547

# Decoding the differences in spatial typology of the old and the new Libyan mosques design via space syntax visibility analysis

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## ABSTRACT

This study introduces fundamental principles and terminologies by decoding the variations in the spatial typology of the old and new Libyan mosques design via Space syntax visibility analysis. The basic tenets explain the complex layouts. Libyan architectural studies have covered some parts of Space syntax as a theory. However, there are still no studies that have filled this gap. This study aims to understand syntactic analysis and get social information from Libyan mosques. The study's sample includes four Libyan mosques, which differ in syntactic values. Also, the cases each have a distinguishing feature highlighted by their genetic identity and spatial typology. The study relies on the syntactical values through the justified graph and visibility graph analysis with the DepthmapX software. The fundamental terms are defined, as is the analysis technique and its application to natural social phenomena. The result demonstrated that the syntactic properties of mosque layouts indicate that syntactic values vary according to the mosques' usage region and the local populace's needs. The study found that using the Space syntax approach, it is possible to determine how Libyan mosques have distinct spaces and how they are related by looking at the visible pattern. Additionally, it establishes a framework, a foundation, for designers and other stakeholders to comprehend and develop future applications of Space syntax analysis to various spatial configurations in Libyan mosque layouts.

## KEYWORDS

Space syntax, Libyan Mosque Layout, visible pattern, Spatial Typology

## 1 INTRODUCTION

Like any other country, Libyan architecture is undergoing development, causing its typology and cultural identity to shift (Alatrash, 2018). This transformation has the most significant impact on the spatial typology of buildings and the built environment (El-Hassi, 2018). The identity-forming features of the spatial typology of Libyan mosques are an essential cultural heritage that should be preserved for

future generations. They, too, will be exposed to the possibility of change, loss, and replacement by an imported culture (Eltrapolsi, 2014). Some studies have recommended a cultural heritage approach to preserve and determine Libyan architecture. However, there is still a gap in understanding the causes of change and determining the appropriate solution using the Space syntax method (Hillier and Hanson, 1984). Additionally, this paper aims to determine the essence of the spatial typology of four different mosques in different periods and regions by using axial and visibility graph (VGA) to investigate the fundamental differences and the similarities in the spatial typology of Libyan mosques and to prove how they have changed.

Furthermore, because there has not been similar analytical research dedicated to this gap in Libya, academic research on Libyan architecture is required to demonstrate this shift by employing Space syntax on the most prominent building in Libyan urbanisation, the mosque. The mosque was chosen as a case study because it is considered the building that most represents and reflects Libyan identity; Figure 1 shows the Google Earth map of Libya with the selected four sample mosques. The chosen mosques are also the most solid of all historical testimonies. It embodies Islamic essence, the significance of which derives from its position on the throne of worship (Kezeiri, 1984; Omar A & Hanafi Zulkifli, 2014; Bahauddin & Ahmad, 2019). Moreover, this paper aims to determine the essence of the spatial typology of four different mosques in different periods and regions by using axial and visibility graph (VGA) to investigate the fundamental differences and the similarities in the spatial typology of Libyan mosques and to prove how they have changed. Figure 2 shows the An-Naqah Mosque located behind Al Saraya Al Hamra Castle in the old city of Tripoli, the capital city of Libya. It is considered the oldest mosque and is greatly important in Libya and North Africa. It was built in 1610 AD before the Al-Azhar Mosque in Cairo and is about 900 square meters in size. The origins of this mosque are relatively unclear. However, in the absence of precise dates, popular traditions surrounding its foundation have invented several legends inspired by the famous story of the camel of the Prophet Muhammad (May Allah bless him and grant him peace).


Figure 1: The Google Earth map of Libya


Figure 2: Google Earth map of An-Naqah Mosque

Figure 3 shows that the Al-Pasha Mosque is the oldest in the city. It is considered the city's icon, almost 8.5 km from Tripoli city centre. It is located in the heart of Al-Khoms, close to the city's central post office. This mosque was built in 1906 AD, 360 square meters in size; it was named after the Pasha because the mosque is attributed to the governor "Rajab Pasha," who was the governor of Tripoli (1322-1326).


Figure 3: Google Earth map of Al-Pasha Mosque

The third sample is shown in figure 4, Hadia Mosque, located in Benghazi city. Benghazi is considered the second biggest Libyan country. Moreover, the mosque's area is about 191 square metres; the northern part is 120 cm lower than the southern part, so eight steps are at the main entrance. The importance of Hadia Mosque is due to its strategic location, which is located in the Al-Baraka neighbourhood, which is the newest residential neighbourhood in the old city of Benghazi. The Al-Baraka developed at the end of the twentieth century and was connected to the port by a railway. It had many quarries, lime kilns, and a military barracks.


Figure 4: Google Earth map of Hadia Mosque. Source: The Google Earth map website_ Hadia Mosque

The last sample is shown in figure 5, Tobaco factory Mosque, located in Tripoli. About 1708.6 square metres in size, the mosque is located in the Tobaco factory in the Draiby neighbourhood, almost 8.5 km from the Tripoli city centre. What makes this sample special is its design; it is modern and different from others.

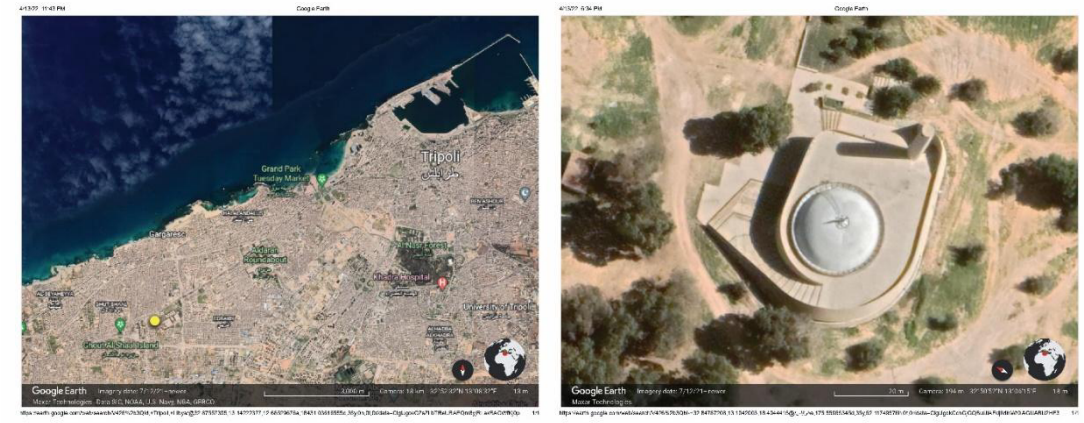


Figure 5: Google Earth map of Tobaco Factory Mosque in Tripoli. Source: The Google Earth map website_ Toba Mosque

## 2 PRACTICING WORSHIP AND THE SOCIAL ROLE OF THE MOSQUE

Sheikh Omar Bakri Mohammad (1996) addressed the social role of the mosque. He stated that some people believe that the mosque exists solely for the performance of Salah (the five prescribed prayers) and that no other activities are permitted within it. Anyone discussing contemporary topics at mosques, such as the political corruption of Muslim rulers or difficulties connected to Islam's economic or social structure, is looked down upon and even arrested. In addition, many mosques have notice boards prohibiting gatherings that debate the concerns of the Muslim Ummah. Additionally, some Muslims have gone so far as to draft constitutions prohibiting talks in mosques and prohibiting Muslims of specific ethnicities from serving on mosque committees. This is especially true in the West, where groups of people frequently run mosques (Mohammad, 1996).

In Islam, all of these man-made acts are prohibited. Nevertheless, the mosque's fundamental existence necessitates that it be central to Muslim activities. Furthermore, Islamic Shari'ah[1] has established that the mosque is supposed to fulfil various vital responsibilities within the Muslim community. Classical scholars have devoted significant sections in Islamic fiqh books (Jurisprudence) to stress these roles. This will become obvious as the tasks for which the mosque is believed to be central are investigated. As a result, the mosque as a building plays a vital and cultural role in the life of the community. (Muhammad, 1996).

Because it is the centre of political, social, cultural, and ceremonial activity, the mosque is recognised as a significant source of Islamic information. All significant news about critical topics is announced in the mosque, and it also ensures direct interaction between the messenger and the receiver of the message. It is regarded as one of the most powerful and successful methods of da'wah[2] and giving information. The adhaan[3], for example, provides information about prayer times while also serving as a method for promoting and spreading Islam (Mokhtar, 2009). The pulpit is where information about the campaign is distributed, and its principles and guidelines are announced.

