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COLONIAL ECHOES: INVESTIGATING THE LINGERING EFFECTS OF THE GERMAN EMPIRE IN AFRICA ON HAMBURG'S BUILT ENVIRONMENT

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Colonialism had a profound impact on the world, causing environmental destruction, social injustice, and economic inequality. German colonial history in Africa, spanning from the 19th century to World War I was a short era of exploitation that demanded a port-city to facilitate it trade. Hamburg was Germany's key port city that played a significant role in this colonial endeavor, profiting from the trade of goods like rubber, ivory, palm oil, and slaves. The city also contributed to colonial administration, particularly through the Woermann-Linie shipping company among others. The consequences of German colonialism continue to influence the city's physical and social structures, as well as multinational corporations' practices in African countries. In recent years, there has been a growing movement to confront and address the enduring impact of colonialism, which was long overlooked in favor of the Holocaust's dark shadow. In 2020, Hamburg's city government initiated a reevaluation of its colonial history, resulting in changes to streets' names, building designs, and uses. This reflects a broader global effort to reckon with the colonial legacy and strive for a fair future. Social media has played a crucial role in raising awareness about German colonialism and its ongoing repercussions. This new medium drew attention to issues such as the repatriation of stolen cultural artefacts and the representation of colonial history in museums, on streets and in public spaces. In this paper, a comprehensive analysis of the legacy of German colonialism in the built environment of Hamburg is undertaken. Historical and spatial analysis method is used to understand the complex ongoing impact of colonialism on the physical and social structures of the city as we try to create a more equitable future.

1. INTRODUCTION

The echoes of history often resonate through the built environment, narrating stories of power, and incidents of exploitation. One of those narratives is a thirty-yearlong chapter of German colonialism in Africa. A chapter that bears the weight of ambitious imperialism for territories in the east, the west, and the south of the African continent. Established in the late 19th century, this segment of history is a witness of the European complex interplay of both economic interests and geopolitical forces which left its traces on the African landscape. It all started with the Berlin Conference in Germany in 1884–1885 which acted as a pivotal moment in the history of European colonialism in Africa and the future of Africa as we know it today, often referred to as the "Scramble for Africa".[1] European nations such as Great Britain, France, Belgium, Spain, and Germany sought natural resources for their growing industrial sectors and subsequently identified Africa as a territorial market for their raw goods. One of the significant outcomes of this conference was the agreement to grant a free trade within the colonies, and the establishment of a negotiation framework for future European claims in Africa. This chapter in history has left a lasting print not only on the African continent, but also within the colonialising countries themselves. Hamburg, a vibrant and bustling city in northern Germany, is one of those cities that still exhibits the echoes of German colonialism in Africa, albeit in a subtle way. The built environment of Hamburg, with its buildings, streets, and infrastructure, mirrors the

legacy of their, relatively, short colonial era. Hamburg is a witness to the aspirations and actions of the past, along with the repercussions of those actions in the contemporary times and, potentially, in the future too. Recently, the call for 'decolonization' has escalated in importance within cultural, academic, and activist circles worldwide [2]. This paper tries to unveil the enduring remnants of colonialism and their concrete imprints on Hamburg's constructed milieu. By delving into these colonial remains within Hamburg, the paper aspires to shed light on the underestimated ways in which colonial legacies endure in shaping the city's urban tapestry and the collective remembrances of its residents.

2. METHODOLOGY

The methodology used in this paper involves a holistic study of the historical trajectory of colonialism, starting from Europe and ending in Germany. This research journey includes an in-depth historical and literary investigation that presents the development of colonialism and its impact on both the European and German contexts. It then looks at the architectural and urban design components that shaped Hamburg's cityscape during the colonial period and demonstrates how colonialism left an indelible mark on the city's built environment. The methodology also includes an in-depth case study with a special focus on the Afrikahaus. This case study examines the building in terms of its alignment with the goals of colonialism, its symbolic significance within the colonial narrative, and its contemporary resonance in public domain. Using this methodological framework, the paper aims to provide a comprehensive and nuanced understanding of the complex interplay between colonialism, architecture, and the public engagement in Hamburg.

3. WHAT IS COLONIALISM?

Colonialism is defined by the dominance of one powerful group over another territory or population. [3] This occurs when a country imposes control over a foreign land and exploits another population while imposing a combination of territorial, juridical, cultural, linguistic, political, and economic domination of the colonised norms on that occupied population. [4] The concept of colonisation had always been associated with exploration with claims of colonialists' need to investigate their actual or potential territories. The practice of colonialsation goes back to the time of the Ancient Greece, Ancient Rome, Ancient Egypt, and others. These civilizations extended their powers into the surrounding borders of other disjointed areas from around 1550 B.C. onward. They founded powerful colonies by exploiting the resources of the land they occupied in order to increase their own power and to benefit their original lands.[3] This era of territorial expansion was followed by the Age of Discovery, in which the founding of a new colony depended on another practise, namely the sponsorship of a wealthy patron, usually a monarch, who owned large ships to search for unexplored territories.[5]

4. COLONIAL EXPANSION IN AFRICA

Gold and slavery were the main magnets to look at Africa. Europe-Africa relations trace to the 1200s when Arab merchants traded gold between African kingdoms and Europe, while slavery routes already existed prior to European involvement. Gold was found in the basins of the Niger and Senegal rivers, and Mali's control over these gold deposits contributed to its prosperity during the late Middle Ages.[6] At the same time Portugal led the European race for African trades and territories, influenced by factors like growing trade networks of Muslim and Jewish traders and advancing European mapmaking and navigation skills.[7] The starting point for their expansion can be plausibly dated to 1324, when Mali's King Mansa Musa made his extravagant pilgrimage trip to Mecca, and stopped in Cairo on the way. According to the Arab chronicler Al Umari, Musa was accompanied by 80 to 100 camel loads of gold and a personal entourage numbering in the thousands. He generously gifted gold to influential individuals during a time when West Africa supplied two-thirds of the world's gold.[7] Mali and Ghana were renowned for their gold wealth in West Africa. Ghana, known as 'the land of gold', since the eighth century, as it held significant influence due to its control of vital trans-Saharan trade routes, despite not producing gold itself.[7] Portugal sought new trade routes and territories beyond Europe, and in 1415, they conquered Ceuta in North Africa, establishing a long-lasting empire. By 1471, when they reached Elmina, a city in Coastal Plain region of Ghana on the Gold Coast, West African trade networks were firmly established. Instead of direct involvement, the Portuguese acted as intermediaries along the coast, using their large ships and capital. In the early sixteenth century, their explorations expanded to the East African coast.[7] In the 1480s, Portugal settled on Africa's west coast, including the Kingdom of Congo, trading arms and cloth for enslaved prisoners of war. The Gold Coast had attracted fortune seekers from Europe for over a century, all competing for the profitable gold trade, claimed by Portugal since 1494. Other European nations, like France and England, soon joined the competition. Alongside gold, slave trading was rampant, with records of 3500 African slaves bought annually on the Upper Guinea coast, according to Portuguese explorer Duarte Pacheco Pereira.[7] In the seventeenth century, European countries sought trade deals on other continents, involving goods like coffee, tea, spices, and slaves. Over time, weapons and alcohol became new preferred forms of payment, leading to agreements with tribal African chiefs.[5] Historian David Eltis noted that Europeans would build forts with African rulers' permission, aiming for preferential access to gold or slaves. However, such assurances often proved unreliable in practice.[8] It was also a fevered time among them to build and operate trading forts along the coast of what is now modern-day Ghana; even nations that few of us today remember as having much history of involvement in West Africa got involved, including the Danish and the Brandenburg Prussians.[7] In 1642, the Dutch ousted the Portuguese from their remaining, smaller forts along the coast. Prior to this, the Dutch had been capturing a significant share of the region's gold exports due to their superior trade goods and more efficient fleet. Gold was the Dutch's primary trade incentive, used to finance their war against Spain. They also locally purchased slaves, sending them to

