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The effect of courtyards design on socio-cultural and environmental-economics aspectsin Constantine (Algeria)

أثر تصميم الأفنية على الجوانب الاجتماعية-الثقافية والاقتصادية-البيئيةفي قسنطينة (الجزائر)

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Abstract

This article is a part of a doctoral thesis on the design of courtyards in the urban area of Constantine. It aims to determine the variance between courtyards design built in traditional, colonial and contemporary periods using a typological approach that considers the urban-morphology, socio-cultural and environmentaleconomicscriteriain a chronological context. A comparative analysis of the analysis indicators of each criterionwas used to reveal the difference between courtyards and whether there were common design indicators.The results show a clear difference between courtyards in the urban morphological indicators and their effects on the socio-cultural and environmental-economics aspects. In addition, the traditional courtyard can be considered the most successful sustainable designstrategy designed with careful attention to socio-cultural and environmentaleconomics contexts.

Keywords: Comparative analysis, Courtyard, Environmentaleconomics, Socio-cultural, Typological approach, Urban morphology.

ملخص

تتناول هذه الورقة البحثية جزء من أطروحة دكتوراه حول تصاميم الأفنية في المنطقة الحضرية لقسنطينة. حيث تهدف إلى تحديد التباين بين تصميمات الأفنية المبنية في الفتراتالتقليدية، الاستعمارية والمعاصرة باستخدام منهج تصنيفي يأخذ في عين الاعتبار المعايير المورفولوجيةالحضرية,الاجتماعية–الثقافية والبيئية–الاقتصادية في سياق زمني. تم استخدام التحليل المقارن لمؤشرات التحليل لكل معيار للكشف عن الفرق بين أنواع الأفنية وما إذا كانت هناك مؤشرات تصميم مشتركة. أظهرت النتائج اختلافا واضحا بين الأفنية في المؤشرات المورفولوجيةالحضرية وتأثيراتها على الجانب الاجتماعي–الثقافي و الاقتصادي البيئي .بالإضافة إلى ذلك ، يمكن اعتبار الفناء التقليدي استراتيجية التصميم المستدام الأكثر نجاحًا و المصممة مع الاهتمام الدقيق بالسياقات الاجتماعية –الثقافية و الاقتصادية البيئية.

الكلمات المفتاحية: تحليل مقارن، الفناء، الاقتصاد البيئي الاجتماعي–الثقافي، النهج النمطي، مورفولوجيا حضرية.

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1. INTRODUCTION

Constantine represents the oldest city in Algeria, dating back to 3000 BC. During the Roman eras, it was called Cirta and was renamed Constantina in honor of emperor Constantine the Great. It was also the capital of the French department of Constantine during the colonial period until 1962.

The architecture of Constantine encompasses a diverse history influenced by several eras, including the Roman empire, the Muslim civilisation, French colonisation and movements for Algerian independence. That resulted in various architectural buildings such as religious, educational, commercial, social and residential, primarily represented in *Masjids* (mosques), *Madrasas* (schools), houses and many others.

By analyzing the design of these architecture buildings, especially dwellings (research samples), it can be stated that the vital and distinctive element existing in the heart of each building was called a courtyard. It was defined as"*an area of flat ground outside that is partly or surrounded by the walls of a building*» (Courtyard definition, Cambridge dictionary: https://dictionary.cambridge.org/fr/dictionnaire/anglais-chinois-simplifie/courtyard, Consulted on 10/05/2021), basically found in the houses, public buildings and many other designs for a long time.

The courtyard is one of the oldest architectural elements used in buildings, traced back at least 5000 years (Taleghani, Tenpierik, & van den Dobbelsteen, 2012). It has appeared in different forms in various old civilizations such as China, India, Iranian and Arabo-Islamic. Therefore, it is considered one of the successful design elements, whether from the environmental, economics, functional, or social-cultural aspects.

However, Constantine city, located in the northeast part of Algeria and one of the ancient cities in Northern Africa, has three courtyards design: traditional, colonial and contemporary, which belong to their built periods. The courtyard designs of these periods are different in terms of style, design principles, socio-cultural and environmental-economics values. Therefore, a comparative study was conducted to determine the difference between courtyards in the mentioned periods using a typological approach that considers urban-morphology, socio-cultural and environmental-economics criteria in a chronological context.