Another physical technique of disseminating information is prayer, particularly group prayer. Meetings and conferences, as well as study circles for the Qur'an and fiqh, are regarded as effective methods of disseminating information about Islam. The mosque was utilised by Allah's Messenger, Prophet Muhammad (May Allah bless him and grant him peace) as a place of worship, a centre of information, a gathering place for Muslims to pray, for research, for counsel, and for educating the mujahideen; those who fight in Allah's (SWT) cause (Mokhtar, 2009). Overall, in reference to Sheikh Omar Bakri Mohammad (1996), the mosque is the centre of (1) a Judiciary Court, (2) a university for Learning and Teaching, (3) a platform for oratory, (4) eloquence and poetry, (5) a detention centre for the prisoner of war, (6) a place where war booties are divided, (7) a hospital where casualties of war are treated, (8) home and refuge for the poor, needy and the travelers (Muhammad, 1996).

## 3 SPATIAL TYPOLOGY OF LIBYAN MOSQUES

Human spaces are organised by one of the most successful techniques that illustrate the specific qualities of society. This strategy achieves the correct spatial typology of building layouts (Mustafa and Hassan, 2013a). Perez et al. (2020) have referred that Buildings are a necessary part of the urban pattern. According to urban morphologists, buildings can be classed by typology; however, culturally specific characteristics can define the types of the building. (Perez *et al.*, 2020).

Likewise, any other architectural structure, the Libyan mosques are typically categorised based on their external appearance, internal architectural elements, how the interior space in prayer halls is treated, and

[1] Shari'ah: It is the legal practice drawn from the Quran's teachings and the Prophet Muhammad's Sunnah

[2] Da'wah: Non-Muslims' call to Islam. Can also incorporate Muslim guidance

[3] Adhaan: Adhaan is the Arabic word for "call to collective prayer." It serves as an alert in the event of an emergency when provided outside of prayer times. As a result, Muslims are being summoned to the mosque for guidance.

their roofing system. In this study, the mosque classification is based on the study of Dr. Ali Mas'ud El Ballushi, which classified the Libyan mosques based on the roofing system**:** (1) Mosque's layout with a centre dome on its roof, e.g., the samples of Al-Pasha Mosque and Tobaco[4] Factory Mosque**,** (2) Mosque's layout with multi domes on its roof, e.g., the An-Naqah Mosque, (3) Mosque's layout with flat roof, e.g., the sample of the old version of An-Naqah Mosque, (4) Mosque's layout with flat roof, e.g., the sample of Hadia Mosque, as shown in the figures below (6, 7). By observing the mosque plans and their pictures, we can recognise the significant similarities and differences between the spatial typology of the four mosques. (El Ballushi, 2007). Consequently, this observation supports this study's objective that the spatial classification of mosques has changed and distinguished from its predecessors.

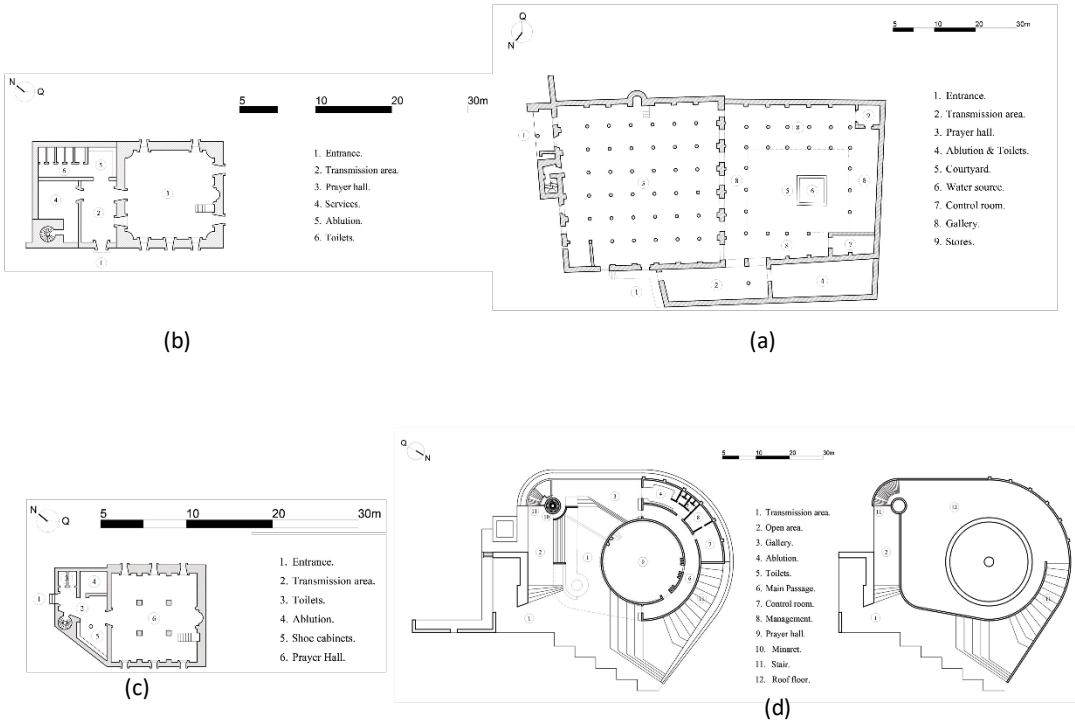


Figure 6: The Plans of all samples (a): Al Naqa Mosque; (b): Al Pash mosque; (c): Hadia Mosque; (d); Ground floor and upper floor of Tobaco mosque; (e); The map key of figure. Source: Re-drawing by authors based on: (a), (b) (El Ballushi, 2007) (c) (Al-Faqih, 1996); (d): (Moretti, n.d.).

[4] Tobaco: It has been written according to the source as shown on the link below.
https://www.google.com.my/maps/place/Tobaco+factory/@32.8502124,13.1097347,17z/data=!3m1!4b1!4m5!3m4!1s0x13a8ec128f210fdd:0x736c3e1800658d9a!8m2!3d32.8502145!4d13.1119196?hl=en

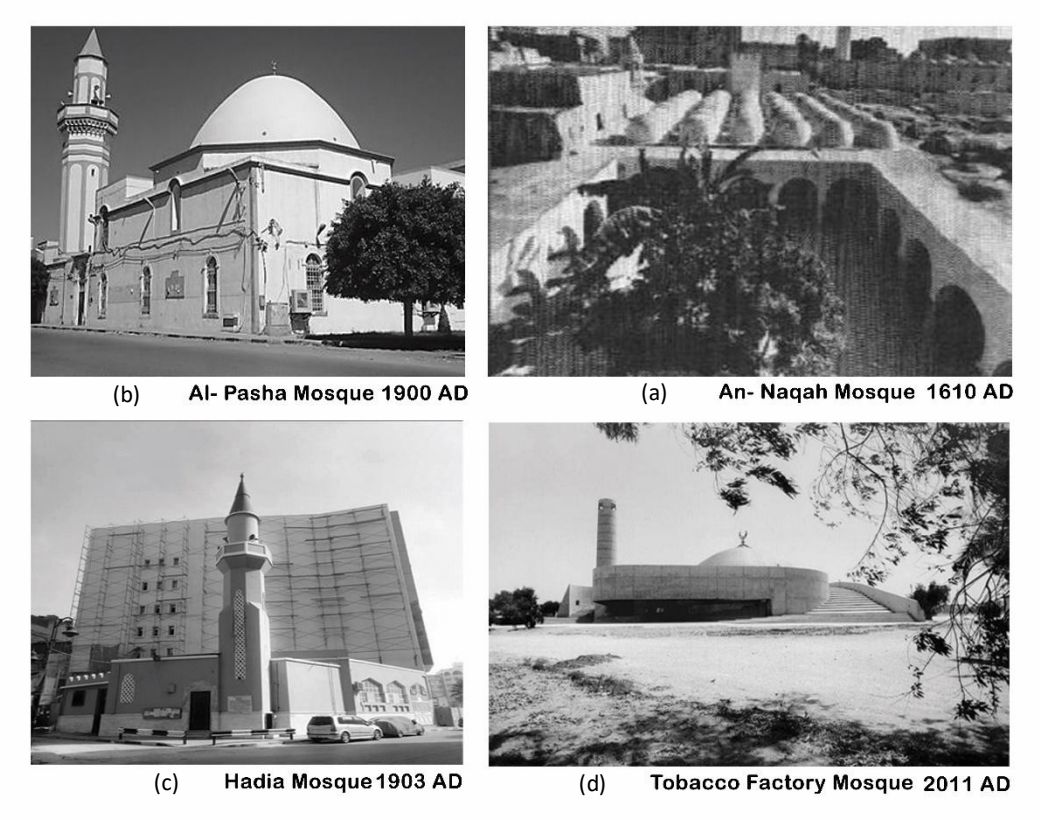


Figure 7: The exterior views of the study samples explaining the classification of mosques according to the type of roofing (a): Al Naqa Mosque (b): Al Pash Mosque (c): Hadia Mosque (d); Tobaco Mosque. Source: (a), (b) (El Ballushi, 2007); (c) (Al-Faqih, 1996); (d): (Moretti, no date).