work on plantations in north-eastern Brazil, seized from Portugal (then united with Spain) in 1630 and held until 1654. The Cape Coast Castle, a crucial fort, was taken by the English in 1664 and significantly expanded. The mid-17th century witnessed ongoing conflict between these two powers over gold and slaves, contributing to the outbreak of the Second Anglo-Dutch War in 1664-1665.[7] As European colonisers intensified their involvement in the African trade, the Portuguese moved further south and increased their slave acquisitions. In contrast, the Dutch and English focused on Elmina and the coastline extending into modern-day Nigeria, experiencing a significant surge in slave trading. By this point, nearly ten percent of Africa was under European control. After over three centuries of the Atlantic slave trade, Denmark initiated slave abolition in 1803, followed by Britain in 1807, marking the end of slave exports for their citizens. This led to a shift to the "legal trade," involving African products like palm oil, peanuts, gold, and ivory.[6] Over the period from 600 to 1900, approximately nine million people were exported through the Trans-Saharan trade. East Africa also exported slaves, with around 800,000 individuals sent out in the 19th century. [6] Great Britain actively campaigned against the slave trade and stationed its fleet to intercept slave ships off the African coast. Some argue that the abolition of the slave trade in England in 1807 was a catalyst that shifted trade from human beings to raw materials. European nations were competing among themselves to trade with African rulers who controlled areas with vast natural resources and many exploration societies would sponsor explorers looking for opportunities. The mid- nineteenth century witnessed a boom in the export of African commodities. The progress of steamship service to the African coast from 1852 ended the monopoly over trade of expatriate companies who owned their own sailing ships. Now steamships, that also carried mail, made regular stops along the African coast, facilitated passenger travel and the cargo of goods. [6] Larger trading companies acquired smaller ones, accumulating significant wealth and influence in both Africa and Europe. They sought military support from their governments to establish a monopoly in the African trading market and challenged non-compliant African rulers. The global economic recession from 1873 to 1896 intensified competition between European and African traders, while influential European merchants advocated for African colonization and subsequently played a key role in Africa's annexation. [6]

By the mid-19th century, Africa was a prime target for exploration, for increased trade, and new settlements, intensifying the European race for African colonies. In 1876, Leopold II of Belgium convened a Brussels conference to discuss the 'rediscovery' of the African Continent, later asserting ownership of Congo, naming it the 'Congo Free State.' During this period, European powers in Africa engaged in fierce competition for economic advantages within the continent.[9] It is also worth noting that historically speaking, a key role in the expeditions and occupation of other continents was played by church leaders who promoted and participated in the takeover and exploitation of these lands and their labour, mostly in the name of Christian conversion. Since the fifteenth century Pops issued a series of papal bulls, known today as the Doctrine of Discovery, stating that colonisation was necessary to save souls and conquer land for the growth of the Church.

Christian missionaries were often among the first to invade new lands., with the notion that they had to convert as many indigenous as possible to Christianity. These expeditions brought with them both religious and cultural customs and a paternalistic attitude towards the natives of the colonies. [15]

5. THE GERMANISED AFRICA

"But we are not yet rich enough to be able to afford the luxury of colonies".

Chancellor Otto von Bismarck[10]

The history of German colonization has its origins in 1683 when the flag of the Elector of Brandenburg was raised on the Guinea coast. However, the Prussians weren't seriously contemplating colonization at that time. It was not surprising that after a period of thirty-seven years, in 1720, they relinquished their interests to the Dutch government in exchange for a substantial payment. It was not until after 1870 that Germany turned its attention to colonial possessions. [9] From that point onwards, Germany actively sought to access colonial markets to accommodate the needs of its expanding population especially with the concerns of Chancellor Otto von Bismarck and his government, as they feared they might be unable to meet those needs. While Bismarck initially opposed to colonial expansion, pressure from the Hamburg Chamber of Commerce eventually compelled him to dispatch military forces to safeguard German trading territories in Africa, with the dual purpose of ensuring protection and promoting German culture among the indigenous populations. [12]

Germany's involvement in this colonial frenzy was motivated by a combination of economic, political, and strategic factors. Economically, Germany sought to access Africa's abundant natural resources, including rubber, minerals, and agricultural products, to fuel its industrial growth. The nation viewed Africa as a potential market for its manufactured goods, driving its interest in colonization. Politically, Germany was eager to compete with other European powers, such as Britain, France, and Belgium, in terms of colonial acquisitions. The acquisition of overseas colonies was seen as a measure of national prestige and power, and Germany did not want to be left behind in this imperial race. Strategically, Africa's geographic location held importance for maintaining naval and trade routes. Control over key African territories provided military advantages and enhanced Germany's influence on the world stage. [10] The fierce competition between the different neighbouring nation over the African territories led Bismark to call for a conference on November 15, 1884 in Berlin to discuss how this quarrel can come to an end and also discuss the future of Africa. Although this did not include a single African, the main intentions were, as claimed, to enable the natives of Africa to join civilization by opening up the interior of this continent for trade and education and beginning to do so by ending slavery, fig.1
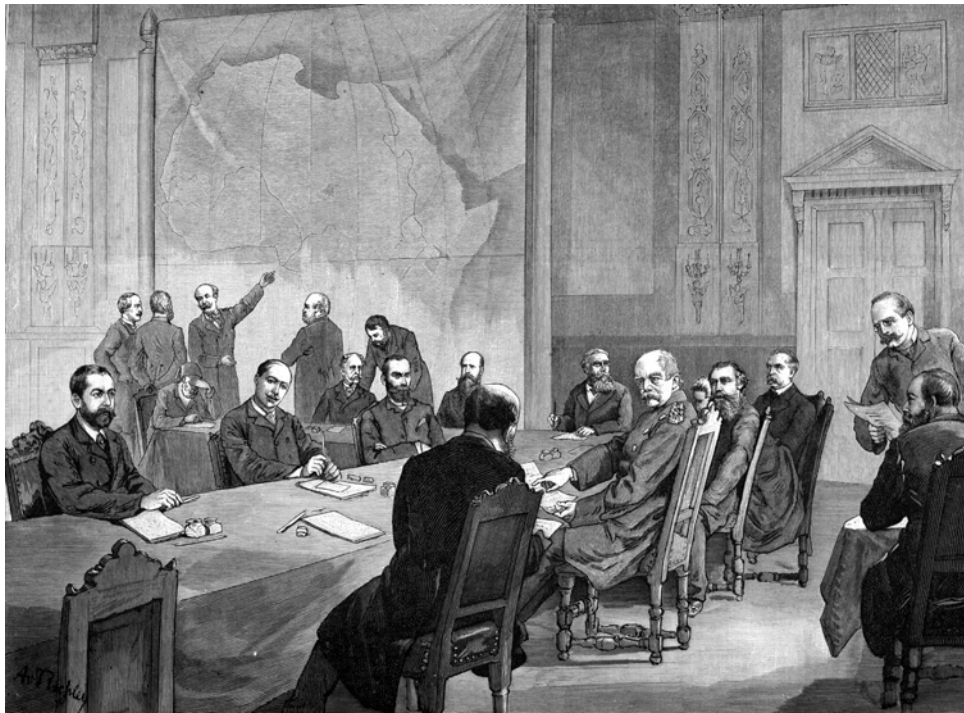
Fig. 1: Berlin Conference of 1884–1885. (Source: Wikimedia Commons, Gartenlaube 1884. Retrieved from deutsche-schutzgebiete.de)

