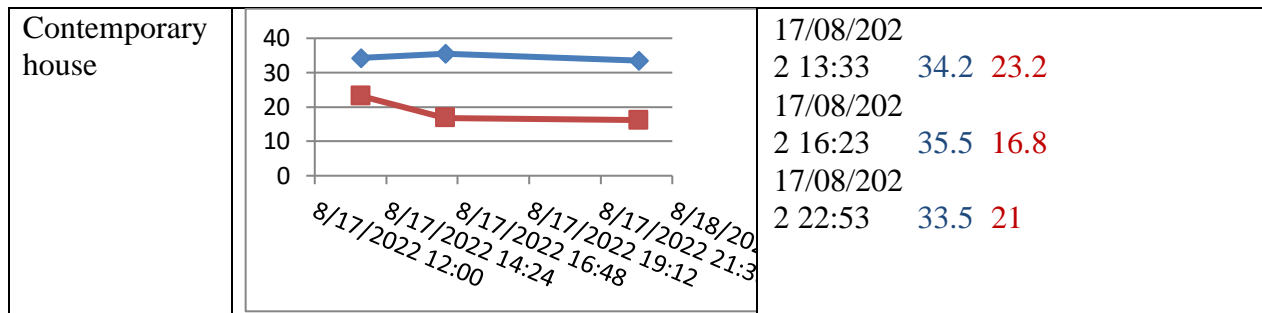
Result are shown in table 3.



Figure 8. Spaces where measurements have been carried out.

Table 3. Main Temperature and relative humidity measurements and results

zone	Main Temperature and relative humidity graph	T/H values
Exterior temperature and humidity		17/08/2022 13:33 34 19 17/08/2022 16:23 34.5 16 17/08/2022 22:53 33.6 15
Traditional house		17/08/202 2 13:33 31.3 24 17/08/202 2 16:23 31 24 17/08/202 2 22:53 30.7 21 18/08/202 2 02:18 30.5 22



3. Results and discussion

The results show that temperature and humidity registered values during a typical hot day in both houses reveal that the vernacular house is remarkably better than the contemporary one. In this regard, the average indoor temperature in the traditional house is less than external values by 3 °C and it is also more humidified. In return, the indoor temperatures measured in the contemporary house indicate values higher than the exterior by 1°C. These results confirm the effectiveness of the passive design strategies used in the vernacular dwellings, especially the envelope thermal behavior which is characterized by a good thermal phase shift besides of the building thermal inertia, and local construction materials.

In contemporary house, the envelope is less efficient thermally because of poor thermal resistance and high transmittance of walls; the best solution is to reinforce thermal insulation especially the SW façade [9].

4. Conclusion

According to previous studies about vernacular architecture in the Auras, and based on a bioclimatic analysis of village of Ain Zaatout, people of this region have adopted their lifestyle to such difficult context and hard climate conditions creating a know-how of adapted building strategies which can be a solutions to actual environmental problems concerning energetic performance. This work is considered as a start of a future research about developing new housing strategies and optimizing the use of site potentials to build sustainable habitations while preserving local identity.

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