The mosque's architecture evolved and became a symbol of religious buildings. The mosque's architecture consists of various components that developed and became sacred icons. However, none of these elements have any religious significance (Khan, 1990). The masjid[5] (the mosque) is defined not by architectural characteristics but by its orientation to the Kabah, hygienic practices, a form of partition to contain the Mihrab[6], the imam's space, and enough area for worshippers to stand in rows and prostrate on a flat surface (Elporolosy, Hassan Sayed and Elfalafly, 2020). Gates, courtyards, water fountains, mihrab (niche), minbar (pulpit), and minaret are all non-essential architectural aspects of the mosque concept. The minaret, for example, was utilised to reach a greater catchment area and was not part of the worshippers' religious sequence (Aazam, 2007).

To simplify decoding the mosque, Aazam (2007) suggested dividing it into spatial categories, which practically all of the mosques chosen for the examination have. The existence of the same space types in so many cases in this sample demonstrates their importance in this institution's social organisation. The spatial categories used in this analysis, shown in figure 8, are the gates (in some cases, a mosque has

[5] The masjid: A mosque (/msk/; Arabic:, romanized: masjid, pronounced [msdid]; meaning "place of ritual prostration"), often known as masjid, is a Muslim religious building.

[6] Mihrab: It's a niche in a mosque's wall that indicates the qibla, or the direction in which Muslims should pray when facing the Kaaba in Mecca.

multiple entrances), marked with the letter (G), the transitional area (T), the courtyard (C), the mosque's ablution and hygiene facilities; the washing and hygiene facilities in the mosque, including toilets, marked with the letter (W), the prayer area, which is the essential room in the mosque, marked with the letter (P). The sixth area contains the Mihrab, where the imam leads worship in front of the Qibla and the Minbar. It is marked with the letter (M). The last space category categorises the different uses found in the sample among the marked functions and is indicated with the letter (F). The most critical parts will be briefly discussed in the following section (Aazam, 2007).

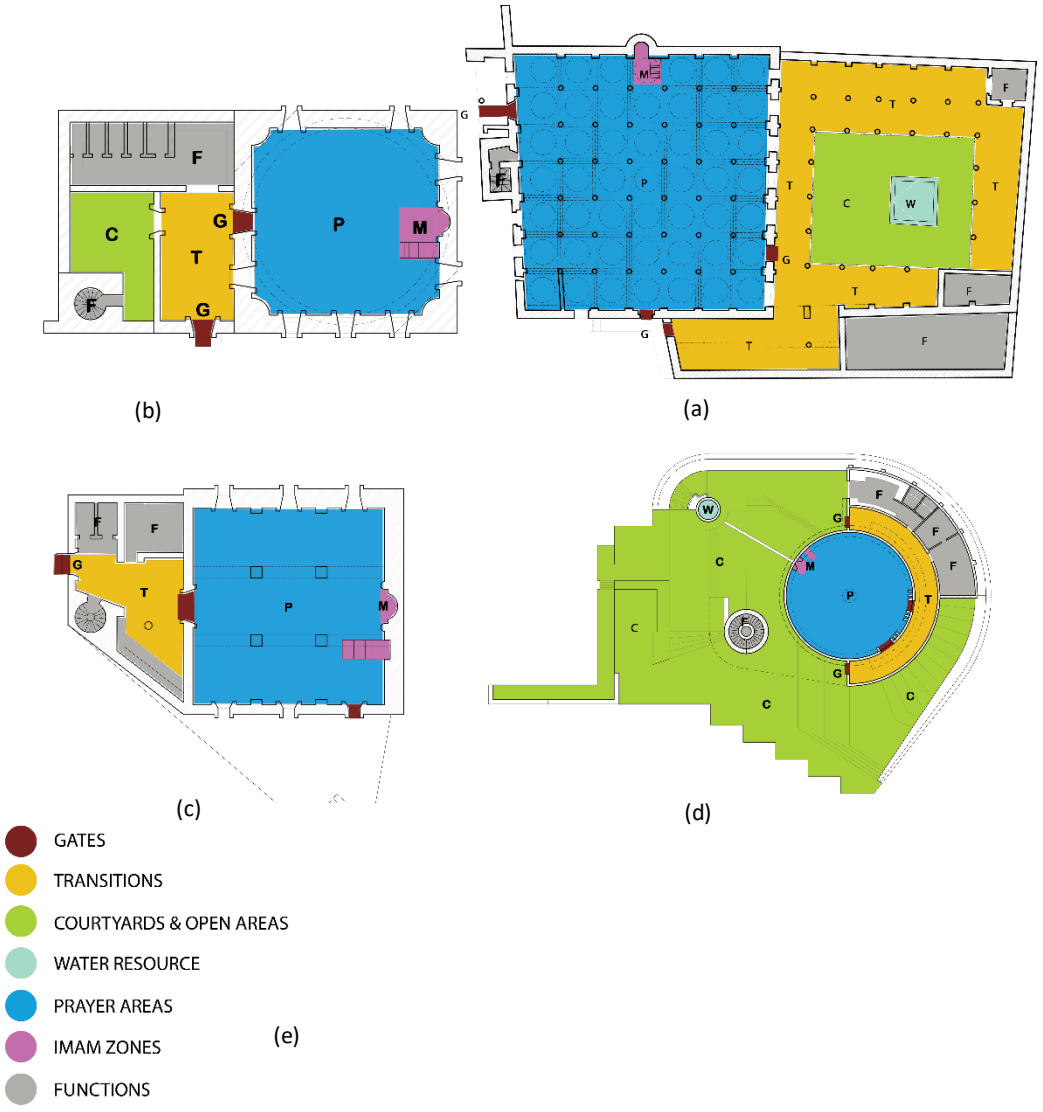


Figure 8: The spatial categories description used of the study samples (a): Al Naqa Mosque, (b): Al Pash Mosque, (c): Hadia Mosque, (d): Tobaco Mosque, (e): Legend. Sources: authors - adopted from (Aazam, 2007).

## 3.2 Spatial categories of the samples

As shown in figure 8, the following are the most important list of the spatial categories considered in the study samples (Aazam, 2007).

1 The gate: this spatial category was called 'G.' The gates of a mosque usually open onto nearby streets, which increases accessibility. The case study includes samples with three gates: An Naqa Mosque, two gates: Tobaco Factory Mosque, and only one gate: Al Pash and Hadi Mosques.

Consequently, there are two types of gates: street gates connecting the building to the outside world and deep gates connecting the courtyard to the prayer area. These two gate types within the category seem to be present in most sample cases, making them similar.

2 Transition space: This spatial category was called 'T.' Two types appear in the sample: the transitional foyer that either leads to the courtyard, as in the Al Naqa Mosque, and the transitional arcade that leads around the courtyard to the prayer area, which is obviously set back, unlike the other examples. The arcade type usually forms a ring around the courtyard, but not in all cases. It is a space that can be used for prayer but was not essentially built for that purpose.

3 The courtyard: This spatial category was called 'C,' which is only found in Al Naqa Mosque and as an open area in Al Pash mosque, unlike the rest of the samples. Aside from its architectural role, it serves as a temporary prayer space extension during Friday prayers and gatherings. The courtyard may also have water fountains, trees, and pavilions.

4 The function spaces: This spatial category was called 'F.' Aside from its architectural role, it serves as a temporary prayer space extension during Friday prayers and gatherings. The courtyard may also have water fountains, trees, and pavilions. The purpose of the ritual of performing ablution at home before coming to the mosque may have contributed to their absence. In certain circumstances, the ablution rooms or public baths are located near the mosque, and they are integrated into the cityscape of the neighbourhood. Consequently, most samples got this spatial area based on their function and needs.

5 The prayer area: This spatial category was called 'P.' The prayer area has rows and a centre bay; This is the mosque's main space, where the ritual performance occurs. The presence in the prayer area during the ritual necessitates a preceding personal and ceremonial purification based on the ceremony's goal. The fundamental reason for being in this area, which everybody respects, is remembering Allah, collectively or individually. The first row of the prayer area has more merit than the remaining rows.

