

Article

A Review of the Geometric Proportions of Shaping a Courtyard of Traditional Architecture in Relation to Human Scale, Tripoli, Libya

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Abstract: Since ancient times, courtyards have played a vital role in architecture, particularly in domestic architecture. Over time, the existence of vernacular architecture has made beauty and harmony; these have always been important components of traditional Libyan architecture. Studying traditional vernacular architecture is key to maintaining vernacular architecture knowledge; this is because these principles, such as modular design, geometry, and proportions, are detectable characteristics of the tradition. Architecturally, proportion is an aspiration of the implementation of design grammar that encloses shapes of structure. A good impression upon the beholders builds in relation to different elements of space, such as a scale of geometric shapes, patterns, organisation, and the hierarchy of space relationships, to achieve aesthetic dimensions, in part and as a whole. In this article, the study searches for a modular, or proportion, that rules the geometric design of traditional houses in Libya. This is conducted through examining the geometry of typical traditional houses and the golden section method to find if a certain proportional relationship existed. From this perspective, the vision relied on studying the form suitability; in addition, it involved an analysis of the elevation as well as the interior courtyard proportion in relation to the building area. The outcome of this research is to find the aesthetic values that could generate a good design of domestic architecture; and to prove whether they are a perfect match with the proportion system and modular design used in traditional houses. The study employs the quantitative method, which includes archival documents, direct observation, and on-site documentation. The study involved an in-depth examination of the proportioning and geometrical principles used in traditional houses and courtyards. Their respective roles in creating harmony and beauty are discussed in this paper.

Keywords: geometric proportions; courtyard design; traditional architecture; human scale



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1. Introduction

Architecture has been driven by a search for general rules of beauty; however, the beauty of the design depends on the beholder's perception, or it is determined by fundamental properties of space [1]. An architect outlines their thoughts into designs reflected in elements, such as space organisation patterns, spatial relationships, geometric shapes, and scale ratios and proportions. Moreover, architecture is the place where the programs go from the viewpoint of user requirements, user needs, and user aspirations, economic and social factors, cultural factors, and legal and historical factors.

In theoretical dialogue, Puspitasari and Lakawa (2020) stated that “the proportions of the formal elements and their spaces can almost always be logically linked to certain numerical progressions” [2]. Mathematically, a shape's geometry is related to its numerical calculation; moreover, its creativity adapts to those calculations.

As the order of architecture, proportion is important for strength, beauty, and utility. In architecture, proportion is only related to nature through the concept of “scale”. The concept of scale refers to a way to bring all the facets of a building into a harmonious proportion using an imaginary yardstick. Adapting these elements to the requirements of humans and addressing certain limitations in materials derived from usage, tradition, and methods of construction and manufacture, is what scale is [3]. As a result, building architectural styles provide us with information about the history and culture of a region. In planning useful spaces, designing structural systems, and creating aesthetically pleasing environments, the concept of proportion plays an important role.

In fact, the excellence in planar and spatial geometry during Muslim history is known to be interrelated in the beauty and goodness linked to optimum proportions. Pattern design is strongly related to geometry, which can be viewed as an aesthetic method for self-refined design. In addition, geometric proportions govern primarily the ordering of patterns; they also serve as a mediator between order and diversity, as well as within aesthetic levels [4].

Historically, aesthetics was a science of analysing beauty based on harmony, where the golden ratio is approximately equal to 1.618 and called *Phi* (ϕ) in Greek. While *Phi* is an irrational number whose terms go on forever after the decimal point without repeating, *pi* and *e* are transcendental numbers since they cannot be obtained as roots of any finite equation. In the golden ratio, the digits keep going and never end, as in 1.61803398874989484820 . . . ; this ratio is called the golden section in cubic geometry. In a golden rectangle, the short to long side ratio is 1:1.618. There is an interesting aspect of the golden rectangle in that one gets another golden rectangle by cutting out a square starting from one of its short sides [5].

In terms of Islamic architecture, the first proportion method is based on the relationship between the diagonal and side of a square mathematically. When the side of the square is given the conventional value of 1, the diagonal will have a value of $\sqrt{2}$. In the next step, the square's $\sqrt{2}$ diagonal is traced as an arc. By intersecting the arch with the extension of one of the sides of a square, a rectangle is formed with sides in the proportion of $1:\sqrt{2}$; this rectangle has a diagonal of $\sqrt{3}$. Repeating the same process using the $\sqrt{3}$ diagonal creates a rectangle with a ratio of $1:\sqrt{3}$ and so on [6].

A study by Tabaa (1987) in Aleppo City of a courtyard in the Islamic Era resulted in a proportional system that uses a primary grid based on modular geometric units of an open courtyard; (13.10 m $\times$ 16.45 m) gives 30 $\times$ 40 cubits, or a ratio of 3:4, making it a perfect 3-4-5 rectangle, or a rectangle made of two Pythagorean triangles [7].

In the traditional urban pattern, Arab architectural typology aligned human needs with an open space, usually called a courtyard; these needs included shelter, work, and rest. Even today, around the world, people continue to use courtyards, taking advantage of the climate patterns. Traditionally, interior spaces are arranged; the courtyard is the key element of their spatial composition; the rooms are arranged around the courtyard. It is a starting point as a primary element that can be found in most traditional houses; the other rooms are then arranged around the courtyard according to their functions, and the concept of the courtyard was significantly linked to the social, cultural, religious, and privacy issues of women [8]. The courtyard is amongst the oldest architectural footprints that has been used in buildings by humans. They are found in houses or in public buildings that offer pockets of meeting places that activate communal and family-oriented activities, such as gardening, cooking, working, playing, sleeping, or even in some cases as places to keep animals [9]. In the courtyard, formality and symmetry may appear at first glance; however, upon closer inspection, they reveal the opposite. Informally designed courtyards are often a result of changes over time; a first-floor gallery can be enclosed, a second-floor gallery added, another arcade enclosed, the courtyard divided, and so on [10].

Muhaisen (2006) stated that the courtyard form is an excellent architectural modifier with an efficient thermal performance associated with the penetration of solar radiation onto the internal envelope. This is due to the courtyard geometrics, as well as the position of the sun [11]. Taleghani et al. (2012) defined courtyards as a place belonging to a

specific type of space, also called ‘transitional space’ [12]. This term covers a wide range of spaces from a passageway and a corridor to a balcony or porch. Transitional zones are the ‘in-between’ architectural spaces where the indoor and outdoor climate is moderated without mechanical control systems. With respect to in-depth insight into the courtyard, Ghaffarianhoseini et al. (2015) mentioned that the relationship between buildings and the surrounding outdoor environment is a modelling that improves comfort conditions by modifying the micro-climate around the building, and by enhancing ventilation as passive air-conditioners in terms of airflow rate and pattern [13].