1.1. Typological approach

The typological approach was emerged in the Italian architecture school in the 1960s by the architects (Muratori, 1959), (Rossi, 1966,p523), (Aymonino, 1973, p244), (Caniggia,1963, p62), and later by a group of researchers (Panerai Ph., Castex J., Depaule J.-Ch., 1997) such as the architect Jean Castex, the urbanist-architect Philippe Panerai and the sociologist Jean-Charles Depaule from the Versailles architecture school in France (University of Nice Sophia Antipolis, Faculty of Spaces and Culture, L'analyse des espace publics: les places: https://unt.univ-cotedazur.fr/uoh/espaces-publics-places/approfondissement-theorique-lanalyse-typo-morphologique/, consulted on 05/08/2021). It is an approach of analysis that combines the study of urban morphology and architectural typology in a given historical, geographical and cultural context (Boutemadja & Reiter, 2015**)**. The ultimate goal is to identify several characteristics related to the architectural typologies of buildings such as size, form, dimensions, construction system, facades treatments, and geometric parameters, then relate them to their assembly within the compositional space, which is the place.

According to (Panerai 1999, p.95), the typological analysis is carried out in four steps as follows;

•The first step defines the corpus by classifying items that fit the same urban fabrics level. Then a field survey is carried out to determine samples of the selected items for the entire area study.

•The second step is the preliminary classification, which describes the criteria of the corpus. Then, it assembles items that offer the same answer to a series of criteria.

• The third step develops the types, while similar criteria of the corpus define the type, and non-similar criteria mark the different variations on the type.

• The four-step develops the typology, which is a set of types and their correlation. This typology will highlight the possible variations on each type, the equivalences, and the hierarchies that structure the urban form. Thus, it leads to an understanding of the architecture in urban structure.

2. METHODOLOGY

Again, a typological approach was adopted in this research that considers urban-morphology, socio-cultural, and environmental economicscriteria in a chronological context in order to highlight the difference between courtyardsand apparent indicators built in the city's urban areas in different periods. Each criterion, in turn, was identified based on several indicators.

According to the typological steps mentioned in the previous section, the corpus of this analysis was the courtyard. The samples were selected on the basis of the field surveys on the urban morphology and socio-cultural and environmental economics indicators of the courtyard in the urban area of Constantine. Thus, three (3) samples of typical neighbourhoods with courtyard buildings were selected to examine and classify the urban morphology of the courtyard at each period. In addition, 568 courtyard samples were chosen to determine and classify the difference between geometric parameters. Six typical samples belong to the traditional period, two typical samples to the colonial period and 560 samples belong to the current period.

The data regarding these samples were collected from different sources: surveys, information, documents and the report of the study of the permanent plan of safeguarding and enhancement of the city of Constantine (PPSMVSS, October 2012).This study was carried out by the national office of management and exploitation of the protected cultural goods of Constantine (OGEBC, 2017). Within the framework of this study, samples of neighbourhoods and courtyards from the colonial and traditional periods were previously examined. In addition, previously published research of (Kedissa, Outtas, & Belarbi, 2016) and (Sahnoune, Benhassine, Bourbia, & Hadbaoui, 2021) have examined samples of the selected neighbourhood and courtyards from the contemporary period.

2.1. Studied criteria and indicators

The urban-morphology, socio-cultural and environmental-economics indicators used in this research can evaluate the chosen samples to determine the courtyard difference for the different periods. These indicators were retrieved from literature reviews that evaluate the socio-cultural and

thermal environment and economics for different buildings with a courtyard (Guedouh & Zemmouri, 2017; Martinelli & Matzarakis, 2017; Meir, Pearlmutter, & Etzion, 1995; Mohsen, 1979; Ratti, Raydan, & Steemers, 2003; Soflaei, Shokouhian, & Zhu, 2017; Steemers et al., 1997).

First, the urban morphology criterion studies urban forms and the agents and processes responsible for their transformation over time(Oliveira, 2016). Urban forms refer to the main physical elements that structure and shape the city, including streets, squares (the public space), street blocks, plots, and buildings, to name the most important. Thus, for the present study, the following indicators were identified the urban forms of neighborhoods.

Second, the socio-cultural criterion involves the social and culturalaspectslike religious or mythological beliefs and lifestyle. Thus, for the socio-cultural aspect of the courtyard, the following indicators were identified the typical layout of the courtyard and its function.