The initial task of the conference was to agree that mouths and basins of Congo River and Niger River would be considered neutral and open to trade for everyone. It also established a protocol for free trade stretching across the middle of Africa. The deliberations lasted from November 15, 1884, to February 26, 1885, and the European powers divided Africa among themselves into smaller pieces separated by irregular geometric borders. Those segments, which ignored the cultural and linguistic boundaries of over 1,000 indigenous regions, led to Africa as we know today.[12] Driven by economic interests, political ambitions, and strategic considerations, as European powers vied for dominance across the African continent. Germany built the third largest colonial empire after the British and French at the time. Four territories or protectorates fell under its control: (Togo and Cameroon) in the west, German Southwest Africa (today's Namibia)**,** German East Africa (today's Tanzania, Rwanda, and Burundi) in the east, in addition to the South-sea Islands. Fig.2 The German's main principle for their effective occupation was to become the catalyst for military conquest regardless of its consequences on its indigenous population.[13] Colonialism had a more significant role to play within German history than has long been assumed. Colonial interactions left their imprint on German society, and the impact of the colonial experience continued after the formal end of the empire. It was not confined to the colonized territories. Rather, it reached deep into metropolitan society and penetrated Germany in a variety of ways. Colonialism left its imprint on the debates of the Reichstag and on the press;

on the realm of representation, from the huge colonial exhibition in 1896 to the arts and popular culture; on the structure of trade and migration regimes; and on the order of knowledge, as many disciplines, including anthropology and geography, were deeply implicated in the colonial project. [14] And it was not limited to the formal ending of the German colonial empire after the with the signing of the Versailles Peace Treaty in 1919 which placed the areas previously annexed by Germany under the mandate of the victorious powers of the First World War. Something that left a scar in the memory of the Germans till this day.[16]

6. HAMBURG, THE COLONIAL METROPOLIS OF GERMANY

As early as the first half of the 18th century, Hamburg as the port city of Germany, rose to become the largest centre of sugar refining and cotton processing in Europe. These industries were closely interwoven with European colonialism, in addition to the plantation economy and the slave trade, and Hamburg's merchants
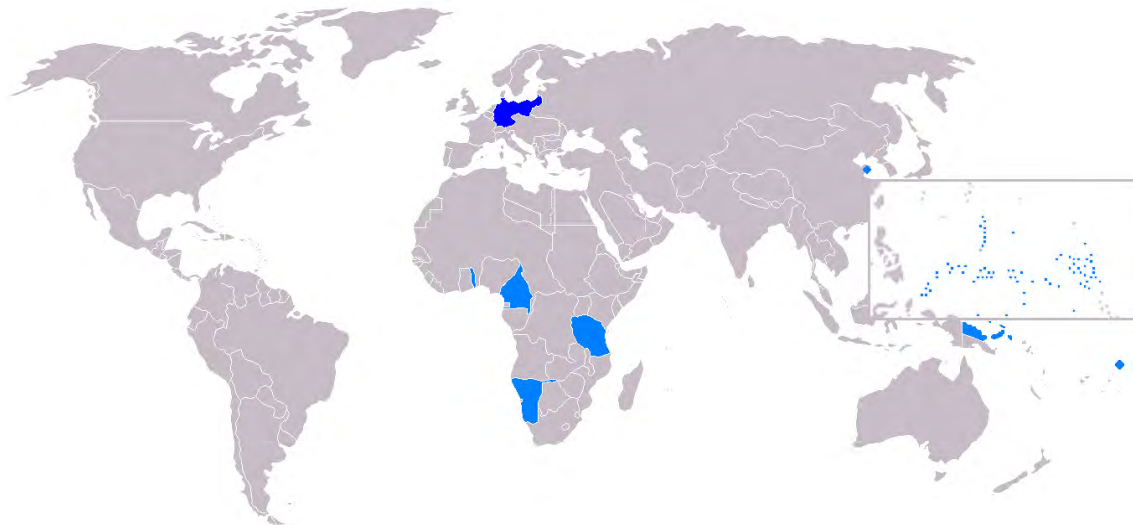

Fig. 2: The German colonies (1984-1919) (Source: Wikimedia Commons)

and traders profited directly from the transatlantic slave trade and the slave-driven economy. Before Germany becomes a colonial empire, this port city benefited from Europe's colonial expansion long before 1884, and it rose to become an important trading centre for colonial goods. During the Empire, Hamburg connected the German colonies in Africa, Asia and Oceania with the Reich and became a major transnational colonial hub. And even after the First World War, Hamburg remained the German gateway to the colonial world.[15]

> "The German flag is flying in Cameroon. Everything is fine"
> Adolph Woermann sent on August 17, 1884[12]

In fact, Hamburg's merchants played pivotal roles in advocating for the colonialisation of the German territories especially in Africa. One of the seminal voices that pushed through and managed to convince

Bismarck to put the possessions of Hamburg merchants in West Africa under colonial protection was Adolph Woermann, the owner of the famous shipping company that still exists today.[12] Woermann, in a presentation to the Hamburg Geographical Society, outlined his vision for a colonial economy based on African plantations, ensuring a sustainable supply of goods for Germany, and in 1886, he established his own plantation in West Africa, cultivating cocoa, coffee, and tobacco. Over the following years, Woermann expanded his operations to include passenger transport, primarily missionaries and merchants. Hamburg was often the last stop of colonial officials, missionaries, merchants, and settlers who went to the colonies. [18]

Fig. 2: Hamburg's port in 1903 (Source: Wikimedia commons
https://commons.wikimedia.org/wiki/File:Hamburg_Hafen_Eis_1903.jpg