2. Tripoli as the Case Study City

Tripoli is Libya’s capital city with an outstanding urban settlement, as well as being one of the oldest cities in this country. Despite this, the city’s spatial planning still reflects traditional patterns. The old town is known as an important commercial hub; approximately 47 hectares of it are built up. It is situated on the Mediterranean coast of North Africa at Lat 33° N and 13 10° E (Figure 1); it is located at the extreme northern point of the Jefara plain and in a central position between Homs city (121 km to the east) and Zuara city (113 km to the west) [14].

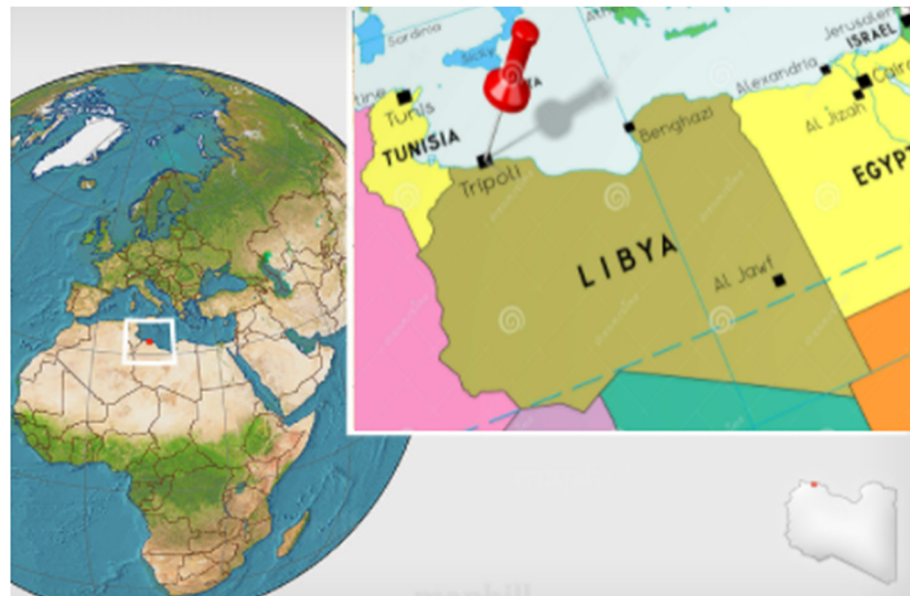


Figure 1. Location of Tripoli, Libya—Reprinted/adapted with permission from Ref. [15].

Historically, in 46 BC, the Romans conquered Tripoli, originally named “Oea”; they built a number of temples, markets, and public baths surrounded by residential buildings. As one of the three cities in Tripolitania, Oea became the regional capital during the Roman era. Hence, the name Tripolis, which means ‘the capital of three cities’ (Oea, Leptis, and Sabratah) [16]. The pentagonal-shaped old city is also surrounded by solid masonry walls and gates; it dates from the Roman period [17]. In its current form, it follows no system and demonstrates an organic growth pattern; its streets have only two to three metres of width, with flying buttresses between opposing street façades. As is common in Islamic quarters, but copiously evident in the old city of Tripoli, these buttresses support and brace the structures [17–19].

Remarkably, it has an excellent location (Figure 2) and rich cultural heritage; in addition, within Tripoli, there are two different communities called the old city and the new city. In the old town are traditional buildings, while the new town has high rises, apartments, and industrial areas.



Figure 2. Location of the Old City in Tripoli—Reprinted/adapted with permission from Ref. [20].

3. A Composition of the Traditional Town

The urban fabric of Tripoli demonstrates that contextual design is evident at both the level of individual buildings and the level of the city at large (Figure 3).

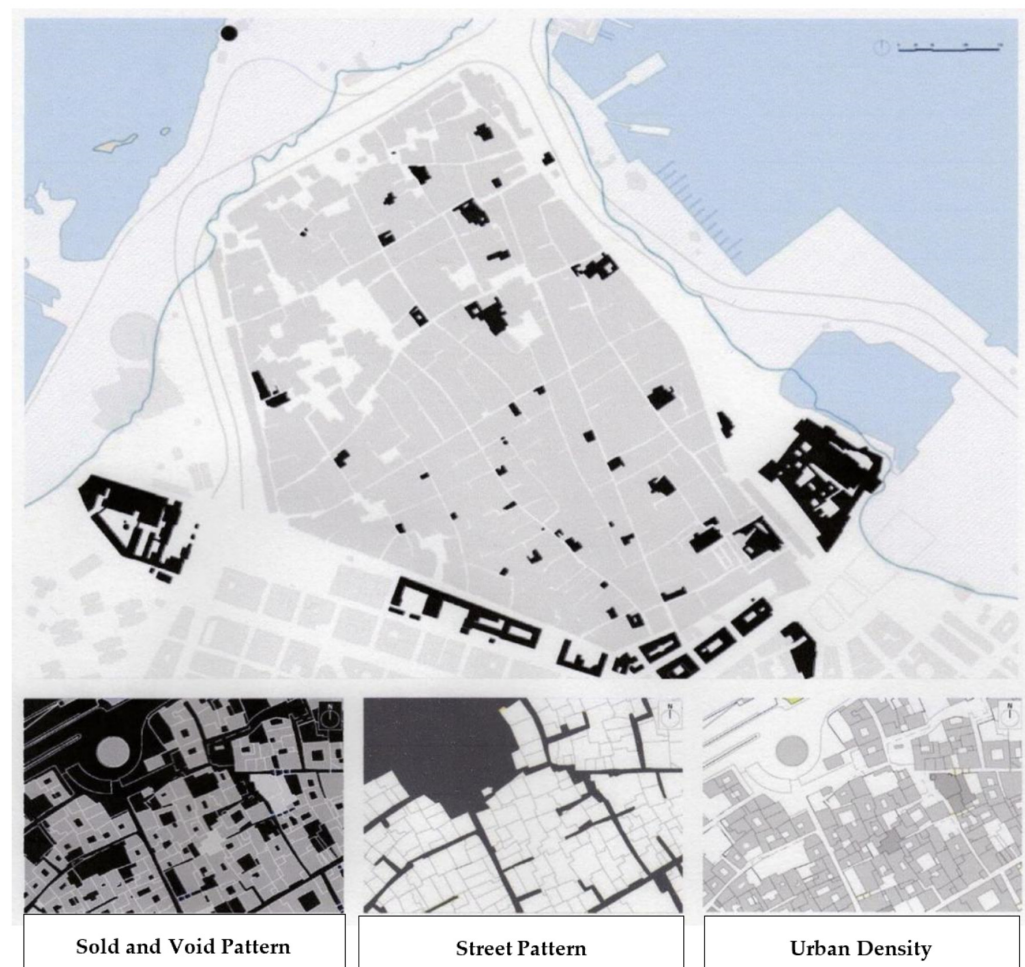


Figure 3. Urban pattern of the Old City—Reprinted/adapted with permission from Ref. [21].