Third, the environmental-economic scriterion focuses on the relationships between the economic system and the natural environment, including the use of the natural environment as an economic asset and the impact on the natural environment of the economic system (Fisher, 1981). Thus, for the present study, the following indicators were identified;

- Environmental adaptation means adapting to survive the climatic conditions of the regions. Therefore, the shape, the aspect ratio (H/W ratio) and the orientation of a courtyard are the most design variants critical to its environmental performance.

- The shape is defined by the width /length (W/L) ratio (Manioğlu & Oral, 2015; Mohsen, 1979).
- The height/width (H/W) ratio defines the degree of openness to the sky (Oke, 1988).
- The orientation is defined by the courtyard longitudinal axis (Meir et al., 1995).

- Economic benefits are the effect of environmental benefits of the courtyard design on the economy. It includes the following indicators;

- Energy conservation and reducing cost.
- Minimising new resources.

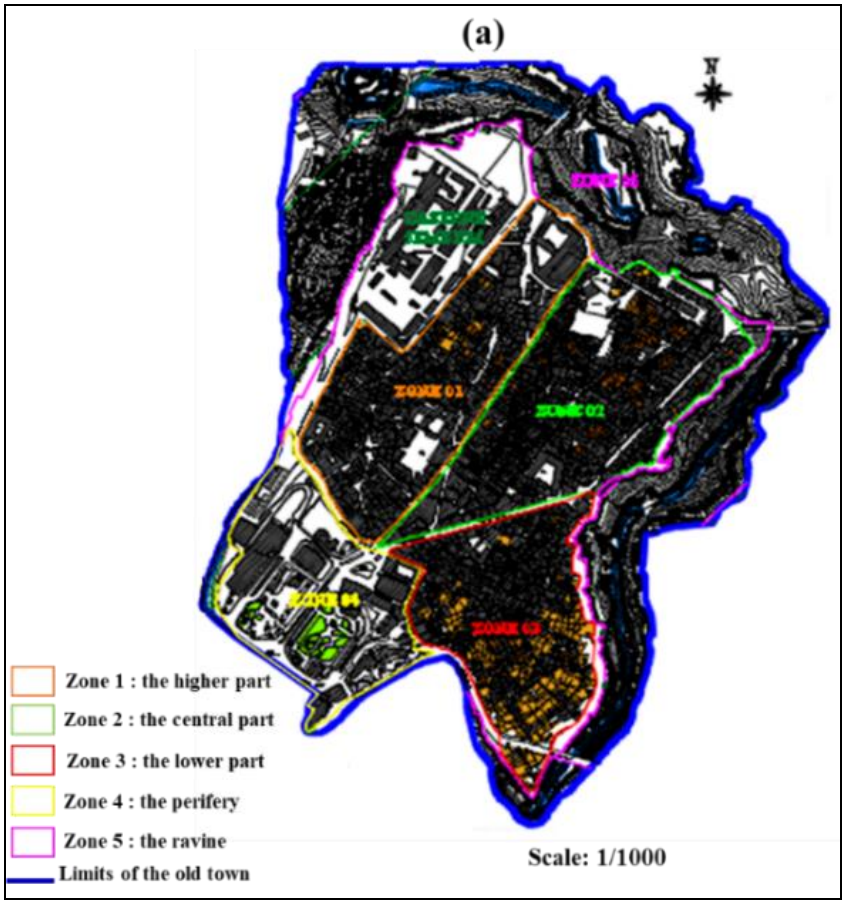
3. RESULTS AND DISCUSSION

The following sections identify the indicators' analysis of selected criteria previously identified in each period.

3.1. The traditional period

The traditional period was characterized by the historical Arab-Islamic type, which represents the Medina of Constantine and is now confined to the old town's center. The old town of Constantine is composed of five zones, limited by the rocky escarpment in the north-west and west, the cultural center (situated in Zone 2) in the south-west and the *Bardo* neighborhoods in the south, as shown in (Figure 1).