### 3.3 Spatial analysis in built-environment research

In their book, The Social Logic of Space, Hillier and Hanson (1984) point out an interesting observation: focusing only on aesthetic styles in architecture discussions is common. Instead, the practical implications of architecture are seen on a spatial rather than an aesthetic level. Architectural design directly impacts social well-being (Hillier and Hanson, 1984). The main problem is the assumption that the physical world has no social content and society has no spatial scope, limiting the discourse on spatial analysis. Unfortunately, modern environments are judged by their general physical characteristics, such as high-rise projects that are considered socially unacceptable because they do not meet these criteria (Perez *et al.*, 2020). Hillier and Hanson (1984) have shown that high-rise projects, unlike low-rise buildings, have a highly modern spatial arrangement that creates a soulless and uninhabited atmosphere compared to the natural spatial patterns of daily life. In contrast to mosques' low-rise buildings, high-rise structures have a very modern spatial layout that creates a soulless and desolate environment compared to natural spatial patterns of daily living (Hillier and Hanson, 1984).

The analysis tool used to decode the case study is Space syntax, a collection of approaches for representing and quantifying complex spatial patterns. It has been used to study layouts, social functions, cultural relevance, and behavioural implications in contemporary and historical contexts and will be used to study the mosques (Hillier and Hanson, 1984). The main argument for this method is that social relations and activities are expressed spatially. The configuration of the two areas considers all other spaces in the mosque. Hillier, Hanson, and Graham explain: "Spatial configuration is thus a more complex idea than spatial relationship, which need invoke no more than a pair of related spaces." In this article, the following types of analysis are used: axial line analysis for lines of movement and the worship lines, visibility graph analysis for the visual points and the prostration points, and justified graph for the spatial boundary analysis.

## 4 Space Syntax analysis

Like any country, Libyan architecture faces a transformation that has changed its typology and vernacular identity through time (Alatrash, 2018). Besides the built environment, the spatial typology of the buildings is also the most affected by this change (El-Hassi, 2018). Although the characteristics of the Libyan typology, which form mainly its identity, are the most important cultural heritage that we should preserve for the next generations, it still faces the risk of change, disappearance, and being replaced by an imported culture (Eltrapolsi, 2014).

Some studies have advocated for a cultural heritage approach to maintaining and determining Libyan architecture (Azlitni, 2009, Omar A and Hanafi Zulkifli, 2014, Kezeiri, 1984, Akel Kahera and Craig, 2009). Thus, there is still a gap in the perception of the transformation causes and finding the best solution using the Space syntax method. Since there is no comparable analytical research in Libya dedicated to decoding the differences in the spatial typology of the old and new Libyan mosques through an analysis of the visibility of the Space syntax, it is necessary to conduct academic research on Libyan architecture to demonstrate this change through the Space syntax on the most influential buildings of Libyan urbanisation, the mosque.

This paper aims to use the axial line analysis, visibility graph analysis, and justified graph analysis to determine the essence of the spatial typology of four different mosques in different periods and regions to investigate the fundamental changes and similarities in the mosques' spatial typology and demonstrate how they transformed (Syed Mahdzar, S. S, 2017).

Bill Hiller proves that Space syntax can analyse the spatial configuration of old patterns based on current maps and correlate the results to the locations of surviving significant historical buildings (Syed Mahdzar, S. S, 2017, Hanson and Hillier, 1981). The pioneer in Space syntax, Bill Hillier, contributed to comprehending the built environment by developing an operational way to study spatial relationships between made things, allowing for a new refined understanding of the relationship between space and human behavior (Yamu, van Nes and Garau, 2021). The approach presented here is a radical one but

commensurate with the issue (Bafna, 2003). Currently, efforts are being made to fill in many scholarly gaps. However, in Libya, Space syntax is not dealt with the scale of the problem. The approach presented here is radical but appropriate to the problem. Nevertheless, no similar Libyan studies address this issue (Al-mohannadi and Furlan, 2021).

### 4.1 Mosque layouts and space syntax

Space Syntax is a method for describing and analysing the relationships between spaces of urban areas and buildings. The Space syntax theory includes a set of quantitative and descriptive analysis tools that can analyse the visible pattern of buildings' layout, neighbourhoods, and landscapes in the space formations (Hillier, 1989, 1997). Space syntax studies point to enhancing approaches for defining occupied space configurations to articulate underlying social meanings. By developing harmonious techniques to analyse visible patterns, Recent studies on Space syntax have attempted to recreate spatial ideas in mosque layout plans and predict how these designs will function (Hillier, 1989, Peponis and Wineman, 2002).

According to Space syntax, the studies, and applications, the spatial typology in any building layout, including mosque design, has a noticeable and quantifiable impact on worshipper behaviour. Given that these impacts can be tailored, anticipated, and enhanced before, architects should comprehend the connection between layout design and human behaviour. Thus, it can be easy to measure the differences through the results of the analyses (Mustafa and Hassan, 2013). Furthermore, some of the definitions used in this study will be addressed and briefly defined in the next section. The reason for choosing the Mosque as a case study is that it is the building that embodies Libyan identity and is the most stable among all other historical evidence. Moreover, this place reflects the identity of Islam, and its importance derives from its place on the throne of worship (Bahauddin and Ahmad, 2019). Figure 6 shows the re-drawing plans of study samples represented (a) An-Naqah Mosque built in the old city of Tripoli, (b) show Al- Pasha Mosque in the city center of Al-Khums, (c) Hadia Mosque in the Baraka area, Benghazi, (d) Tobaco Factory Mosque in Tripoli.

### 4.2 The definition of fundamental terminologies

To better understand syntactic tools, define the fundamental terminologies necessary to comprehend how they work. According to the study of Hillier and Hanson (1984), a building layout can be transformed into a structural diagram known as the syntactic structure. Three basic types of syntactic organisation are used to characterise the building space. They are as follows (Hillier and Hanson, 1984); as shown in figure 9, (1) looped or ringy syntax; the segments are connected in a series of systems by a variety of paths (Figure 9-i). This system is the shallowest among the rest. (2) Fanned syntax; refers to different features that branch off from a single segment with complete control and access to other components (Figure 9-ii). This system shows the middle situation. (3) Linear syntax; segments are arranged in a series of sequences. This system is the deepest among the rest (Figure 9-iii).

Syntactic analysis was done with the Depthmap software developed by Alasdair Turner at University College London. The calculations used in this paper, carried out by the Space syntax method, are the Convex Map and Justified Graph Analyses (Turner, Penn and Hillier, 2005).

Figure 9 shows that three main spaces have been joined together to form a genotype model. (A) and (B) are combined with (C), an exterior room. To clarify the syntactic values, we assume that (A) is an ablution room, (B) is a prayer room, and (C) is a shared space such as an open area (Hillier, 1997), which can be used to demonstrate the correlation and types of syntactic analysis (Dovey, 2008, Ismail, 2008). Before analysis, the formula of basic terminologies should be identified to present a complete perspective.

- The Mean Depth (MD): can be calculated and expressed after understanding the depth values (Van Nes and Yamu, 2021, Hillier, 1989).

$$MD = \frac{\sum TD}{n-1}$$

MD: Mean Depth

$\sum TD$: Total value of depth for all spaces from the root space

n: Total number of spaces in the graph

When the Mean Depth (MD) of a space is determined from a given root point, it is possible to determine the depth or shallowness of the space. When all spaces are directly connected to the root space, the depth is the smallest, indicating that the system is the shallowest, as shown in status (i) and status (ii), (iii) (Syed Mahdzar, 2008).

As shown in status (iii), the depth is greatest when the spaces are connected in a linear sequence with only one space directly connected to the root space, as shown in (iii).

- Relative asymmetry (or relative depth) (RA): It compares how deep a system is from a given point to how deep or shallow it could theoretically be – the least amount of depth exists once all spaces are connected directly to the original space. The most depth exists when all areas are arranged in a unilinear sequence away from the original space, i.e., each extra space in the system adds another level of depth to the system. This is a theoretical method of calculating total depth. The following equation can be used to calculate the (RA) (Hillier and Hanson, 1984, Yamu, van Nes and Garau, 2021):

$$RA = \frac{2\,(MD-1)}{n-2}$$

RA: Relative Asymmetry

MD: Mean Depth

n: Total number of spaces in the graph

- Integration: It is the inverse concept of RA. A space with a high (RA) value has a low integration with the system, and vice versa (Bafna, 2003); (Misana, 1998, Al_Sayed, K., Turner, A., Hillier, B., Iida, S., Penn, 2014).

$$Integration = \frac{1}{RA}$$

Additionally, each space has a fixed number of immediate neighbours and provides its immediate neighbour with 1/n. These are added together to determine the control value for each space. A high control value indicates that the space has a high degree of connectivity, while a low control value indicates that the space has a low degree of connectivity. Overall, the following table (1) briefly describes the terminologies and their meanings mentioned. (Hillier, Bill, 1989).