As the context dictates the form of the courtyard and the house, the building operates on the city fabric in an outward direction. Dialectical relations suggest the dynamic interplay between solidity and void in the courtyard houses and their environment [21,22]. As well as the built environment, public spaces with experiential, social, and historical values create the appearance of historical cities and affect urban life [23]. The traditional town consists of these levels of enclosure combined into a complex that offers a mix of public and private living areas. Tripoli's historic old town's physical characteristics contribute to its ability to respond to culture, and make its built environment attractive and habitable for its residents. Mumford (1970) writes, "The elemental unit of planning, then, is no longer the house or the house-block: the elemental unit is the city, because it is only in terms of this more complex social formation that any particular type of activity or building has significance" [24]. As a result, the traditional old town in Tripoli offers numerous visual experiences and unique experiences. On a more environmental level, the building's courtyard and the urban organic design scale at old Tripoli city mitigated the harsh climate and represented an evolution of architecture as it evolved through time and across generations.

In urban configuration (Figure 4), the width of a street is also influenced by public, semi-public, private, and semi-private ownership. Property owners often maintained streets on their own due to the lack of a formal authority. As shown in Figure 5, various built environments in the old town, such as streets, mosques, markets, houses, and urban spaces, remain a part of the new towns. Today, however, there are major differences in their physical and spatial natures.

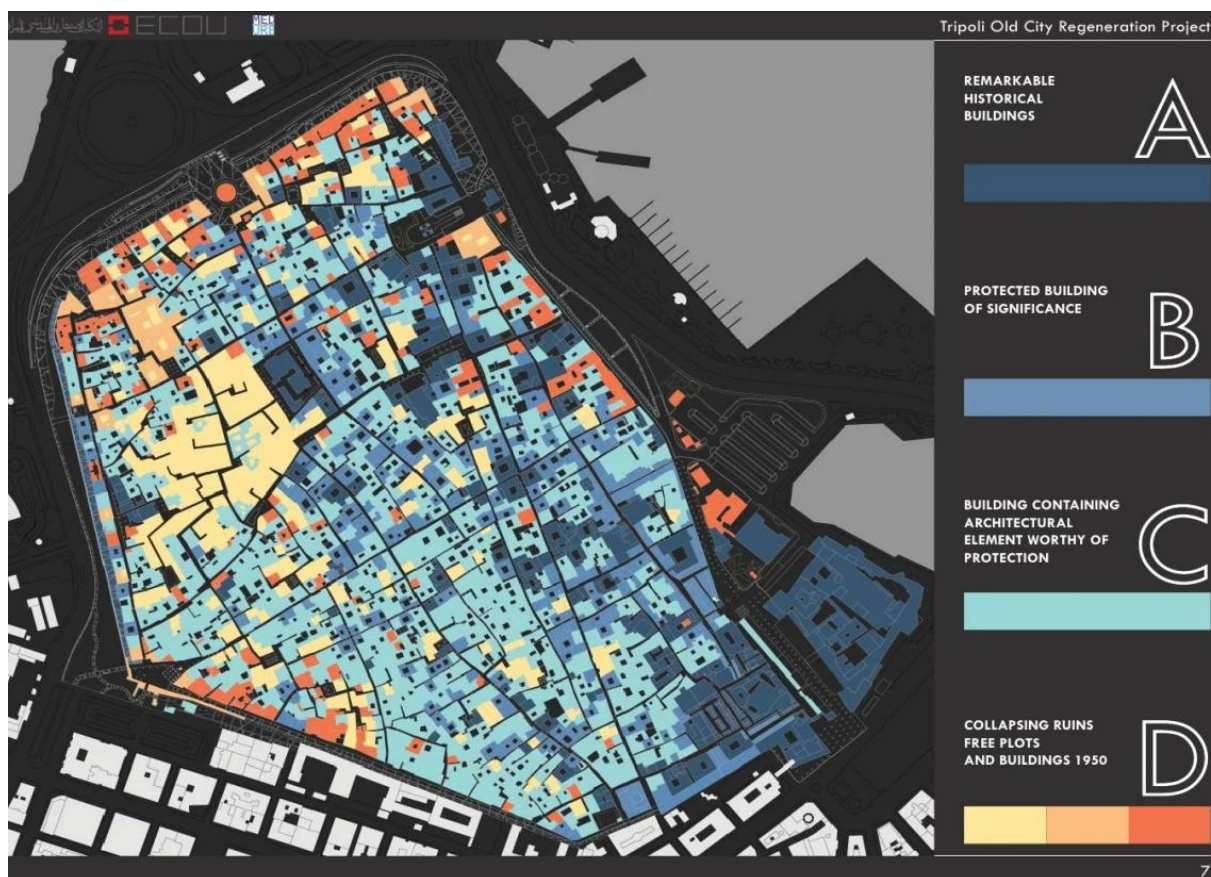


Figure 4. Aerial photo of the urban image of the Old City—Reprinted/adapted with permission from Ref. [25].



Figure 5. Urban structure of the Old City—Reprinted/adapted with permission from Ref. [26].

Traditional Libyan architecture is characterized by the consideration of rhythmic relationships between humans in the microcosm of indoor architecture and the macrocosm of outdoor urban design that function together to produce aesthetic harmony in the entire city.

4. Traditional Buildings

The traditional architecture of Libya reflected a long-term understanding of both the natural environment and the social environment where they live. Tripoli, like other traditional cities, is characterized by the simplicity of design and construction methods; these involve the use of local building materials, such as stones and bricks for walls, gypsum, and palm trunks for roofs, all of which contributed to creating a distinctive character. As an expression of a deep social and environmental awareness in the Arab-Islamic community, a compact system of construction that adapts to the natural environment and responds to the social and economic needs has been widely regarded [27]. In Tripoli, the courtyard is the main theme of the traditional houses in the local neighbourhood; it is divided into a public area for men and guests, and a private area for the woman and family, providing total freedom and privacy. The divisions of larger houses are more pronounced (Figure 6) and the opening into the communal living areas extends this pattern of enclosure into the private living spaces of the family as well.

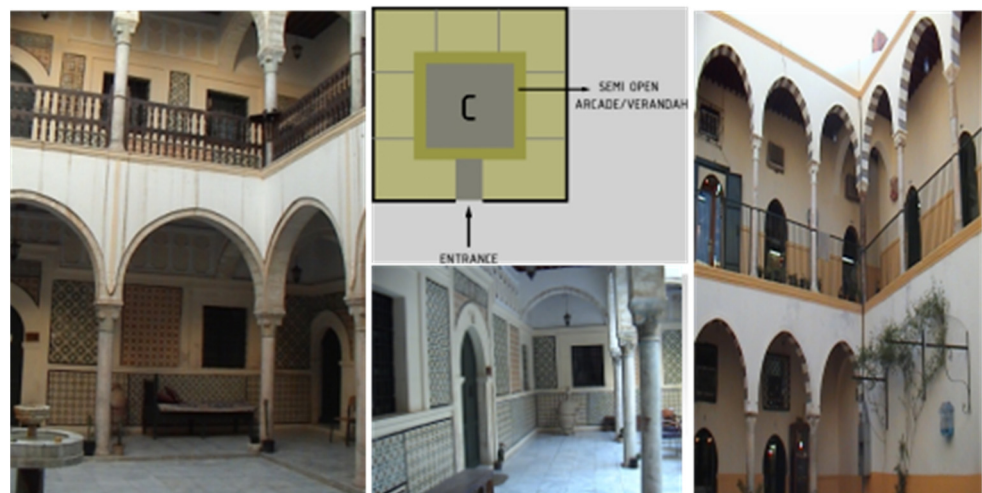


Figure 6. Courtyard position.