However, the accumulation of wealth in Hamburg and corporate prosperity was largely underpinned by aggressive land seizures, displacement of native populations, exploitation of economic resources, and a disregard for the indigenous welfare. To safeguard German interests, military forces were dispatched to the colonies, particularly in response to numerous protests and uprisings in various regions. One of the main aggressive operations that left a mark in the German colonial history was the distinction of Herero and Nama tribes in South-West Africa.[19] In 1903, an uprising took place, led by some of the Herero tribes in Namibia, resulting in the deaths of approximately 120-150 German settlers. Tragically, many victims suffered torture and mutilation prior to their demise. To restore order, German troops were dispatched from Germany.[12] However, General Lothar von Trotha, leading these forces, issued ruthless orders, commanding the killing of every male Herero and then forced displacement of women and children into the desert. The remaining tribal members were confined to concentration camps, while others were subjected to forced labor for German businesses. The harsh conditions led to the deaths of many Herero due to overwork and malnutrition. Not

until 2015 did the German government admit that the massacres were equivalent to genocide and formally apologised in 2016.[19.] South-west Africa was not the only land that fell under extreme colonial measures by the Germans, and Woermann's company was one of those who benefited from this constant subdue. In 1892, the Duala tribe in Cameroon complained to the colonial governor that the German merchants broke the Protectorate Treaty to control the intermediate rubber trade.[19] As a result, a protection force was sent to the villages on a punitive expedition. Hundreds were chased out of their shelters into the bush, numerous opponents were shot down after a short resistance while many women and children were slaughtered (Almost every soldier brought back a head as a trophy). Following this martial oppression, in 1898, Adolph Woermann founded the South Cameroon Society, which set itself the goal of exploiting the rubber resources in Cameroon. A government official from Berlin, who was traveling in the colony on behalf of the Foreign Office, explained the scene as: "…the prisoners were tied to the railing on the ship for days in the blistering heat in such a way that worms got into their bloodthirsty and swollen limbs had nested. Then, when the poor prisoners were dying, they were shot down like wild beasts…"[12] The German oppression in Africa was an easy way to claim more resources to benefit Germany and from that Hamburg flourished, and its booming economy left its mark on its built environment.

> "Colonial period is our history, is the history of the Hamburg economy. And accordingly, of interest to us."
> Astrid Nissen-Schmidt, Vice President of the Chamber of Commerce[20].

6. COLONIAL IMPACTS ON HAMBURG'S ARCHITECTURE

Upon the establishment of the free port zone in 1888, Hamburg emerged as a key hub for the trade in colonial goods and the subsequent refinement of products from overseas, including coffee, spices, palm oil, and tobacco. Hamburg praises itself as the gateway to the world, but this world came into being because until recently it was a colonial world based on hard measures.[5] They traded with colonial powers, they bought and sold people and colonial goods, and they left their mark on history. Missionaries, merchants, officials, soldiers, and explorers collected not only artifacts and tools, but also stuffed animals, human skeletons, and skulls, and today the German museums are full of them.[5] Most colonial monuments were planned and built during the period of German colonial rule (1884-1919). They promoted the identification of the population with the German-occupied territories overseas. Colonial monuments in the colonies were also a clear instrument of power.[16] Hamburg's architectural panorama tells the story of a city closely linked to world trade and testifies to the city's historical importance as a major international port. The iconic Chilehaus is an example of expressive architecture and stands as a tribute to Hamburg's central role in the world economy at the beginning of the 20th century. A whole residential area on the Elbe was flattened to build the free-

harbour with its warehouse district (Speicherstadt- now declared a World Heritage Site by UNESCO), a complex of red brick and neo-Gothic buildings, underlines Hamburg's importance as a hub for shipping and storing large quantities of goods from all over the world.[22] The MAARK Museum, which exhibits African artefacts from the colonies to this day. The Hamburg Chamber of Commerce, which is spatially attached to the city hall and thus a clear symbol of the traditionally close relationship between business and politics in Hamburg. The Kolonialinstitut (Colonial Institute), founded in 1908 as one of the central predecessor institutions of Hamburg University, founded in 1919, which served as an archive for all reports and items brought back from the colonies and was also an important source for the development of a thorough basis on the conquered nations. The Afrikahaus, the headquarters of the Woermann company, which still exists today and is a tangible testimony to the city's historical links with German colonial ventures in Africa. The imposing Bismarck statue with its exaggerated scale to commemorate Chancellor Otto von Bismarck, who wanted to promote German culture among the African population. The Hagenbeck Zoo, founded by Carl Hagenbeck, that performed as a living testimony to Hamburg's role in world trade. It became famous for its acquisition of tribes that displayed African people and exotic animals from various countries, including Africa. The architectural elements of the zoo reflect a fusion of cultural influences stemming from global trade networks. Hamburg's colonial heritage is also reflected in the street names and commemorative plaques that provide a lasting link to the past. [21]These streets bear names that memorialize colonial figures and offer valuable insights into the city's involvement in colonial endeavors, even though Hamburg itself was not a colonial power, it played a crucial role in German colonial activities. These architectural landmarks indeed offer a rich tapestry of Hamburg's past as a hub of global trade and commerce.

Many of those monuments are from before the time of the Holocaust. They are still standing in Germany today, while many of the buildings and elements associated to the Nazi time have been demolished, despite the fact that the colonial time laid the foundation for the basis of the Jewish concentration camps in Europe, and although they came under criticism during the student protests in the 1960s, which led to several monuments being toppled.[16] Since the 1990s, there has been an increasing number of activist or artistic confrontations with colonial monuments, demanding their removal or rededication,[16] but many are still an integral part of the public space in German cities, especially in Hamburg.

7. AFRIKAHAUS

"Should we completely prevent a large line of business from philanthropy for the Negroes, who have not been our German brothers for so long?"

Adolf Woermann, 1885

The reason why this paper took this particular building lies in several factors: it was the headquarters of the Woermann company, which played an important role in the early days of the German colony. It has distinct elements and manifestations that represent African culture and can be directly associated with Africans, and above all, how it is used and the way it is perceived by the public today. This paper will discuss ten features that can be used with any other colonial landmark as a comparative tool:

1.Historical Context: Woermann was privately involved in the copper mining on the northern edge of the Herero area, which triggered bloody battles as mentioned previously. Some scientists call these colonial wars the " first genocide of the century." Afrikahaus was the building were most of those deadly decisions were made back in the time.[23]

2.Architectural Features: The Woermann shipping company was in full bloom at that time and needed a proper headquarters in Hamburg to run the business. Adolf Woermann then commissioned the architect Martin Haller in 1899 to build an office building and called it Afrikahaus (The African House). The choice of the architect was important at this point, as Martin Haller was considered one of the most influential architects in Hamburg who shaped the cityscape of the city. In 1899, Construction of Afrikahaus began, replacing the existing residential and office buildings. On a total of 7,500 square meters, Afrikahaus is divided into a front building, two courtyard blocks and a back building. It features a grand entrance symbolizing its importance and providing an imposing gateway that reflects on its colonial role as a gateway into Africa.