Fig.1. The Old Town (Medina of Constantine)



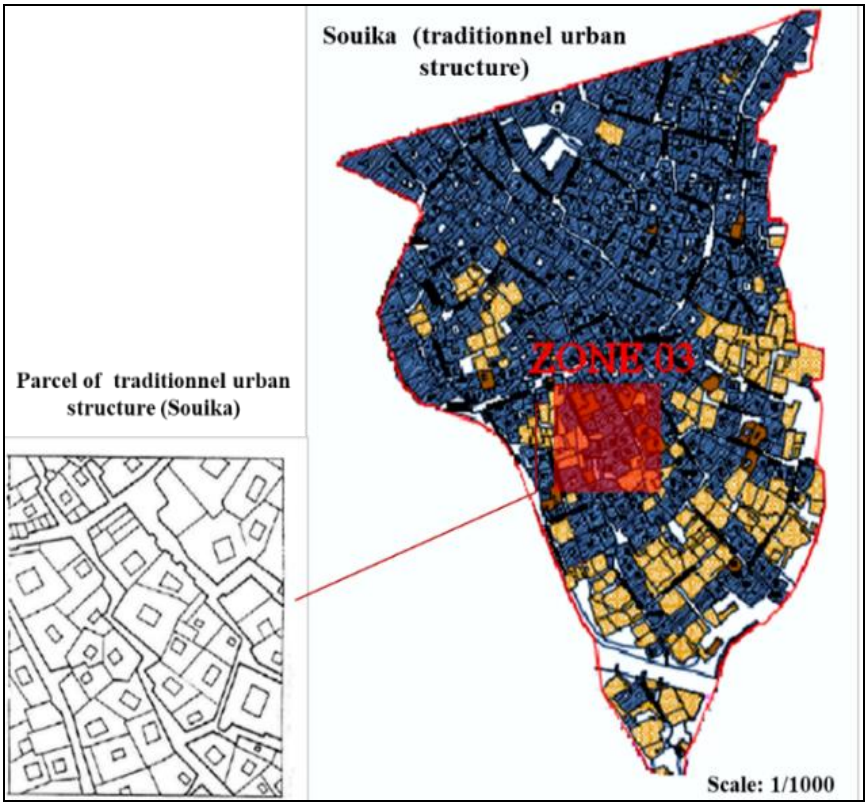
Source: (PPSMVSS, October 2012)

Zone (1) represents the higher part and is characterized by a colonial urban structure in the majority, like the neighborhoods of *El-Kasbah*. Zone (2) represents the central part and is composed of mixed urban fabric (colonial, traditional and hybrids) like the neighborhoods of *Trik-Jdida*. Zone (3) represents the lower part and is composed of the traditional urban fabric in the majority, like the neighborhoods of *Souika*. Zone (4) represents the periphery (rocky plateaus). Finally, zone (5) represents the ravines.

3.1.1. The urban morphology analysis

The urban fabric characterises the traditional period and architectural design of the Islamic civilisation, called the Medina of Constantine. This part of the city has a compact urban structure with very narrow streets and typical courtyard house**s** as shown in (Figure 2).

Fig. 2. Traditional urban forms of Souika



Source: (PPSMVSS, October 2012)

The latter are contiguous with sharedwallswith windowlessexternal walls except the facade giving onto the street.Thisarrangement reduces the total exposed surface area and the totalsolar energy received by each courtyard house.In addition, the houseswere either heated or cooled, where the smaller surface area decreasesthe building's energy demand. The compactness also creates a highpopulation density, organized around travel by footfor social activities and interactions. We also mention that the windows are smaller in size and smaller amount in number,situated at a high level, and protected to ensure security,privacy and ventilation.

3.1.2. The socio-cultural analysis

The type of courtyard houses in this period was built based on the influence of the Muslim lifestyle, its social organization, traditions, as well asits particular desire to protect privacy.Thus, they have an average of two floors and spaces arranged around a smaller and deeper central courtyard with porticoes, divided by a gallery of arcades. This arrangement allows fresh air to circulate through the building into each house room while keeping the shade long to reduce heat gain and solar radiation.Moreover, the size of courtyard houses is varied according to the social status of the owner.

The courtyard often contains vegetation and water to provide comfortable conditions and a beautiful setting.It is generally used for domestic activities and social life, predominantly females.Besides, itis used forcultural activities and family events like marriage.

3.1.3. The environmental-economics value

The traditional courtyard was identified as a microclimate modifier that improvedthe comfort conditions of the surrounding environment.Most traditional courtyards are rectangular-shaped enclosed,formed along with north-south (N-S) directions with longer facades on the east and west. This orientation is idealin maximizingthe usage of summer and winter living spaces and servicespaces at the east façade (receiving west daylight), acting as a bufferzone for the heat (Soflaei et al., 2017). Moreover, the H/W ratio valuesvary between 1.0-2.0 (Table1).