A number of significant reasons are attributed to Libyan courtyards in Tripoli based on their design variants for their environmental performance and behaviour (Figure 7).

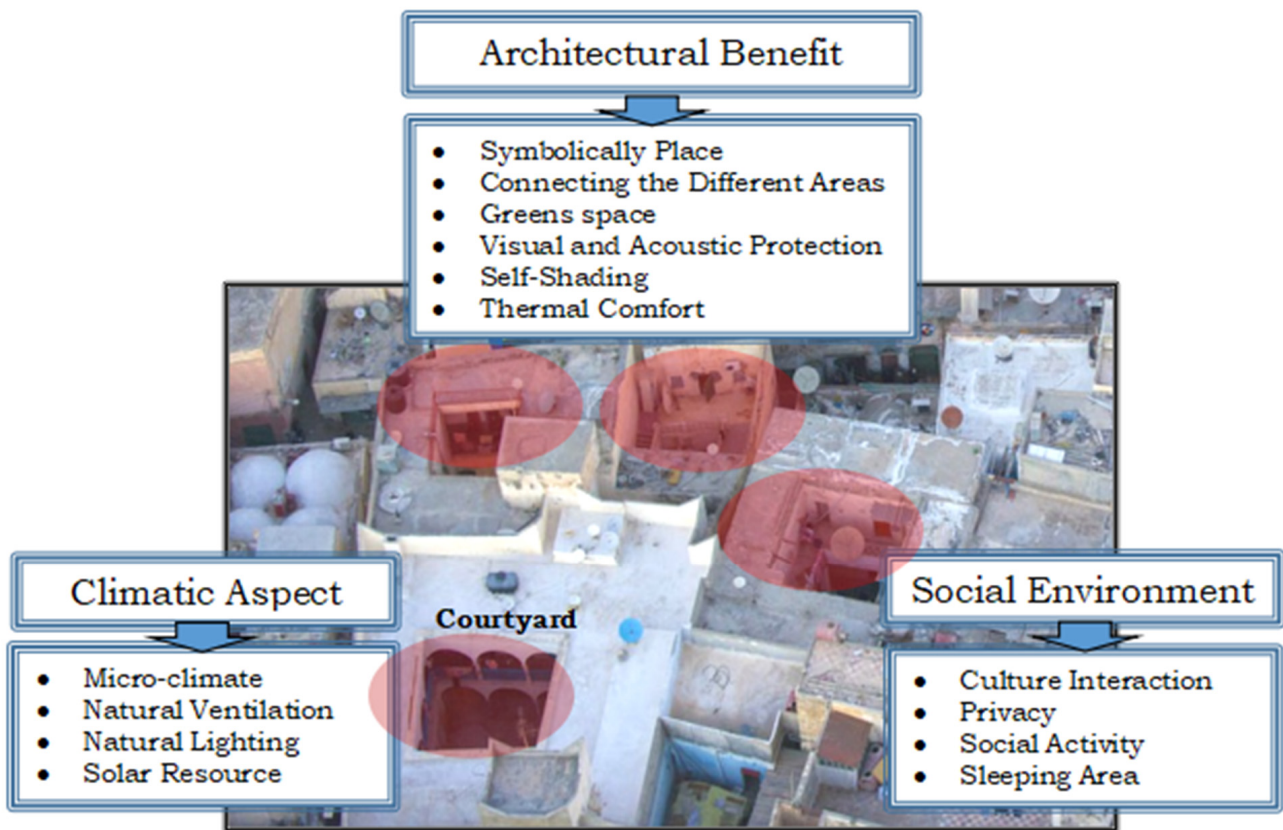


Figure 7. The important aspects that affect courtyard place—Reprinted/adapted with permission from Ref. [28].

4.1. In the Role of Architecture

“Yet, the courtyard is more than just an architectural device for obtaining privacy and protection. It is, like the dome, part of a microcosm that parallels the order of the universe itself” [29]. The courtyard forms a symbolic focal place; the common function of centres in houses and buildings is to connect the different rooms and functions. “Al-Fenaa” is the Libyan name of the courtyard; moreover, the courtyard’s role has always been reciprocal in shaping the spatial arrangement and space organization of the traditional courtyard house, as well as its socio-cultural surroundings [21,22]. In Tripoli, Arab houses are characterized by their flexibility, privacy, and simplicity; each of the internal spaces can accommodate different functions; the relationship between them is elastic [30]. Additionally, it provides visual and acoustic protection to the building; in addition, it is an example of a pergola, trees and flower plants that sit in shaded areas.

4.2. In the Character of a Social Environment

Correia et al. (2014) stated that “The Arab wants to secure his house against the desert on the outside, opening parts of the inside of the house to the sky, such as courtyards which give relief to the inner rooms. The courtyard space gives the inhabitants a sense of ease and calm, and the feeling that they have their own piece of sky to use and to protect them”. Accordingly, the court serves as a living room in the evening to entertain guests and as an extension of the kitchen during the day; it is a place that can be used for rest, play with children, women’s activities, and exercise [12]. Overall, in traditional houses of Tripoli, patios are places of sharing, socialization, and household work. Throughout the day and during special family occasions and festivities, it is a place where all the family

members get together. In addition to being a place for guests to be welcomed, it is a place where people can carry out their activities independently [31].

4.3. In Climate Position

The organic urban design in Old Tripoli city and construction of the buildings and the placement of the courtyard have resulted in indoor comfort for living; while the courtyard is a microclimate and a temperature regulator. In the summer, a courtyard house's passive cooling can provide acceptable thermal comfort without relying on mechanical systems; the courtyard serves as both an air shaft and a source of natural light for the rooms surrounding it [32]. During hot, dry seasons, the courtyard operates on three regular cycles [33]:

1. A cool night air permeates the courtyard during the first cycle; the rooms, floors, columns, roofs, ceilings, and furniture within are cooled until the late afternoon by the cool night air. During the summer, the courtyard loses heat by radiating to the sky; this makes it an ideal place to sleep;
2. The sun directly strikes the courtyard floor at midday in the second cycle. While the cool air rises and leaks out of the adjacent rooms, the arcades at the perimeter provide much-needed shade; while keeping the water flowing helps to cool by evaporation in dry climates. As a result, convection currents are generated in the room; this may increase comfort, and the courtyard acts as a chimney. Adobe walls are excellent insulators, and an external wall of average thickness may take up to twelve hours to dry; thus, the house remains enclosed on all sides and is insulated from heat gain during the day;
3. At the end of the third cycle, when the outside temperature is very high, the inside of the house and the courtyard floor will be warmer; this will lead to the creation of further convection currents. As the sun sets, most of the cool air trapped inside the rooms escapes; whereas, in the late afternoon, the street, the courtyard, and the building are protected by the shadows cast by the tightly-knit 'mud-lump' structure. The air temperature begins to decrease rapidly at sundown as the courtyard begins to receive the irradiation of the clear sky, and cooler air descends into the courtyard.