3.Colonial Symbols: The building was a symbol of power and strength being designed by the most acclaimed architect for the most successful merchant on the most sought-after location in Hamburg. Two almost life-size cast-iron elephant sculptures. Stand at the back of the courtyard,[12] with the statue of an African warrior, and a facade in the colours of the Woermann shipping line the building creates a visible sign of its achievements till this day. The company became one of the largest shipping companies in the world, with 43 steamships and "branch offices in Amsterdam, Rotterdam, Southampton, Lisbon, Las Palmas, Bathurst, Bissau, Freetown, Monrovia, Grand Bassa, Accra, Lomé, Cotonou, Lagos, Victoria, Duala and Lobito". [22]

4.Colonial Role: Afrikahaus had a pivotal colonial role as an administrative center, trade hub, and cultural exchange venue for German colonial activities in Africa during the late 19th and early 20th centuries. ts significance lies in its contribution to the colonial narrative of the time and its role in shaping Germany's colonial interests in Africa.

5.Public Perception: The colonial past of the port city has also become a teaching topic in schools, and some high school collaborate with other African school in projects that study the colonial legacy and its consequences.[23] Afrikahaus is always the first on the list of case studies for the students. This is a very

important point since it involves younger generations to learn more about the long forgotten dark history.

6.Public Engagement: Afrikahaus is featured in a digital database, which has been compiled and is poised for potential accessibility by the public in a digital format. The project manager's vision encompasses the creation of a 'colonial visualization' that delves into the material and visual vestiges of colonialism. This will bring more public to be more engaged with the building amongst others.

7.Post-Colonial Transformation: Since the building is a listed monument. It has become a touristic destination for many.

8.Use of Space: Each floor is rented to small companies and medical clinics. And in the courtyard, there is a famous restaurant that occupies a big section of the courtyard on daily basis and is always packed with customers. The Woermann company itself is still occupying few stories in the building as well.

9.Cultural Significance: In 1972, Afrikahaus became a listed building due to its long-time history. It is one of the main monuments in Hamburg and represents a specific time of economic success that is based on the exploitation of another nation.

10.Urban Context: The building is in Große Reichenstraße, just few hundred meters away from the city hall and the Hamburg Chamber of Commerce. Haller chose a location close to the port and the Speicherstadt, where the goods from the colonies were stored, and became the logistical base for colonial imports as the largest in the world after London. The imported goods included human remains as well as people. The remains were sent to the scientists to be medically examined, while the living was used for constant displays at the human-zoo created by Carl Hagenbeck. It was the time when the euphoria for everything African was rising and people wanted to know more about those faraway German lands.[12]

Generally speaking, Afikahaus is one of those monuments that initially appear as an unchanging buildings, erected to specifically commemorate certain historical events, and today poses itself as a pivotal architectural element in the culture of remembrance in the center of Hamburg.

Fig. 3: Afrikahaus. (Source: Wikimedia Commons)
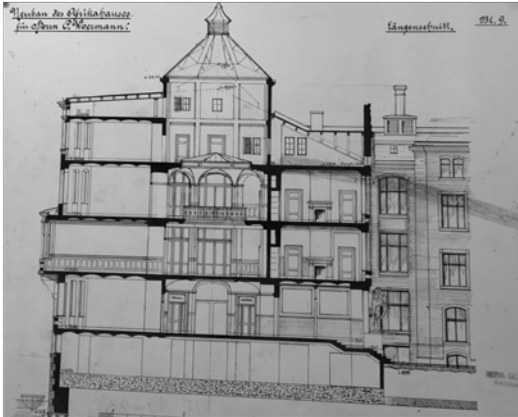
Fig.4: Section drawing of the building hanging in the stairwell inside Afrikahaus. (Source: Author 2022)

Fig.5: The African warrior at Afrikahaus. (Source: Author 2022)

Fig.6: Big scale elephantsin the courtyard of Afrikahaus. (Source: Author 2022)

Fig.7: A mural depecting the African features hanging in the courtyard of Afrikahaus. (Source: Author 2022)

Fig.8: Stolen African artefacts hanging in the stairwell of Afrikahaus. (Source: Author 2022)

7. THE CULTURE OF REMEMBERANCE

"We, in Germany, have sold ourselves the illusion that we came out of the colonial times with just a few scrapes, or that German colonialism was too short to create lasting damage," Michelle Müntefering, the minister of state for international cultural policy.

Presently, the urban space of Hamburg shows traces of colonialism, most of which are hard to clearly identify as such. They can be found within city planning in the form of architecture, street names and monuments, within cultural institutions, where knowledge is made apparent, as well as in the political discourses that shape the public discussions. Such historic traces can serve as sites of memory since they contribute to the formation of identities and are therefore constitutive of the urban community. In this sense, the debate on colonial history as it is being held in Hamburg and many other major European cities can serve as an example for the constitutive nexus of citizenship and culture of remembrance.[21]

The German discourse on colonialism in the politics of memory began at the turn of the century and continues to this day. It was preceded by the scientific establishment of remembrance research and the worldwide so-called remembrance boom, during which a wide variety of groups demanded a remembrance of the violent crimes of the last century, which had been kept silent and ignored. As a result, the crimes committed in the German colonial empire entered the public memory where the atrocities of the Shoah had previously been discussed.[16] Since the beginning of the 21st century, many postcolonial initiatives and diasporic groups have also been founded nationwide, consisting of activists, artists and scientists who have since then been calling for the recognition of colonial injustice and the integration of colonialism fight in public remembrance. [16] With postcolonial city tours, street festivals and demonstrations, they show colonial

Fig.9: School visits exploring Afrikahaus. (Source: Author 2023)

traces in the cityscape, for example, several street names that continue to honor German colonial officers gives the public a chance to call for their renaming and rededication into postcolonial places of remembrance.

Despite these recent developments, there is talk of a "colonial amnesia "Spoken in Germany, although this does not mean completely ignoring the topic of colonialism, but rather expresses that the memory of it continues to relativize all guilt and rejects civil society demands for a post-colonial culture of remembrance. [17] Since the end of the 1990s, various civil society groups, including above all Black communities and People of Colour, have brought the issue to the public's attention with great commitment and creativity. In 2014, Hamburg was the first German metropolis to finally decide to address this difficult legacy. In the same year, the research center "Hamburg's post-colonial heritage Hamburg and early globalisation" was established at the University of Hamburg. In recent years, Hamburg's museums have begun to represent Hamburg's colonial history and to research the colonial provenance of collection objects. The research team at the research center for Hamburg's post-colonial legacy headed by Prof. Dr. Jürgen Zimmerer has created an app that makes Hamburg's colonial history accessible by smartphone. Users can choose from 3 thematic tours: Politics, Culture, and Society; Business and Trade; and Science and Research, to get to know the colonial connections among various places in Hamburg, no prior knowledge necessary and at the frontiers of research. The research center is thus providing low-threshold access to colonial history and showing how history scholarship can contribute to a modern city.[24]