Table 1. Dimensions of courtyards in the traditional period

Dimensions	Width	Length	High
Values	Varies between 3.01-5.88m	Varies between 6.27-9.27m	Varies between 6-9m (Increment of 3)

Source:(PPSMVSS, October 2012)

On the other hand, the traditional courtyard was adopted to the individualism way of life supported bythe cheap energy policies, which aimed at serving an energy-intensiveglobal economy.Such a way of life affected the performance of thetraditional communities, the ambition for improving energy efficiency,and reducing energy demand (Table2).

Table 2. Economic benefits in the traditional period

Energy Conservation	- Compact urban fabrics reduce the total exposed surface area and minimize thesolar radiation gain for each house. - Use ofthick walls as thermal mass to warming passively by thesun absorption and store during the day, and release back into spaces at night.
Minimizing new resources	- Use renewable resources such as wind energyfor passive cooling and naturalventilation and solar energy for passive heatingby using high thermal capacity-building materials. - Use materials such as brick, stone, Toub and wood regarding the importance of their thermo-physical properties in hot-dry regions.

Source: (PPSMVSS, October 2012)

3.2. The colonial period

During the colonial period (French colonization), the Old City underwent various transformations represented by the demolition of many traditional buildings and the realization of primary urban planning and architectural design operations within and beyond the boundaries of the Old City (Figure 3).

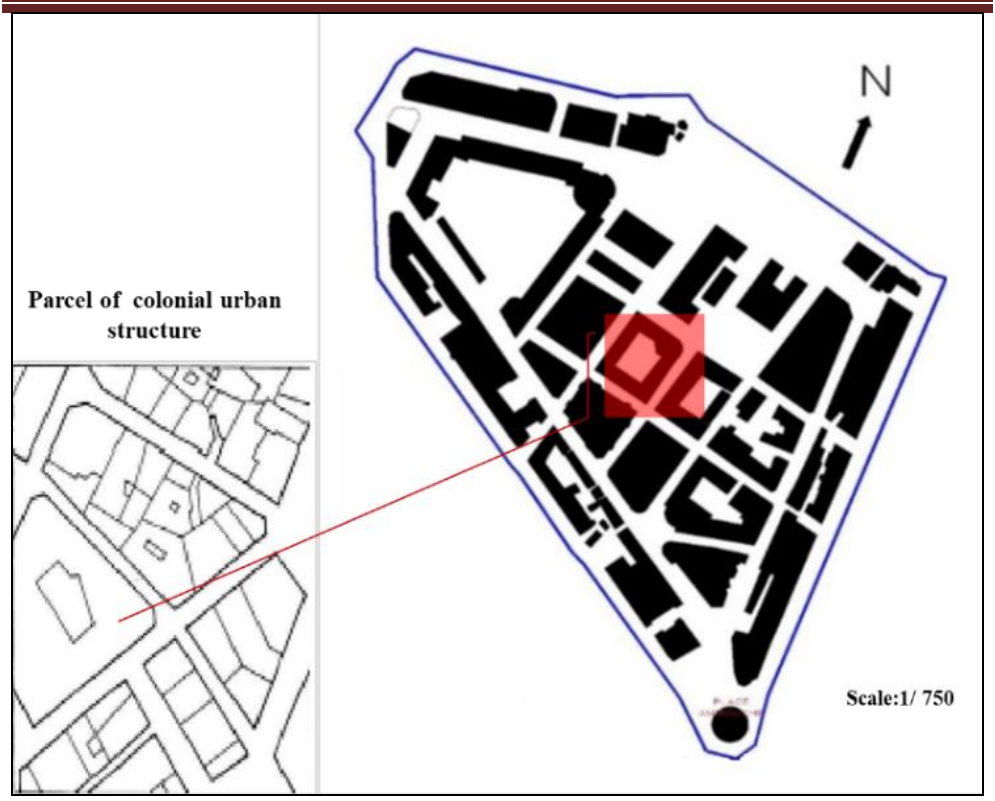
Fig.3. Evolution and transformation of Constantine in the colonial period

Source: (PPSMVSS, October 2012)

3.2.1. The urban morphology analysis

In the colonial period, the city was characterised by a very dense urban structure with a typical European design (the Haussmann style) coupled with canyons of narrow streets. The courtyard building has an average of three to five stories with smaller courtyards, where each space has its clear functionaldefinition (Figure 4).