5. The Case Study

Specifically, the search for proportions that dominate courtyards (in traditional/heritage buildings) and their dimensions were examined to answer the following two questions:

1. Is the proportion of the courtyard "square or rectangular size" determined according to the golden ratio?
2. Is the area of the courtyard presented in a proportional relation with the house area?

To answer both questions, a number of geometric examples are analysed, beginning with finding the size of the courtyard. The following methods led to a seven-type square courtyard and a four-type rectangular courtyard, as shown in Figure 8; these occur after a series of attempts to discover a meaningful geometrical relation between the inner courtyard and the house pattern.



Figure 8. The locations of the Case Study buildings in the Old City.

6. Square Courtyard Shape

The beginning of the geometrical analysis ($a \times b$ and $c \times d$) of a traditional building is to define the square centre of the courtyard (Figures 9–15). Then, a circle is drawn around that centre with a radius reaching the furthestmost point of the courtyard.

In the second step, if one confines this circle with squares with 45-degree cross angles from the intersections that occurred between one arch square's diameter and the other's side, one obtains four squares hierarchically reduced in size toward the centre. In this case, one can determine the side of the courtyard; its location has possibilities of the golden section.

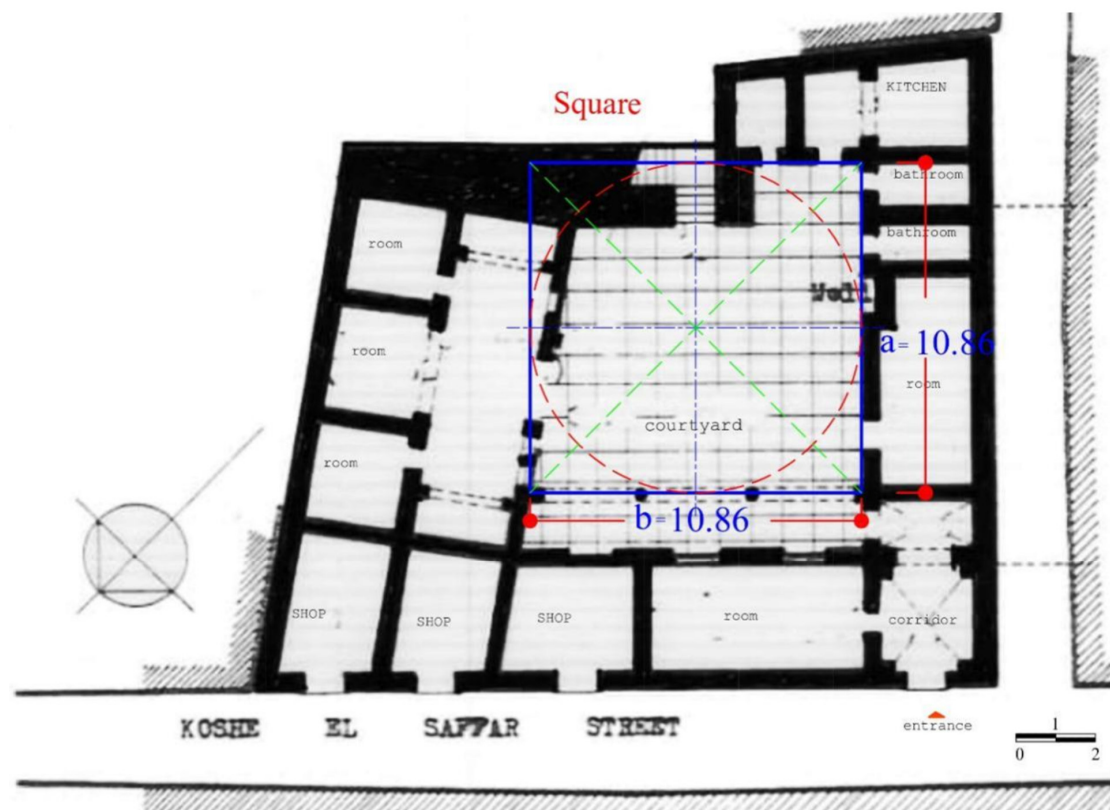


Figure 9. Ghadamsi House's plan and the ratio ($a \times b$).

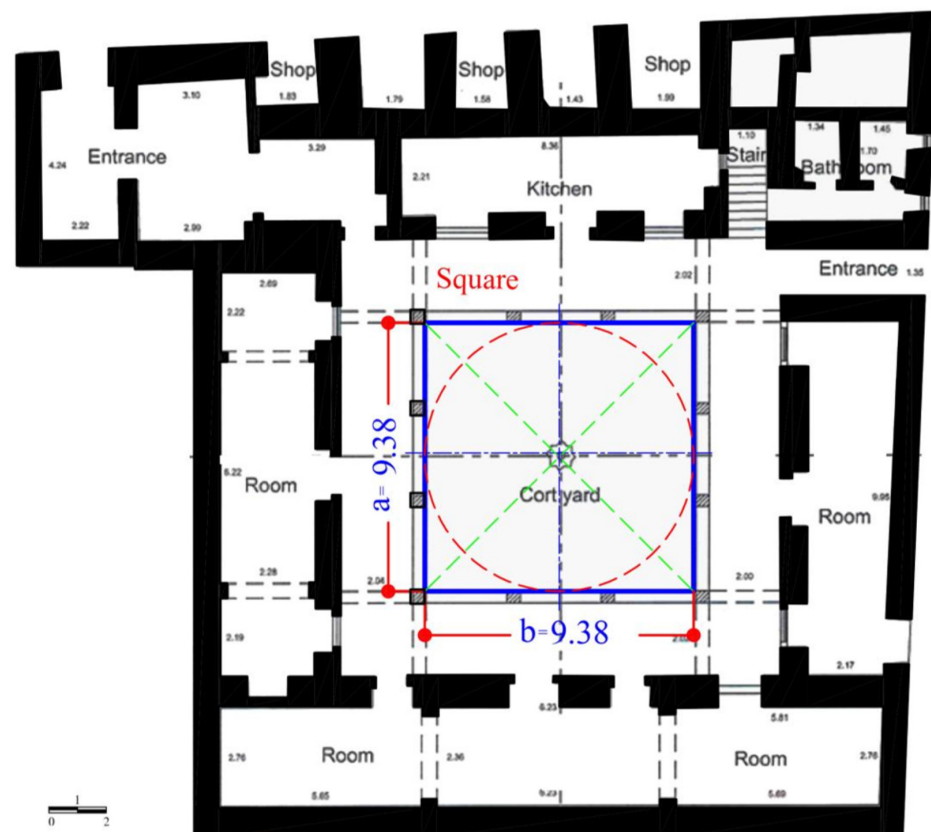
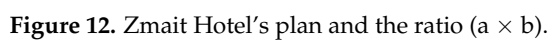


Figure 10. Bait Al-Qarmanli House's plan and the ratio ($a \times b$).