8. CONCLUSION

Research on the impact of colonialism in Germany is conspicuously sparse, especially when compared to the extensive studies on colonialism in the former colonies. This research gap points to critical areas where further investigation is vital. First, there is a significant need to explore the influence of the colonial legacy on contemporary German society, examining how colonial history shapes social attitudes, stereotypes and racial dynamics. Furthermore, an unexplored area lies in understanding how colonialism has left its mark on Germany's architectural and urban landscapes, which reflect the physical remnants of this historical influence. While Juergen Zimmerer, a prominent colonial scholar, argues for exploring how colonialism has influenced cultural institutions, museums and the representation of colonial history in German cultural life, there is a call for broader participation by scholars and historians. Furthermore, the impact of postcolonial migration on German society and its contributions to discussions on identity, multiculturalism and racism have not yet been sufficiently explored. Finally, the challenge of accessing colonial archives and sources requires further research to deepen our understanding of German colonial history. These unexplored areas contribute to a more holistic understanding of how colonialism permeated different facets of Germany and its society. In particular, monuments that not only reflect the past but also initiate contemporary social debates play an important role in this context. When analysing colonial monuments or spaces as sites of remembrance in a (post)colonial framework, it is crucial to distinguish their original purpose when erected from their later reception and interpretation. In order to promote a postcolonial culture of remembrance, the active inclusion

of the voices of the descendants of the colonised in shaping the discourse is essential. As South Asia historian John McQuade observed, "It takes a highly selective misreading of the evidence to claim that colonialism was anything other than a humanitarian disaster for most of the colonized." [15] The term "place of memory" or "lieu de mémoire"," coined by historian Pierre Nora, refers to symbolic elements where memories are exhibited. [17] These places are both an expression and consolidation of collective memory in society, they transcend generations and become an integral part of cultural, social and political norms. Their evolution parallels shifts in perception, care and use. It is essential to distinguish their original function from how they are perceived today, whether they manifest as buildings, statues or street names.

NOTES AND REFERENCES

[1] Gates, Henry Louis, and Appiah, Kwame Anthony. "Encyclopedia of Africa" Oxford University Press: Oxfordshire, England, 2010.

[2] Africavenir, Press Release: Germany Must Repatriate Human Remains and War Spoils from Cameroon, Togo, Tanzania and Rwanda. last visited 12.06.2023. https://www.africavenir.org/fr/newsdetails/archive/2014/december/article/press-release-germany-must-repatriate-human-remains-and-war-spoils-from-cameroon-togo-tanzania-an.html?tx_ttnews%5Bday%5D=17&cHash=b69726bee25d37b83bac6e41465f2c77

[3] Blakemore, Erin. What is Colonialism? History and culture: National Geographic, 2023. Last visited 08.10.2023. https://www.nationalgeographic.com/culture/article/colonialism

[4] Murrey, Amber. European Colonialism(s), International Encyclopedia of Human Geography (Second Edition), 2020. Last visited 13.02.2023 https://www.sciencedirect.com/topics/social-sciences/colonialism

[5] Bohr, Felix, Ulrike Knöfel, and Elke Schmitter, Die deutsche Blutspur im Paradies. Der Spiegel. 2021.

[6] Akyeampong, Emmanuel. 2015. History of African Trade. Harvard University. Last visited:29.10.2023. https://elibrary.acbfpact.org/acbf/collect/acbf/index/assoc/HASH0100/039e055d/606b9c4a/9550.dir/History-of-African-Trade.pdf

[7] French, W. Howard. 2022."Born in Blackness: Africa, Africans, and the Making of the Modern World, 1471 to the Second World War". P. 50

[8] Eltis, David. 1999, "The Rise of African Slavery in the Amircas". Cambridge University Press: UK

[9] Hard, Michael. 2023. Communicating and Trading in West Africa: Talking Drums and Pack Animals. Springer. Last visited: 30.10.2023 https://link.springer.com/chapter/10.1007/978-3-031-22813-1_3

[10] The 'Scramble for Africa', BBC. Last visited 14.06.2023. https://www.bbc.co.uk/bitesize/topics/z7kvf82/articles/zrfjqfr

[11] Wright, Hagberg.German Methods of Developement in Africa. Journal of the Royal African Society. Vol.1 No.1 (Oct.1901). Oxford University Press: Oxforshire, UK https://www.jstor.org/stable/714701

[12] Braker, Bedour. Afrikahaus, The Stories Of. 2023

[13] Sontheimer, Michael. Brutales Herrentum. Der Spiegel. 2016. Last visited 05.06.2023. https://www.spiegel.de/geschichte/suedwestafrika-der-deutsche-voelkermord-an-den-herero-a-1073974.html

[14] Conrad, Sebastian. "German Colonialism: A Short History". Cambridge University Press:UK, 2012, p.3-6

[15] Blakemore, Erin. 2023. What is Colonialism. National Geographic. Last visited 29.10.2023. https://www.nationalgeographic.com/culture/article/colonialism

[16] Jung, Rosa. 2021. Postkoloniale Erinnerung: Zur Aushandlung des kulturellen Gedächtnisses am Beispiel der kolonialen Denkmalanlage auf dem Gelände der ehemaligen Lettow-Vorbeck-Kaserne in Hamburg-Jenfeld. Hamburg Universität. Last visited 17.10.2023. https://fiona.uni hamburg.de/0641fe3c/postkolonialeerinnerungfinal.pdf

[17] Kößler, Reinhart. 2019. Zwischen kolonialer Amnesie und konstruktivem Engagement. In: Melber, Henning. Deutschland und Afrika. Anatomie eines komplexen Verhältnisses. Frankfurt a.M.: Brandes & Apsel.

[18] Gittermann, Alexandra. 2021, Steinreich durch Schnaps und Zwangsarbeit, Spiegel.

[19] Hielscher, Hans .2019, Die Tragödie um Rudolf Manga Bell, Spiegel

[20] Storost, Ursula. 2020. Hamburgs Reichtum durch den Kolonialhandel. Deutschlandfunk. Last visited: 16.03.2023. https://www.deutschlandfunk.de/aufarbeitung-der-kolonialgeschichte-hamburgs-reichtum-durch-100.html

[21] Kellermann, Katharina. 2019. Silence, Motifs and Echoes: Acts of Listening in Postcolonial Hamburg.