Fig. 4. The colonial urban forms of Koudiat (Old city centre)



Source: (PDAU Constantine 1998, DUC) and (PPSMVSS, October 2012)

3.2.2. The socio-cultural value

The courtyard of the colonial period is closer to what we call today a patio in a Mediterranean environment. However, it contributes to the climatic regulation of the building. It was mainly used to make oneself comfortable and enjoy the cool atmosphere of the garden.

3.2.3. The environmental-economics value

Colonial courtyardscontribute to the climatic regulation of the building.They are mainly enclosed with varied shapessuch as rectangular, triangleandtrapezoidal. Besides, they are formed along north-south, northeast-southwest, or northwest-southeast. The H/W ratio values vary between 0.7-0.8 for a rectangular (Table 3).

Table 3. Dimensions of courtyards in the colonial period

Dimensions	Width	Length	High
Values	Varies between 11.9-18 m	Varies between 22-24.7 m	Varies between 9-15 m (Increment of 3)

Source: (PDAU Constantine 1998, DUC) and (PPSMVSS, October 2012).

Furthermore, the colonial courtyardspresenta reduced state ofconservation where several pathologies affect their structure. Besides, structural and thermal insulation regulationshave changed since thosecourtyard buildings were built (Table 4).

Table 4. Economic benefits in the colonial period

Energy Conservation	- The colonial urban forms are exposed to the sun most of the day and the dark asphalt covering most surfaces acts as a heat trap, causing overheating instead of reflecting the solar energy to space.
Minimizing new resources	- Use materials such as brick, stone, plaster, or marblewith important thermo-physical properties.

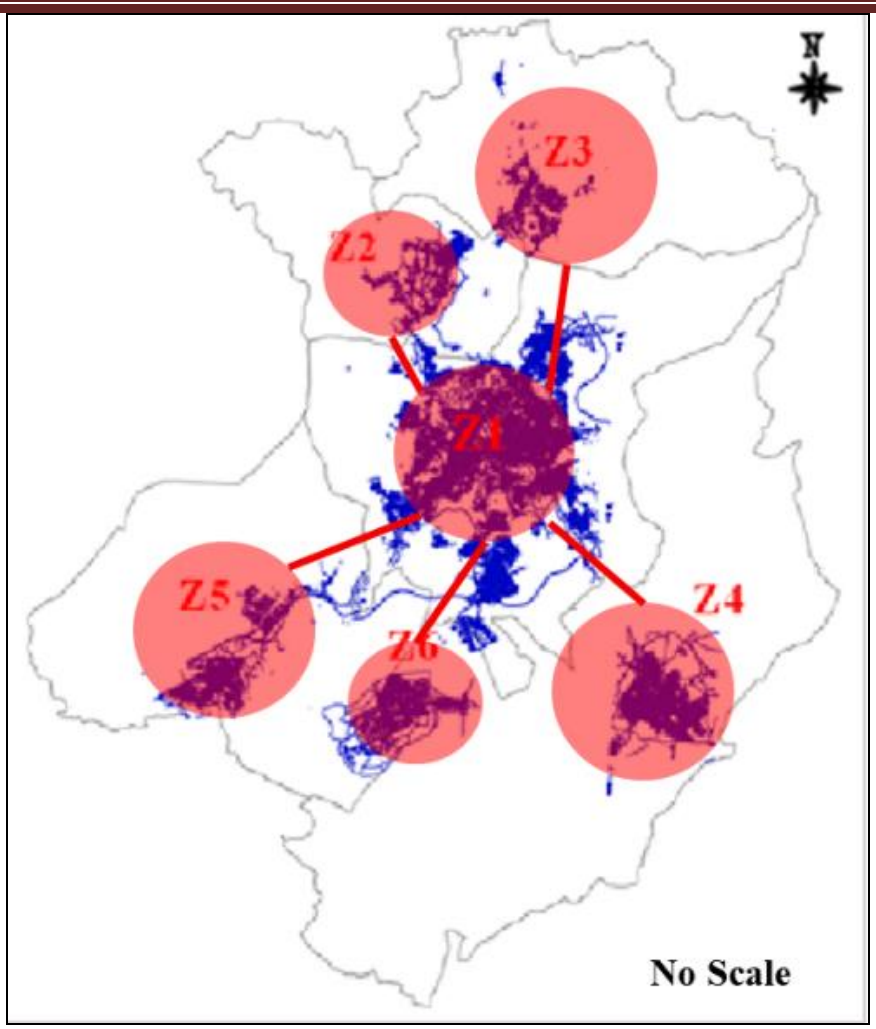
Source: (Bourbia & Boucheriba, 2010)