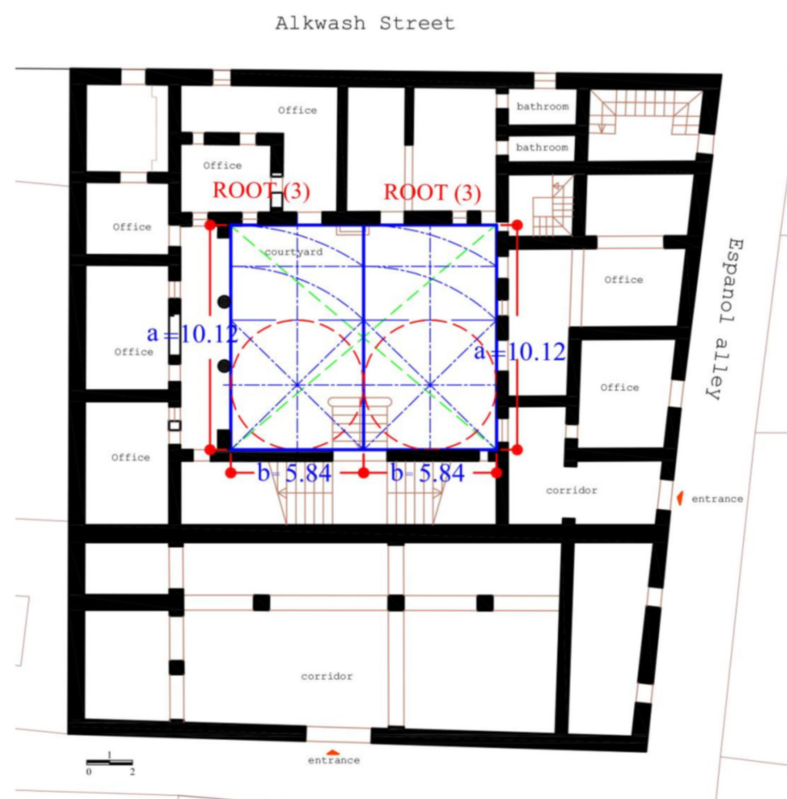


Figure 13. English Consulate plan and the ratio ($a \times b$).

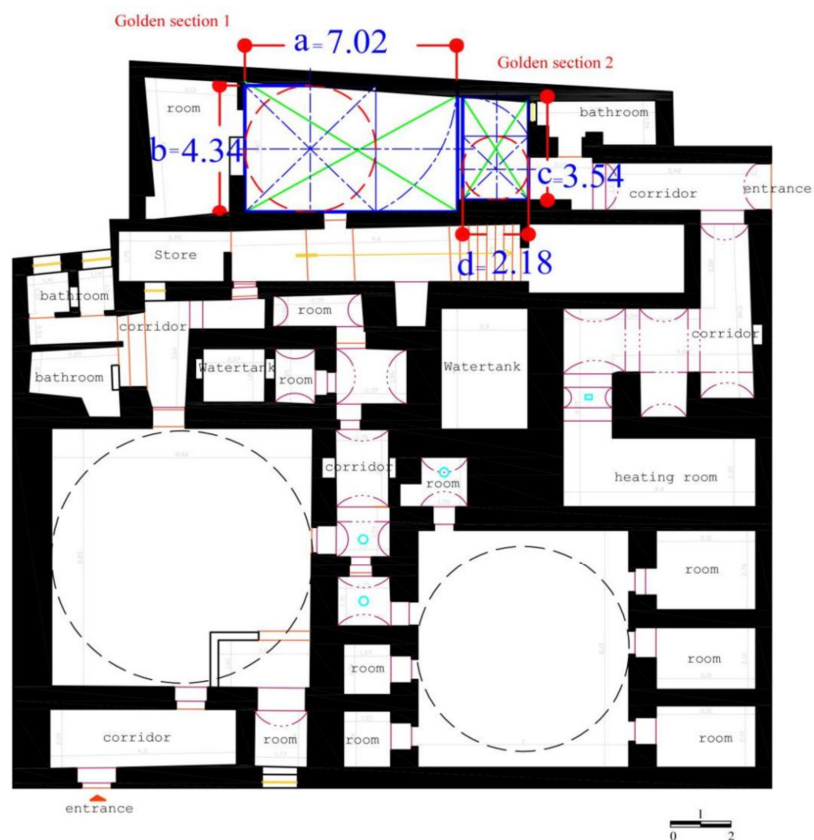


Figure 14. Dergut Pasha Hammam's plan and the two different ratios ($a \times b$ and $c \times d$).

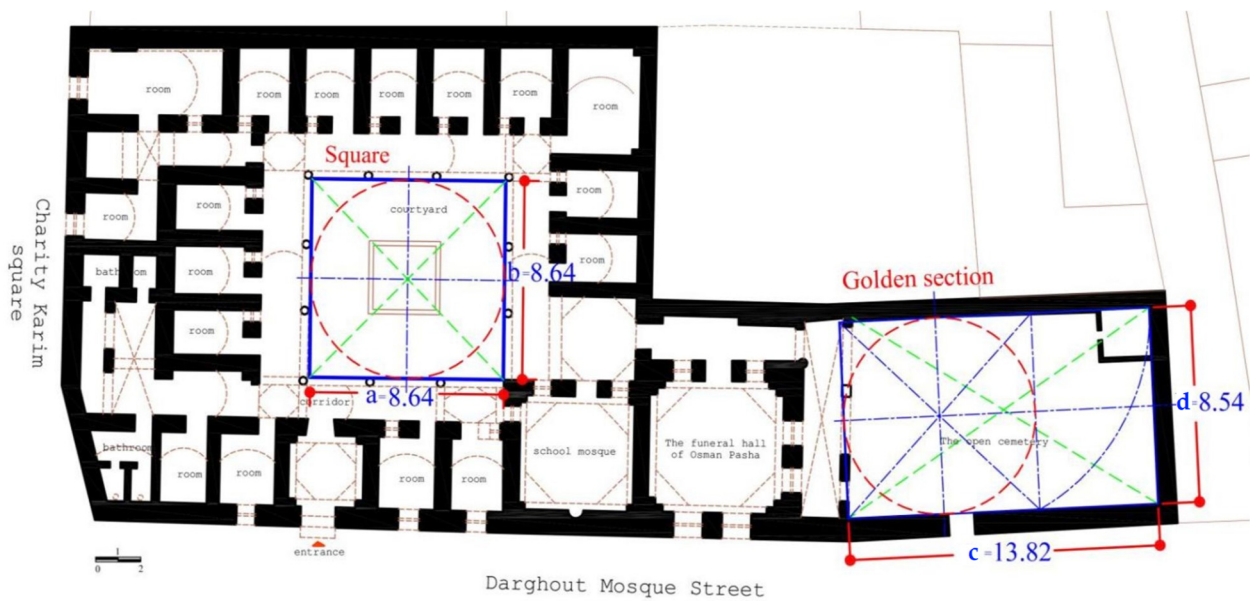


Figure 15. Madrasat Uthman Pasha's plan and the two different ratios ($a \times b$ and $c \times d$).