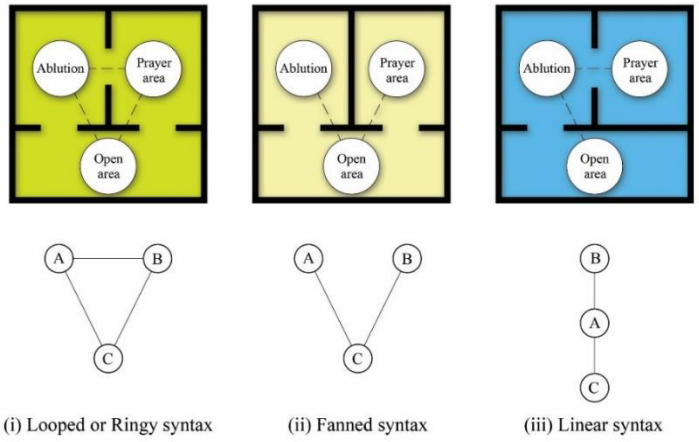


Figure 9: A model representing the different statuses of syntactic structure values between the spaces (A, B, C) used as a genetic mosque model. Source: (Julienne Hanson, 1994, Dovey, 2008, Ismail, 2008).

| **Terminologies** | **Greater value** | **Smaller value** |
|---|---|---|
| Depth | Far away from root space | Close to root space |
| Mean Depth (MD) | Deep system | Shallow system |
| Relative asymmetry (RA) | Low integration with the system | High integration with the system |
| Integration | High integration with the system | Low integration with the system |
| Real relative asymmetry (RRA) or Control Value (E) | Higher connectivity | Lower connectivity |

Table 1: Conceptual clarification of the terminologies utilised in syntactic analysis. Source: (Hillier, Bill, 1989)

As shown in figure 9, state (i) shows that (MD) and (RA) have the least value for all three areas (A), (B), and (C). The open, ablution, and prayer spaces are all important in accomplishing their goals, and the system is shallow and highly integrated. Furthermore, the control value (E) is similar in that all spaces are connected (Hillier and Hanson, 1984). This makes it easier for users to access and use the various places in state (i); in this scenario, the setting is considered very efficient.

The open area (C) has a lower value (RA) than (A) and (B) in state (ii), indicating that (C) is more integrated into the system than the other two areas. Moreover, the control value (E) of (C) is high, indicating high connectivity and the importance of the space as a core space. The state (ii) is less efficient than (i) because it has less connectivity between the ablution and prayer spaces, although ablution and prayer are closely related without depending on any additional function. Although ablution and prayer places are intimately related without relying on any additional function, state (ii) is considered less efficient than state (i) because it has less connectedness between the ablution and prayer regions. The state (iii) represents the worst-case scenario. The ablution area is the most integrated place here, with high (E) and low (RA). As a result, the accessibility of the rest areas is reliant on the ablution space. In practice, we see this result as an indication of the inadequacy of the overall system because every time worshipers enter or leave the prayer area, they must pass through the ablution.

The above model illustrates the terminology of syntactic analysis (Hillier and Hanson, 1984). The model also demonstrates the kind of information that may be provided regarding people's culture and behaviours in a certain civilisation. For the model, the ideal conceptual configuration of a house of worship is decided by the ease of access and usage of the different places among the aforementioned conceptual configurations. This ideal configuration is supported by the syntactic values (depth and connectivity). This condition can be illustrated by the example of a complicated spatial configuration. In the next section, two examples of Libyan mosques are presented to explore what kind of cultural information can be associated with the changing syntactic properties of these mosques.

## 5 SYNTACTIC TOOLS

The axial map and visibility graph analyses of a layout will be used as syntactic analysis tools in this paper to distinguish the differences (Syed Mahdzar, S. S. & Seo, 2017). This paper will refer to which lines of movement and lines of worship. In addition, visibility graph analysis is a method for identifying the visibility connections between spatial layouts and urban space. The visibility of strategic entry points can be demonstrated using visibility graph analysis in all spatial layouts, referred to in this paper as visual and prostration points. In addition, the justified graph analysis to analyse the spatial boundaries of the mosque's continuous interior, an interpretation of the social intention in the space is necessary. Apart from the outer functions, the rooms cannot be specified for any particular use, as they are used for various rituals and social activities. Furthermore, it can be possible to recognise the mosque layouts are shallow or deep from the root (Al_Sayed et.al, 2014).

### 5.1 The axial line analysis

This analysis will illustrate the movement and worship lines that will be discussed in the result and discussion section. Based on the study of Aazam, Z. (2005), the mosque has two kinds of lines; the line of movement and the individual's line formed to pray because worshippers are required to stand behind and form rows parallel to the wall of the Qibla. This fundamental necessity transforms the worshipping area of the mosque into a wall facing Qibla that is extended, depending on the area of the whole mosque. Figure 10 shows the axial analysis of the mosques (Al_Sayed et.al, 2014). Although the open space has

been turned into a field of columns by structural requirements in some cases, there is a high expectation of the movement between columns at any angle. In theory, this option generates a perfect grid just as close as a building can be. Accordingly, the axial lines pass through the mosque layouts in parallel and perpendicular directions to the wall of Qibla. Thus, this study excludes possible diagonal lines of movement to achieve an initial basic resolution. (Turner, Penn and Hillier, 2005)

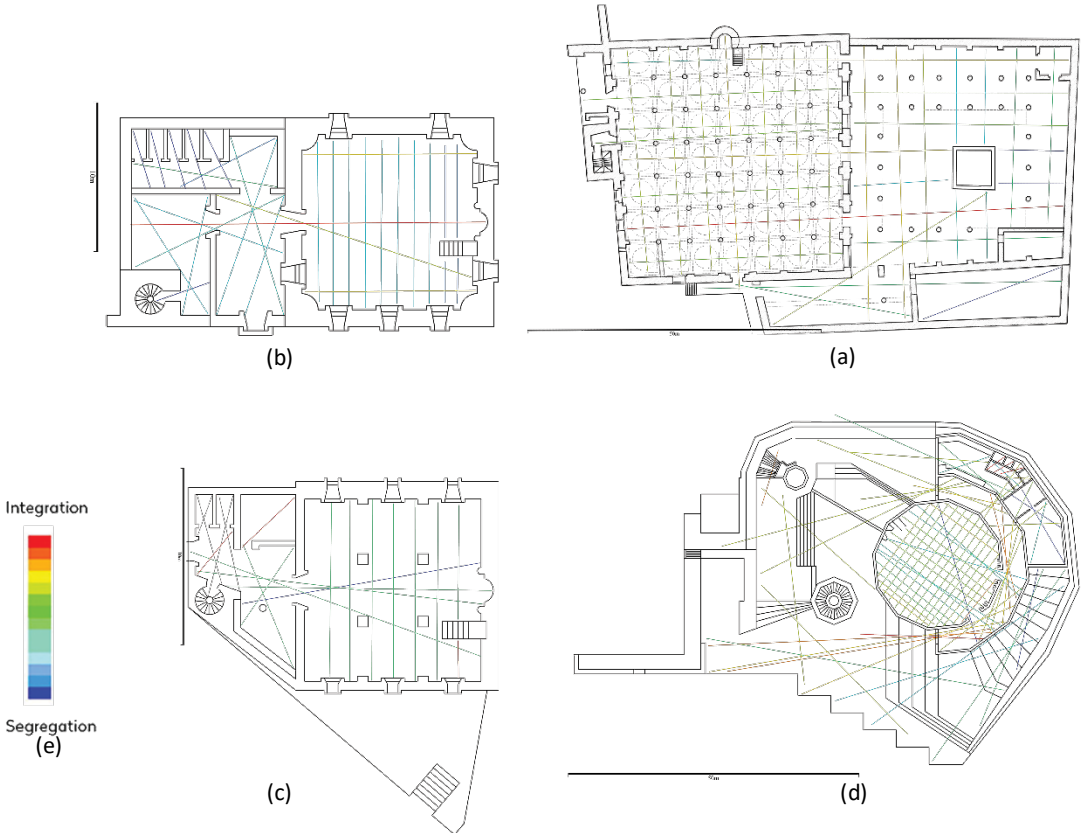


Figure 10: The Axial Lines of the All samples (a): Al Naqa Mosque, (b): Al Pash Mosque, (c): Hadia Mosque, (d); Tobaco Mosque, (e): The legend.