3.3. The contemporary period

In the contemporary period (starting from the next five-year plan 1980-1984), the physical planning of cities was recognised to be essential. It promoted the so-called"Plan d'Urbanisme Directeur" (PUD) for urban expansion. Therefore, it has shown an expansion of the old town center. Five urban areas have been developed due to the high population density (Figure 3). The zone (Z2) (*Hamma Bouziane*) is situated in the North-West of the old city center. The Z3 (*Didouche Mourad*) is situated in the North-East of the old city center. The Z4 (*El-Khroub*) is situated in the South-East of the old city center. The Z5 (*Ain Smara*) is situated in the South-West of the old city center. Finally, the Z6 is the new habitat zone of *Ali-Mendjeli* (Figure 5).

Consequently, their architectural design has taken many forms, dimensions and detailed treatments.

Fig.5. Urban agglomerations of Constantine



Source: (Sahnoune, Benhassine, Bourbia, & Hadbaoui, 2021)

3.3.1. The urban morphology analysis

The contemporary phase has shown an expansion of the ancient city and the development of five urban agglomerations resulting from the high population density (Figure 6).

As a result, the urban structure has taken on many forms, dimensions and detailed treatments. Tall buildings characterise it with typical urban courtyards, large street canyons and an urban landscape of asphalt, brick, metal and dark roofs.

Fig.6. The urban forms of the urban habitat zones, *Ali Mendjeli* (new town)

Source: (PDAU Constantine, 2015)

3.3.2. The socio-cultural aspect

Courtyards design during this period presents a space of passage between the private and the public, rather than a space that responds to climatic conditions or the socio-cultural aspects.

3.3.3. The environmental-economics value

The contemporary courtyards vary from deep to wide, effectively providing maximum radiation in winter. They are mostly rectangular and enclosed, rangingalong the west, north-south, northeast-southwest,and northwest-southeast. The H/W ratio values vary between 0.1-0.6 (Table 5).

Table 5. Dimensions of courtyardsin the contemporary period

Dimensions	**Width**	**Length**	**High**
Values	Varies between 30-135 m (Increment of 15m)	- Varies between 60-270 m (Increment of 15m)	Varies between 3-72 m (Increment of 3 m)

Source : (Kedissa, Outtas, & Belarbi, 2016)

They are effective in winter by providing maximum radiation while not effective in protecting against the intensity of solar radiation in summer.

Furthermore, the contemporary courtyards require a considerable amount of sources, in order to meet the energy demands, due to the population and economic growth in both developed and developing countries. Also, there are not enough resources in the world to fulfill these enormous demands (Table 6).

Table 6. Economic benefits in the contemporary period

Energy Conservation	- The contemporary urban formsare characterised by asphalt, brick, metal and dark rooftops soak-up an enormous amount of energy from sunlight reflecting even more light densely built-up areas.
Minimizing new resources	- Use of materials such as concrete with low thermally conductive

Source: (Sahnoune, Benhassine, Bourbia, & Hadbaoui, 2021)

3.4. Comparative analysis results

By comparing the analysis results shown in the previous section of different courtyards in the traditional, colonial and contemporary periods in the urban area of Constantine, some interesting findings can be summarized as follows:

The courtyard is considered a common element in the design of buildings in traditional, colonial and contemporary periods,regardless of its dimensions. It was used as a central space around which the rest of the spaces are organized. It was also used as a passage space between the private and the public.

It was also noted that most of courtyards of the study samples have a rectangular shape in the different periods, representing the typical shape in this area. In comparison, fewer tend to take other shapes such as the square or the triangle, especially in the traditional and colonial periods.

By looking at the typo-morphological analysis, the results show that urban forms in the traditional period were based on the principles that the past is a practical and cultural resource, to be actively recognized and developed. They provide a comfortable environment on hot days by supporting natural ventilation and protecting buildings from solar radiation. Its performance depends on its urban fabric compactness, affecting surfaces'

heat gain from solar radiation (Al-Hafith, Satish, Bradbury, & de Wilde, 2017a). However, in the colonial and contemporartyperiod, urban forms were characterised by a very dense urban structure, exposed to the sun most of the day and practical to the colonial culture. Moreover, urban fabrics are based on isolated buildings, traffic, pedestrian separation, and strict functional zoning. Thus, these applied urban regulation does not consider the climatic or cultural contexts (Raboudi & Saci, 2013).