7. Rectangular Courtyard Shape

To analyse the geometrical rectangular shape (Figures 13–15), the determination of the lengths of the rectangular courtyard's sides forms the starting point.

One starts with drawing two 60-degree-angle lines: one line from the corner (a) of the bordering square; and the other from the opposite corner (b). Both lines will intersect at point (c). This intersection represents the centre of the short side (Figure 16). By connecting both side ends, one reaches the final rectangle; this has the proportion of 1:4. The results are three rectangles with different proportions; these are: $\sqrt{2}-\sqrt{3}$ and $\sqrt{4}$. The first proportion recalls the golden rectangle, whose proportion is equal to 1.618.

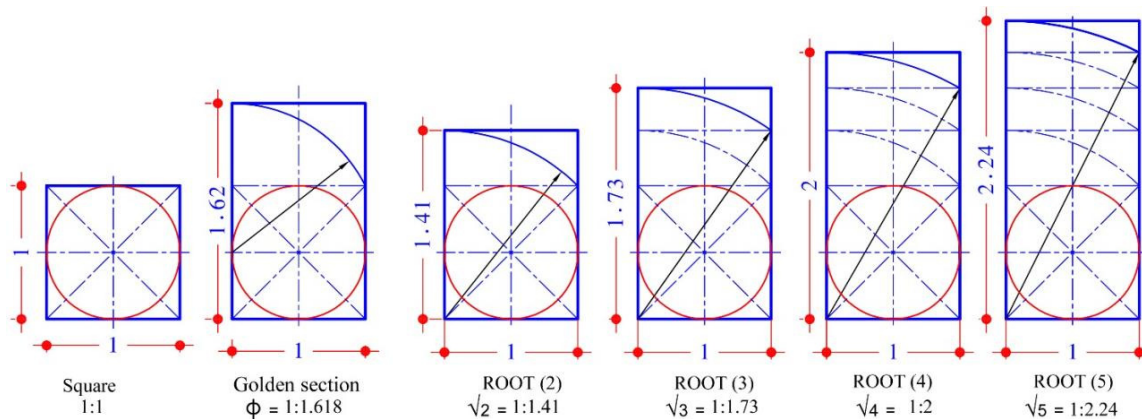


Figure 16. Proportion sections.

8. Discussion

The golden ratio is a good principle to consider as proportion is a major subject in architectural theory; this is not only sketches, but also to find the beauty of shape and harmony with space. This study reveals that though the ratio of width to length for square courtyards ranges from 1:1 to 1:1.41, the ratio of 1:1.73 to 1:2 appears in rectangular courtyard cases, which represent the common width and length proportions (Figure 16). However, all the proportions related to 1:1.618 of width to height in the case of all the eight houses are also well supported by the golden ratio principle. Ergonomically, the golden ratio is a related relationship design and is a very subjective profession. Therefore, the

golden ratio should be used as a measure in architecture because its application brings beauty and harmony in the overall design.

9. Conclusions

According to what has been reviewed above, the traditional architectural elements are partially not governed by a fixed proportion. As a consequence of this, the urban pattern of the old town of Tripoli is created by dense clusters of patio houses without any specific land shape; moreover, they are built wall-to-wall with adjacent buildings, eliminating the wasted spaces that are reflected in the urban pattern as irregular forms. In other words, the courtyard design has no proportional constraints; this is a flexible approach as different cases will require different proportions or a range of proportions. As a result, the spiritual and aesthetic values of the whole can be understood. Observations from the study suggest that the golden ratio will continue to open new vistas in understanding life and the universe. Using the golden ratio to measure the local architecture explored the following details:

- In Tripoli, traditional architecture conforms to well-matched, matured aesthetic patterns and proportions;
- A sense of proportion establishes an understanding of important objective grounds for beauty, as was the case in earlier architecture;
- In general, proportion is a multilevel concept, and the golden section is a subcategory of the term proportion.

According to Hale (1994), “The difference between our age and the past is in our way of seeing. Everywhere in the buildings of the past is a relationship among parts: contrast, tension, balance. Compared to the buildings of today we see no such patterns. We see fragmentation, mismatched systems, and uncertainty. This disintegration tends to produce not ugliness so much as dullness, and an impression of unreality” [19]. As a last thought, beauty is a necessity since it encourages human well-being and allows us to function fully; there is no doubt that architects, designers, and others need to work together to appreciate and recognize the importance of the courtyard in order to generate interest in it. It is essential that residents become familiar with the potential benefits and advantages that the courtyard building has for improving the appearance of the environment, and making the place more desirable.

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References

1. Kappraff, J. System of Proportion in Design and Architecture and Their Relationship to Dynamical Systems Theory. *Symmetry Cult. Sci.* **1999**, *10*, 299–316.
2. Puspitasari, P.; Lakawa, A. Revealing The Vernacular Concept Through Proportions in Architecture. *Int. J. Sci. Technol. Res.* **2020**, *9*, 1415–1420.
3. Josephine, E. The Study of Geometric Forms, Proportion and Scale of Heritage Buildings Due to Architectural Theory. In *Architecture Research and Design (Ar + Dc)*; Institut Teknologi Sepuluh: Surabaya, Indonesia, 2016; Available online: <http://File:///d:/Akramoses%20c/Music/Paper%202018/2/Writting/169815-En-The-Study-of-Geometric-Forms-Proportion.Pdf> (accessed on 18 December 2021).