## 5.2 The visual graph analysis (VGA)

This analysis will illustrate the points of visual and prostration that will be discussed in the result and discussion section. Syed Mahdzar, S. S. & Seo (2017) mentioned that "visual graph analysis is a tool for analysing urban space intervisibility relationships." Turner, A et al. (2001) indicated that a "Visibility graph analyses the properties of a visibility graph produced from a geographic context. The visual graph analysis may be applied on two different levels: eyes level for what people could see and knees level for how people could move, which is important for understanding spatial layouts (Turner *et al.*, 2001). Figure 11 shows the results from the VGA analyses.

According to Turner et al. (2001), visual graph analysis analyses the inter-visible linkages inside buildings or urban networks in design. In addition, visibility graph analysis emerged from the architectural idea of Space syntax. The high visibility of the spatial typology is the major characteristic of the mosque's space samples. Individuals (worshipers) anticipate a high level of visual command

when they get into the mosque till they locate the way to their selected personal prostration space (Syed Mahdzar, S. S. & Seo, 2017).

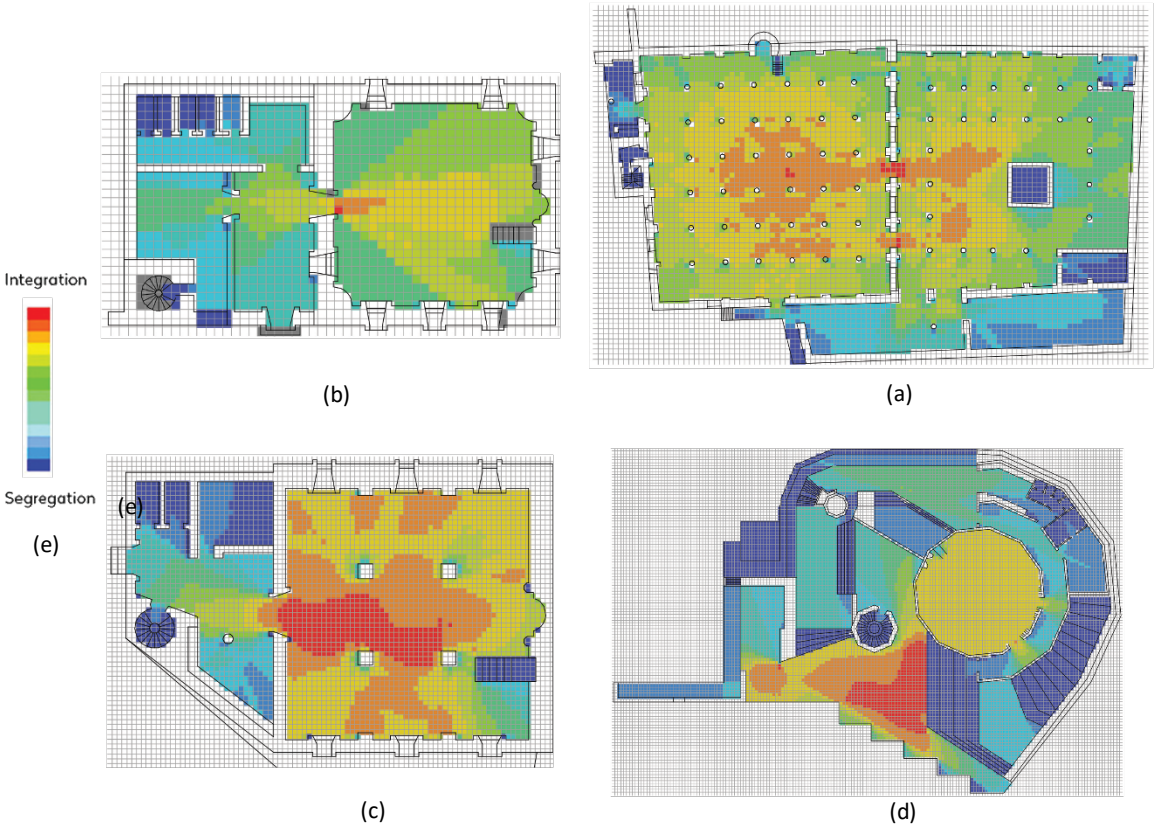


Figure 11: The visibility graph analysis (VGA) of all samples, (a): Al Naqa Mosque, (b): Al Pash Mosque, (c): Hadia Mosque, (d); Tobaco Mosque, (e); Legend.

Other worshippers, racks, or small dividers on the ground may obstruct movement routes. Even though individuals have high visual integration at any point in time, this indicates that they have been ordered to find a space for occupying. In addition, tables 2, 3, 4 and 5 show the syntactic values of the mosque spaces were calculated and ranked, as explained in the results and discussion section.

| | No. & name of Spaces | Connectivity | Visual Control | Visual Integration [HH] | Visual Mean Dept |
|---|---|---|---|---|---|
| 1 | Entrance. | 404 | 1.06 | 9.48 | 2.07 |
| 2 | Transmission area. | 622 | 0.95 | 8.39 | 2.16 |
| 3 | Prayer hall. | 1748 | 1.24 | 13.17 | 1.75 |
| 4 | Ablution & Toilets. | 409 | 0.92 | 6.15 | 2.85 |
| 5 | Courtyard. | 1540 | 1.30 | 13.5 | 1.72 |
| 6 | Gallery. | 1649 | 1.35 | 14.15 | 1.68 |

Table 2: The visibility graph values of Al-Anqa Mosque

| | No. & name of Spaces | Connectivity | Visual Control | Visual Integration [HH] | Visual Mean Depth |
|---|---|---|---|---|---|
| 1 | Entrance. | 179 | 0.78 | 6.72 | 2.09 |
| 2 | Transmission area. | 223 | 0.95 | 8.64 | 1.85 |
| 3 | Prayer hall. | 590 | 1.29 | 13.69 | 1.35 |
| 4 | Services. | 235 | 1.07 | 8.40 | 1.87 |
| 5 | Ablution. | 228 | 1.31 | 7.32 | 2.00 |
| 6 | Toilets. | 14 | 0.60 | 2.92 | 3.51 |

Table 3: The visibility graph values of Al Pasha Mosque

| No. & name of Spaces | | Connectivity | Visual Control | Visual Integration [HH] | Visual Mean Depth |
|---|---|---|---|---|---|
| 1 | Entrance. | 734 | 0.69 | 11.41 | 1.80 |
| 2 | Transmission area. | 1430 | 1.19 | 15.76 | 1.58 |
| 3 | Toilets. | 178 | 0.50 | 7.35 | 2.24 |
| 4 | Ablution. | 236 | 0.89 | 6.85 | 2.33 |
| 5 | Shoe cabinets. | 480 | 0.64 | 10.73 | 1.85 |
| 6 | Prayer Hall. | 2108 | 1.17 | 22.90 | 1.39 |

Table 4: The visibility graph values of Hadia Mosque

| No. & name of Spaces | | Connectivity | Visual Control | Visual Integration [HH] | Visual Mean Depth |
|---|---|---|---|---|---|
| 1 | Transmission area. | 1754 | 1.18 | 23.75 | 1.37 |
| 3 | Gallery. | 889 | 1.12 | 6.31 | 2.52 |
| 4 | Ablution. | 747 | 1.05 | 5.68 | 2.68 |
| 5 | Toilets. | 65 | 1.30 | 3.34 | 3.78 |
| 6 | Main Passage. | 1015 | 1.15 | 6.61 | 2.45 |
| 9 | Prayer hall. | 1526 | 1.06 | 5.24 | 2.83 |

Table 5: The visibility graph values of Tobaco Factory Mosque

### 5.3 The Justified graph analysis

This analysis will illustrate the spatial boundaries analysis that will be discussed in the result and discussion section. The four mosques were divided into convex and axial segments. Each convex space or axial line was assigned a mathematical value depending on how integrated or detached that element was in the overall structure of the mosque. A segregated element is spatially separated from the majority of the other elements of the mosque. An integrated element is a space close to all the other spaces of the mosque. (Syed Mahdzar, S. S. & Shuib, A. Y, 2016).

A segregated element is spatially separated from the majority of the other elements of the mosque. Another way to visualise integration is to create permeability graphs for each mosque as it unfolds from various spaces. A bush is the most integrated array of elements possible from a single root, and a sequence is the most segregated array of elements possible from a single root (figure 12). Graphs were drawn for each mosque based on the plans, prayer hall, open spaces, ablution, and toilets to show how these functions were embedded differently in the configuration. The permeability diagrams show a second characteristic of the configuration, called ring-shaped, which shows the potential of each mosque to provide a choice of pathways for worshippers (Julienne Hanson, 1994).