Springer. Last visited: 28.02.2023. https://link.springer.com/chapter/10.1007/978-3-319-97502-3_7

[22] Ganz feine Kaufleute, Speigel. 2016. Last visited: 23.06.2023. https://www.spiegel.de/kultur/ganz-feine-kaufleute-a-31c5cbc0-0002-0001-0000-000143711895

[23] S.Hasse, Edgar. 2015. Stadtgeschichte: Hamburg Koloniale Vergangenheit. Hamburger Abendblatt. Last

visited: 23.05.2023. https://www.abendblatt.de/hamburg/wandsbek/article205267735/Stadtgeschichte-

Hamburgs-koloniale-Vergangenheit.html

[24] Newsroom Editorial, First Scholarly App on Hamburg's Colonial Past Goes Online. Last visited 17.05.2023. https://www.uni-hamburg.de/en/newsroom/im-fokus/2023/0517-koloniale-orte.html

[25] Konzept des rassistischen Terrors, Der Spieagel Geschichte. 2016. Last visited 18.06.2023. https://www.spiegel.de/geschichte/konzept-des-rassistischen-terrors-a-8a4baf16-0002-0001-0000-000141793818

[26] Hart, Michael A. Indigenous Social Work, International Encyclopedia of the Social & Behavioral Sciences (Second Edition), 2015. Last visited 26.06.2023 https://www.sciencedirect.com/topics/social-sciences/colonialism

THE USE OF BIOMIMICRY IN THE RESTORATION OF HERITAGE BUILDINGS: THE CRACKS OF AL-BYADDIAH PALACE AS CASE STUDY

Layan Husni Rayes

THE USE OF BIOMIMCRY IN THE RESTORATION OF HERITAGE BUILDINGS: THE CRACKS OF AL-BYADDIAH PALACE AS CASE STUDY

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The aim of this paper is to preserve the cultural and historical significance of humanistic culture by using biomimicry as a means of restoring structures. Furthermore, the preservation of cultures serves to facilitate the transmission of ancestral knowledge and historical heritage to subsequent generations. The main emphasis is on exploring the potential use of biomimetic gecko glue in the repair of cracks.

1. INTRODUCTION

The adaptation and growth of both individual and communal human identities depend heavily on the preservation and protection of architectural heritage. A nation's cultural legacy is a distinctive and priceless expression of its cultural identity. Imbued with a message from the past the historic monuments of generations of people remain to the present day as living witnesses of their age-old traditions people are becoming more and more conscious of the unity of human values and regard ancient monuments as a common heritage. The common responsibility to safeguard them for future generations is recognized it is our duty to hand them on in the full richness of their authenticity[1]. This commitment extends to a number of fields such as engineers where they can represent the techniques using the knowledge provided by previous generations. Additionally, the repercussions of this phenomenon are widespread and have an impact on many socioeconomic areas, including tourism and the sustainability of infrastructure. These two elements considerably contribute to a country's overall economic resilience, both alone and together. The desire to create a new purpose that is harmoniously aligned with the building's interior design, location, and cultural importance, or the conviction that the structure has inherent worth, are the two main driving forces behind the restoration of historical buildings[2]. Additionally, Historical structures are valuable to nations all around the world. In the instance of Saudi Arabia, a special campaign has been launched to maintain these monuments and preserve the rich cultural past they represent. Saudi Arabia has many different cultures due to its different provinces starting with the Central Region Style (Najd Style) and the Logic Style. The Western Region (Red Sea Basin), the Southern Region Style (Al-Sarat Style), and the Regional Style Oriental (Arabian Gulf style) Each of these regions has its own environmental characteristics and cultural connections[3]. The abundance of cultural materials in the nation's heritage is derived from diverse identities shaped by factors such as building materials, agricultural practices, and residents' lifestyle. The architectural heritage across regions holds cultural treasures. Based on the Saudi interest in urban history and its frequent efforts to maintain it as a cultural component, the Saudi 2030 vision held the effort to completely progress in its projects involving urban heritage. Several programs have evolved in recent years to attain this objective[4].

1.1. The City of Makkah Al-Mukarramah

Makkah Al-Mukaramah, which is located in the western region of the Kingdom of Saudi Arabia (the Hejaz)[5]. The city of Makkah holds significant importance due to the religious aspect, strategic, geographical, and economic aspects. Also, from a spatial perspective, the geographical positioning of Holy Makkah has historically served as a mediator international trade between the southern region of Yemen and the northern region encompassing levant countries[6]. The city's natural characteristics, particularly the hilly topography, had a considerable impact on the urban growth and architectural style of the city. The circular architectural design that encloses the Holy Masjid area was largely influenced by its surrounding topography[5]. Furthermore, it has several historic palaces, including the Bayadiyah Palace, which is studied as a case study, as well as the Al Suliman Palace, Kuwair Palace etc.

2. AL-BAYADDIAH PALACE

Al-Byaddiah is formerly known as Al-Hukum Palace, however, the historian reader Fawaz Aldahas claims that it is wrongly named as Al-Saggaf Palace[7]. Interestingly, the Palace housed a prominent figure in Saudi Arabia's history, King Abdul Aziz bin Saud, who lived here when he entered Makkah to unite the country in 1924[8,25]. This historical fact adds charm and national importance to the palace's history[25]. The palace is considered a masterpiece for the representation of environmental architecture methods, the palace is located in Al-Maabada neighborhood which is one of the most well-known neighborhoods in Makkah Al-Mukaramah, specifically Al-Gemmayzeh street next to King Faisal Palace (Fig. 1). It has an area of 9,000 square metres, and is divided into several sectors, each consisting of two floors, with an area of approximately 4,500 square metres. The Bayadiya Palace contains more than one hundred rooms[7]. The palace also includes a large theater and reception areas that were used to entertain international leaders for the World Muslim League meeting. In fact, King Abdulaziz welcomed state dignitaries to the palace, a practice that continued under King Saud and King Faisal in his official position[8]. Al-Bayadiya architecture reflects the authentic cultural history of Makkah in the form of many original architectural features. For example, the Roman and Andalusian styles were combined in Al-Bayadiya Palace[8]. The palace is also distinguished by the Makkah architectural style, which shows simplicity and the use of stone materials. As the lower floors were unpolished, while the upper parts were made of brick and covered with painted marble. Also, the facades of the palace are distinguished by the use of geometric decoration known as a hexagon ring in the marble railings of the balconies (Fig. 2)[7]. The palace relied on the idea of an open courtyard to have many sitting rooms and reception halls overlook it from its four sides. The rectangular courtyard of Al-Byaddiah utilizes a dynamic flow ventilation system which allows the air to flow into the courtyard[25].
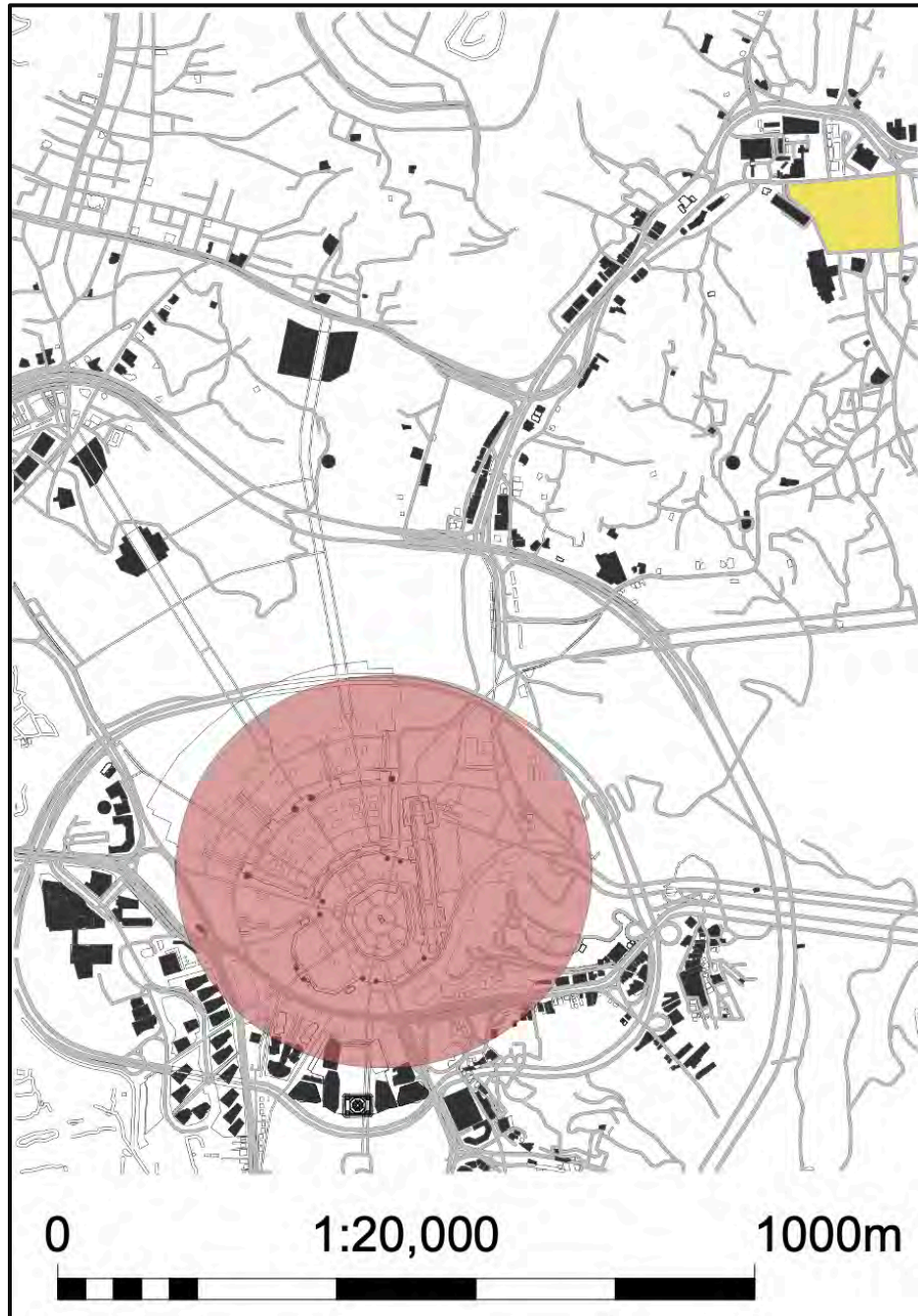
Fig. 1: The road from the Holy Mosque to the Al-Byaddiah palace area.