From the socio-cultural point of view, this research addresses how socio-cultural aspects like historical context, beliefs, religions, values, ideologies, and lifestyles influence the spatial organization of the courtyard. However, the results found that the traditional courtyard offers the highest level of human mental comfort by considering privacy and security.

Furthermore, by looking at the environmental-economics and considering the shape, the H/W ratio and the orientation as the most significant geometric parameters of the courtyard design that influence its environmental performance (Al-Hafith, Satish, Bradbury, & de Wilde, 2017b; Rodríguez-Algeciras, Tablada, Chaos-Yeras, De la Paz, & Matzarakis, 2018),the analysis results were variant, which is a definite difference between the three types of courtyard designs.More significantly, the H/W ratio defines the space and gives various senses of enclosure or disclosure according to its value.Accordingly, in these studied cases,the value of the H/W ratio ranges between low and high, with values of 0.1 to 1.7. For example, courtyard designs that give a sense of full enclosure due to H/W values were reported in the traditional and colonial periods. They ranged from 1.2 to 1.7 for the traditional courtyard and 0.7 to 1 for the colonial courtyard.

On the other hand, the courtyard design in the contemporary period has a sense of disclosure with values of H/W ranging between 0.1 to 0.6. In addition, this variance in values of the H/W ratio has a significant effect on the climatic function of the courtyard. It was verified that this ratio influences the microclimatic performance of the courtyard and, consequently, its thermal environment by modifying the radiative and convective heat exchange processes (Almhafdy, Ibrahim, Ahmad, & Yahya, 2013; MEIR, 2000; Soflaei, Shokouhian, & Shemirani, 2016a, 2016b), as well as the thermal comfort of surrounding spaces (Meir et al., 1995;

Zamani, Heidari, & Hanachi, 2018). Thus, some suggestions for the design of courtyard H/W ratios were recommended by (Muhaisen, 2006)**,** where deep and narrow courtyards with high values of H/W ratio are appropriate in a hot climate, while low and large courtyards with low values of H/W ratio are suitable for cold climates.

Accordingly, the results of the H/W ratio in the three periods (traditional, colonial and contemporary) highlight that courtyard design from the traditional and colonial periods are appropriate for the hot conditions, and reduce the energy demand for cooling, consequently affecting the economypositively. On the other hand, the courtyard design of the contemporary period is suitable for cold conditions and not adequate for the regions' climatic conditions, which increases the demand for heating and negatively affects the economy.

4. CONCLUSION

Historically, the courtyard as an outdoor design space has been used for many social, cultural, environmental and economic purposes. However,building with a courtyard is more prevalent in North Africa, which was adopted by the Islamic civilizations that controlled the north coast of Africa. Therefore, the courtyard design was characterised by Islamic culture. However, courtyard designs in Algeria, especially Constantine, have passed by different periods, such as traditional, colonial and contemporary. Accordingly,the main objective of thisstudy was to compare the different designs of courtyards in these periods using typological analysisby considering the urban-morphology, socio-cultural and environmental economics criteria in a chronological context.

The study shows a variety in the selected criteria, which gives substance to the study. It also shows a clear difference in several determining indicators and characteristics for each courtyard. In general, the rectangular shape of the courtyard design was predominant in the urban area of Constantine. By considering the environmentaleconomics,the courtyard in the traditional and colonial periods was designed as a cooling strategy to cope with the hot conditions of the region's climate and contribute to the economy's growth by reducing the energy demand for cooling. In addition, they give a sense of full enclosure with a H/W ratio ranging between 0.7 to

1.7, which is beneficial for both environmental economics and socio-cultural aspects.

In contrast, the courtyard designs in the contemporary period are not in accordance with the climatic context of the region, especially the summer conditions. Moreover, they give a sense of disclosure with a H/W ratio ranging between 0.1 to 0.6. Thus, they do not fulfill the energy demand and consequently the economy.

Furthermore,this research addressed the socio-cultural aspects like historical context, values, norms, ideologies and even everyday lifestyle that influence the spatial organization of the courtyards. Therefore, the traditional courtyard houses offer the highest level of humanmental comfort by considering privacy and security, compared to the colonial and contemporary.

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