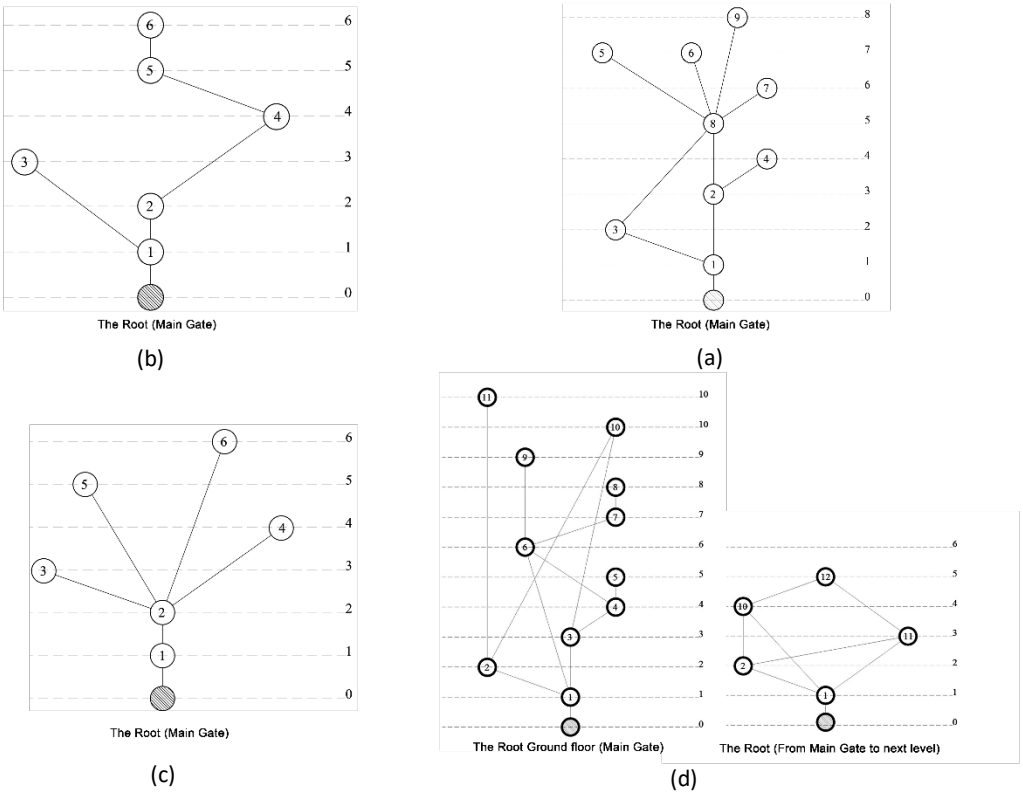


Figure 12: The justified graph of all samples (a): Al Naqa Mosque, (b): Al Pash Mosque, (c): Hadia Mosque, (d); Tobaco mosque.

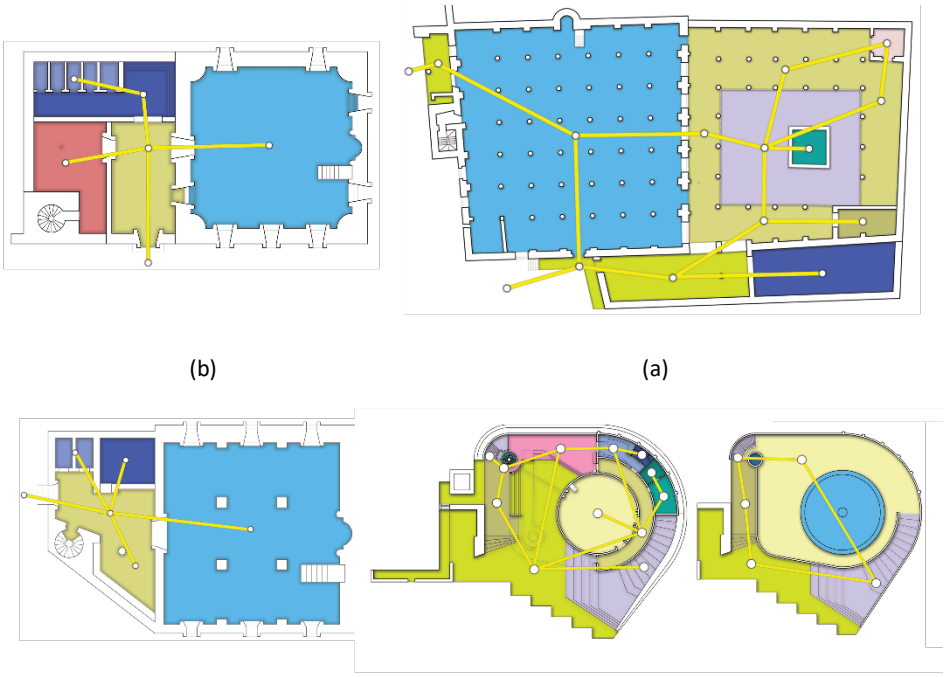


Figure 13: The Convex Map of all samples, (a): Al Naqa Mosque, (b): Al Pash Mosque, (c): Hadia Mosque, (d): Tobaco Mosque.

According to Julian Hanson (1994), the basic dimensions of space configuration are depth and rings, and its architectural dimensions are convex and axial organisation. Figure 13 show the convex organisation refers to the mosque as seen in repose, while axial organisation refers to the mosque as seen in movement (Figure 12).

## 6 RESULTS AND DISCUSSION

The primary prayer space was used and compared to the other mosques to achieve the best results to decrease the volume of the data and the likelihood of distracting the reader.

### 6.1 Movement and worship lines

The analysis reveals that, while the grid is nearly flawless, there are usually some commonalities when comparing the integration values of the sample layouts, which indicated and approved that there is a strong integration average between all spatial areas on all samples. "The greater an axial line's average integration value, the easier it is to get to the line from all other lines" (Rashid et al., 2006, Koohsari et al., 2016).

While comparing the average connectivity, values of the sample layouts revealed a significant variation in the average values. Unlike other mosques, the average connectivity values of the Tobaco Factory Mosque showed the most considerable connectivity value, which points out that it has a greater number of choices of movement. Moreover, because there are no columns in the Tobaco Factory Mosque, the Al Pash mosque comes after the Tobaco Factory Mosque, while the Hadia Mosque is the last. In An Naqah Mosque, the integrated lines of the system seem to be as integrated into the prayer spaces as they are in the courtyard and transition spaces. In contrast to the other samples, no integrating lines pass throughout its prayer areas, although lines passing through the courtyard are substantially integrated. At the same time, it differed from the others due to the courtyard's absence.

As a result, where there is a differentiation of integration values, the prayer spaces expected for seclusion and occupation may be for much movement - the prayer spaces alternate between occupation and movement regulated by the time of formal rituals and their intervals. Individuals who choose to perform the rituals at the interval times may need to negotiate their individual prayer space of occupation to avoid lines of movement.

### 6.2 The points of visual and prostration

As shown in both (Table 6) and (Figure 14), the analysis shows naturally no similarity, which showed Hadia Mosque with high visual integration in the prayer space compared with the rest of the cases. In contrast, the Tobaco Factory Mosque remains with less visual integration with the highest visual mean dept. The Al-Anqa Mosque tends to be a sufficient sample even though it is an old version. On the other hand, it is the intersection of interior spaces that possess the highest integration or least mean depth. Cases like Al Basha mosque, Tobaco Factory Mosque, and An-Naqah Mosque have areas with less

visual integration, indicating potential places for isolation. In comparison, the Hadia Mosque appears to have high visibility across the prayer areas.