4. Dabbour, L. Geometric Proportions: The Underlying Structure of Design Process for Islamic Geometric Patterns. *Front. Archit. Res.* **2012**, *1*, 380–391. [CrossRef]
5. Thapa, G.; Thapa, R. The Relation of Golden Ratio, Mathematics and Aesthetics. *J. Inst. Eng.* **2018**, *14*, 188–199. [CrossRef]
6. Bashier, F. The Systems of Proportioning in Medieval Muslim Architecture. In Proceedings of the World Congress for Middle Eastern Studies, Barcelona, Spain, 19–24 July 2010.
7. Tabbaa, Y. Geometry and Memory in The Design of the Madrasat Al-Firdows in Aleppo. In *Theories and Principles of Design in The Architecture of Islamic Societies, Proceedings of the A Symposium Held by The Aga Khan Program for Islamic Architecture at Harvard University and the MIT, Cambridge, MA, USA, 6–8 November 1987*; Aga Khan Program for Islamic Architecture: Cambridge, MA, USA, 1988.
8. Abdelkader, R.; Park, J. Spatial Principles of Traditional Cairene Courtyard Houses in Cairo. *J. Asian Archit. Build. Eng.* **2018**, *17*, 245–252. [CrossRef]
9. Almhafdy, A.; Ibrahim, N.; Ahmad, S.; Yahya, J. Courtyard Design Variants and Microclimate Performance. *Procedia Soc. Behav. Sci.* **2013**, *101*, 170–180. [CrossRef]
10. Reynolds, J. *Courtyards: Aesthetic, Social, and Thermal Delight*; John Wiley: New York, NY, USA, 2002.
11. Muhaisen, A. Shading Simulation of the Courtyard Form in Different Climatic Regions. *Build. Environ.* **2006**, *41*, 1731–1741. [CrossRef]
12. Taleghani, M.; Tenpierik, M.; Van Den Dobbelsteen, A. Environmental Impact of Courtyards—A Review and Comparison of Residential Courtyard Buildings in Different Climates. *J. Green Build.* **2012**, *7*, 113–136. [CrossRef]
13. Ghaffarianhoseini, A.; Berardi, U.; Ghaffarianhoseini, A. Thermal Performance Characteristics of Unshaded Courtyards in Hot and Humid Climates. *Build. Environ.* **2015**, *87*, 154–168. [CrossRef]
14. Khuga, M. The Growth and Functions of Tripoli, Libya. Ph.D. Thesis, Durham University, Durham, UK, 1969.
15. Dreamstime. Tripoli Map [image]. 2022. Available online: <https://www.dreamstime.com/illustration/tripoli-map.html> (accessed on 3 March 2022).
16. All Awadh, A. The Morphology of Tripoli's City Center. In *Space Syntax*; TUDelft: Amsterdam, The Netherlands, 2005; Available online: <http://spacesyntax.tudelft.nl/media/Papers/208.pdf> (accessed on 27 June 2022).
17. Rghei, A.; Nelson, J. The Conservation and Use of the Walled City of Tripoli. *Geogr. J.* **1994**, *160*, 143. [CrossRef]
18. Bianca, S. *Urban Form in the Arab World—Past and Present*; Thames & Hudson: London, UK, 2000; Available online: <https://www.archnet.org/publications/10765> (accessed on 2 March 2022).
19. Rai, J. Mathematics and Aesthetics in Islamic Architecture: Reference to Fatehpur Sikri. *J. King Saud Univ.* **1993**, *5*, 19–48.
20. Google Earth Map. Tripoli, Libya [Map]. Available online: https://earth.google.com/web/search/Tripoli/@32.89872941,13.17765566,4.21562013a,224.67521155d,35y,-150.07189042h,44.9394215t,0r/data=CigiJgokCSGKp3KoQjFAER-Kp3KoQjHAGY9Tx2_4YyFAIS2xYsFpAFbA (accessed on 25 July 2022).
21. Mezughi, M. The Echo of the Court in the Imran Fabric of Mediterranean Cities: The House with a Courtyard in the Old City of Tripoli. (البيت ذو الفناء في مدينة طرابلس القديمة: صدى الفناء في نسج عمران مدن المتوسط) Mustafa Mezughi. 2015. Available online: <https://mustafamezughi.wordpress.com/2015/01/29/%d8%b5%d8%af%d9%89-%d8%a7%d9%84%d9%81%d9%86%d8%a7%d8%a1-%d9%81%d9%8a-%d9%86%d8%b3%d9%8a%d8%ac-%d8%b9%d9%85%d8%b1%d8%a7%d9%86-%d9%85%d8%af%d9%86-%d8%a7%d9%84%d9%85%d8%aa%d9%88%d8%b3%d8%b7-%d8%a7/> (accessed on 3 March 2022).
22. Mezughi, M.; Gabril, N. The Resonance of Courtyard in The Traditional Mediterranean City Fabric Case Study: Courtyard House in The Medina of Tripoli. In Proceedings of the Traditional Architecture in The Western Mediterranean International Conference, Mértola, Portugal, 13–15 May 2015.
23. Birer, E.; Adem, P.C. Role of Public Space Design on the Perception of Historical Environment: A Pilot Study in Amasya. *Front. Archit. Res.* **2022**, *11*, 13–30. [CrossRef]
24. Mumford, L. *The Culture of Cities*, 2nd ed.; Harcourt Brace Jovanovich: San Diego, CA, USA; New York, NY, USA; London, UK, 1970.
25. Engineering Consultancy Office for Utilities (ECOU). *The Restoration of the Built Heritage*; Engineering Consultancy Office for Utilities: Tripoli, Libya, 2010.
26. Engineering Consultancy Office for Utilities (ECOU). *Tripoli Old City—Rehabilitation Project. City Code*; Engineering Consultancy Office for Utilities: Tripoli, Libya, 2010.
27. Azlitni, B. The Libyan Architectural Features between Tradition and Modernization. *Hous. Sci.* **2009**, *33*, 137–148. Available online: <http://www.housingscience.org/html/publications/pdf/33-3-2.pdf> (accessed on 4 March 2022).
28. Google Image. Courtyard House, Tripoli [Image]. Available online: https://www.google.com/search?q=Courtyard+in+Tripoli&tbm=isch&chips=q:courtyard+in+tripoli,online_chips:libya+tripoli:aUh-MVPpCTw%3D&rlz=1C1YQLS_enLY972LY973&hl=en&sa=X&ved=2ahUKewiH6KnI8ar2AhXOQUEAHcUdAk8Q4IYoBHoECAEQJA&biw=1349&bih=568 (accessed on 3 March 2022).
29. Fathy, H. *Natural Energy and Vernacular Architecture*; University of Chicago Press: Chicago, IL, USA, 1986.
30. Shibub, M.M.T. The Modern and Traditional Houses in Libya. *Int. J. Arts Sci.* **2017**, *9*, 511–520.
31. Correia, M.; Dipasquale, L.; Mecca, S. *Versus: Heritage for Tomorrow: Vernacular Knowledge for Sustainable Architecture*; Firenze University Press: Florence, Italy, 2014; Available online: https://www.esg.pt/Versus/Pdf/Versus_Heritage_For_Tomorrow.Pdf (accessed on 1 March 2022).

-
32. Eissa, M. Ecological Aspects of the Courtyard House as a Passive Cooling System. CPAS. 2004. Available online: https://www.cpas-egypt.com/pdf/Mahmoud%20Eissa/Researches/2004_Ecological%20Aspects%20of%20the%20Courtyard%20House.pdf (accessed on 4 March 2022).
 33. Dunham, D. The Courtyard House as a Temperature Regulator. *New Sci.* **1960**, *11*, 181–186. Available online: <http://www.jstor.org/stable/43613511> (accessed on 4 March 2022).