In contrast to the other cases, the Tobaco Factory Mosque shows high connectivity value passing through its prayer spaces and lines passing through into all other spaces, making the worship area more easily accessible (Table 6) and (Figure 14, 16). Once again, the visibility graph values revealed significant differences in most cases, demonstrating that using such techniques is highly beneficial.

| Name of Spaces | Connectivity | Visual Control | Visual Integration [HH] | Visual Mean Dept |
|---|---|---|---|---|
| Al-Anqa Mosque | 1748 | 1.24 | 13.17 | 1.75 |
| Al Pasha Mosque | 590 | 1.29 | 13.69 | 1.35 |
| Hadia Mosque | 2108 | 1.17 | 22.90 | 1.39 |
| Tobaco Factory Mosque | 1526 | 1.06 | 5.24 | 2.83 |

Table 6: The correlations of visibility graph values of the main prayer hall in all mosques

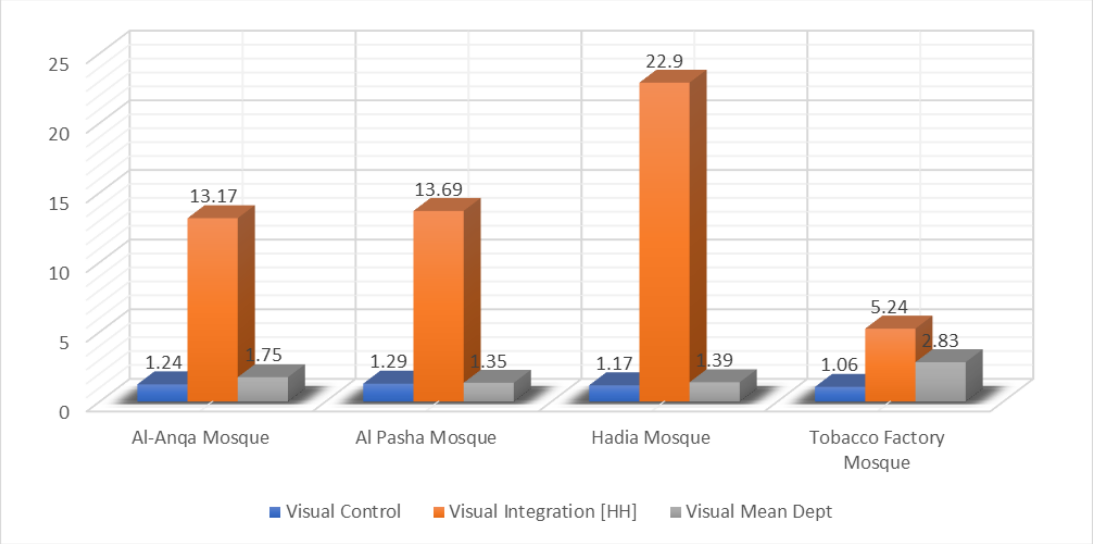


Figure 14: The correlation percentages of visibility graph values of the main prayer hall in all mosques

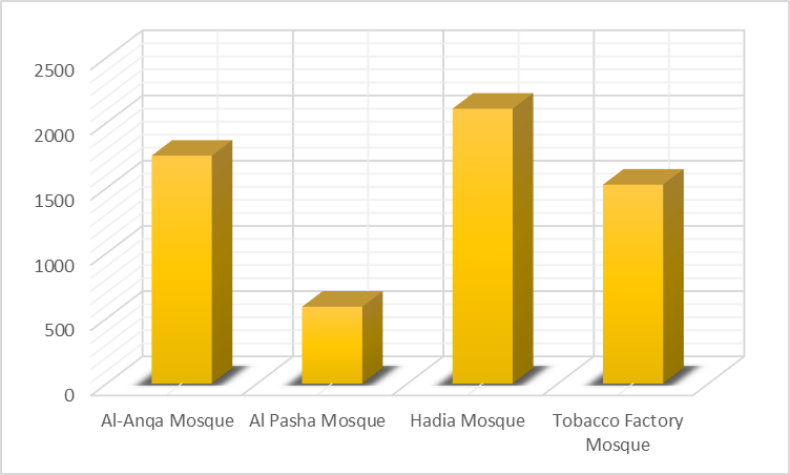


Figure 15: The correlations percentages of connectivity values of the main prayer hall in all mosques

### 6.3 Analysis of Spatial Boundaries

As mentioned above, the main prayer hall was chosen to represent similar spaces at other mosques. This method would clearly explain the differences between the mosques. According to Aazam's study (2007), some interpretation of social intention in space is required to analyse the spatial boundaries of the mosque's continuous interior. Other than the peripheral functions, the spaces cannot be labelled for any specific use because various rituals and social activities occupy them. Therefore, the spatial boundaries were interpreted based on the predominant ritual use and the architectural form of the spaces, which suggest designations such as prayer row, imam area, transition, courtyard, and other spaces. These designations are the same as the spatial categories mentioned earlier.

Upon examining the justified graphs of the four cases (Figure 12), they appear not similar in shape, especially the Tobaco Factory Mosque. In some cases, the extreme high and low number of prayer spaces is also noticeable. Another look at the basic graph data (Table 7), figure 16 reveals the Control (E) of Al-Anqa Mosque with 2, which gains the higher connectivity while the others remain with 2. The Tobaco Factory Mosque also shows a higher Mean Depth with 2.29, which means the deepest system.

| Name of Mosque | Connectivity | Control (E) | Integration | Mean Depth |
|---|---|---|---|---|
| Al-Anqa Mosque | 2.00 | 1.75 | 1.15 | 1.86 |
| Al Pasha Mosque | 1.00 | 0.25 | 0.70 | 2.00 |
| Hadia Mosque | 1.00 | 0.2 | 0.87 | 1.8 |
| Tobaco Factory Mosque | 1.00 | 0.25 | 0.77 | 2.29 |

Table 7: The correlations of visibility graph values of the main prayer hall in all mosques

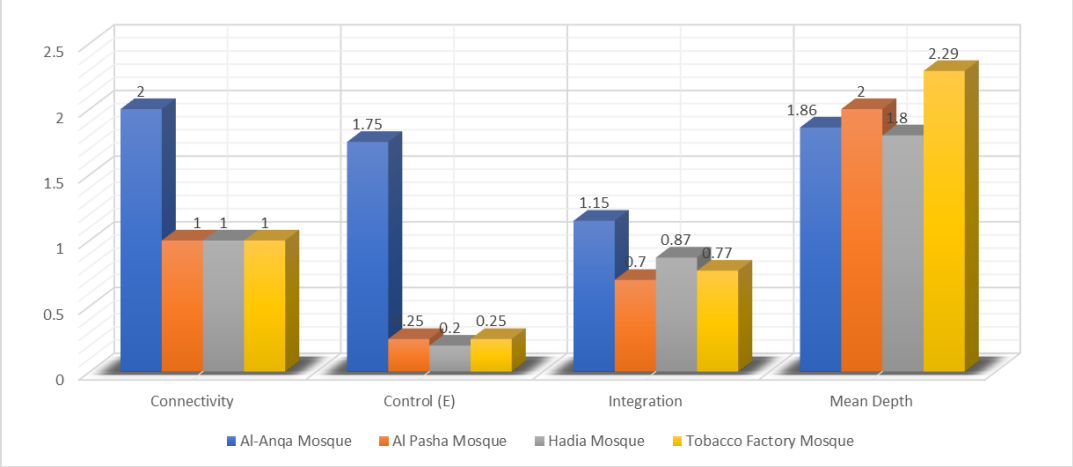


Figure 16: The Correlations of visibility graph values of the main prayer hall in all mosques

In order to discuss what constitutes knowledge of decoding the differences in the spatial typology of the old and new Libyan mosques design via Space syntax visibility analysis, this paper proposes that tacit 'structural similarities' need to be found and made explicit to form a more coherent understanding. Although this tacit knowledge is largely based on intuition and experience in architectural practice, evidence-based knowledge will only support and complement our view of the type and the institution. To demonstrate the possibility of an explicit understanding of such an approach, the findings indicate that specific spatial properties are characteristics of the mosque type. Consider the lines of movement

and convex spaces in the samples. They have demonstrated a broad agreement to express highly integrated lines and spaces in specific areas of the mosque's prayer area. This could point to two sorts of prayer areas that have not been identified: the isolated one with less movement and the busy one with greater activity.

## 7 CONCLUSION

The article concludes that these various spatial typologies provide insight into the following: (1) A propensity for spatial syntactic features comparable among buildings, regardless of their formal categorization. (2) In accordance with Islamic beliefs, there are certain commonalities in the nature of the less controlling 'interface' between them. Despite the culturally various forms, laws, and codes of behaviour in Muslim cultures, this trend implies a high level of agreement with the notion of the mosque as a cohesive institutional structure founded on Islamic principles and aims.

Adding to this research will be further inquiries on the mosque's relationship with the city's structure as well as the nature of its local interface and global integration, among other things. As a whole, the contribution will contribute to the broad understanding of this specific building form, which may then be used in practice as a reasonable foundation for design.

The paper concludes that these different layout forms prove the following: Although the similarities in the nature of the mosque layouts functions conform to the Islamic traditions, there is a clear difference that made each sample unique and special, which confirms and proves that the change in the spatial typology of Libyan mosques has evolved over the years and different times.

This finding helps confirm the study's main purpose that each sample has improved its spatial connections, but it has traces of changing patterns of spatial typology from the previous periods. Therefore, using the Space syntax method as a tool will efficiently help identify and raise the best design ways for facilitating the functional use of mosques.

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