Aldahas also argues that the palace has managed to keep its strength, which is evidence of the building's capacity to endure, despite the variety of transformations as well as tremendous obstacles[7]. These challenges include a catastrophic fire that destroyed the theater and VIP reception area. Despite these challenges, Al-Bayadiya Palace underwent several changes without losing its resilience but there were some side effects such as cracks on walls, stairs, ceiling…etc[8].

Fig. 2: Al-Byaddiah Facade[28].

2.1. Cracks

The presence of cracks in buildings is a pervasive issue seen on a global scale. Cracks in building components are seen to occur when the force exerted on the components surpasses their inherent strength. The stress experienced by building components may arise from external pressures, including dead, live, wind, seismic loads, and foundation settlement[9]. Additionally, interior factors such as temperature fluctuations, moisture changes, and chemical activities can also create stress. The presence of cracks in a building may significantly impact its aesthetic appeal, compromise the structural integrity of the walls, jeopardies the safety of the overall structure, and perhaps diminish its long-term durability[10]. Generally, cracks can be divided into two types:

1. STRUCTURAL CRACKS: may rise due to various reasons such as incorrect design, overloading of the structural components. Structural cracks endanger the stability of the building and may be difficult to be rectified as:

   A. BEAMS

   - Shear cracks: The shear crack occurs due to the shear failure, and it occurs near the supports of the beam. It appears at an angle of 45 degrees, and it is a very serious structural active crack. It can appear as diagonal cracks at quarter points along the beam and designate to serious structural problems. This happens due to a lack of shear reinforcement or due to insufficient stirrups cross-section in the beam.

- Flexure Cracks: There are two types of flexural cracks. The first type development of the crack happens at the top of the support. Which known as negative. The second one, Is the one that develops at the bottom, which is known as positive. This crack develops at the bottom near the mid-span and spread upwards. It may be single or multiple cracks and occur when the tension of the beam occurs at the bottom due to heavy load flexural cracks forming. This is due to maximum bending moment inside the beam, poor design, insufficient reinforcements, or insufficient concrete cover.

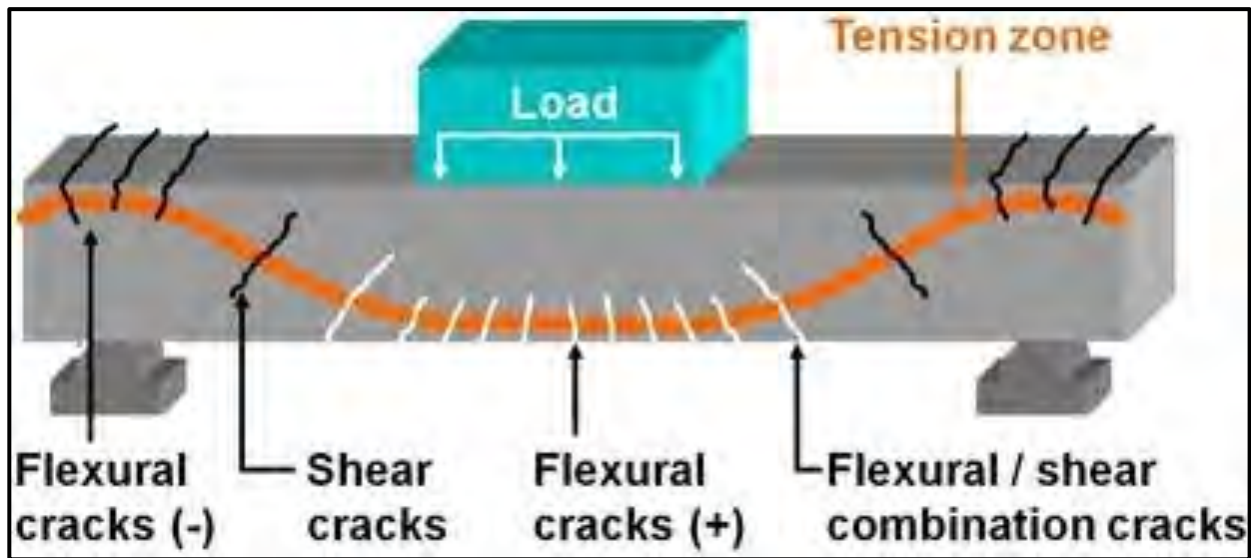- Torsion crack: Pure torsion in a beam, it is a crack running throughout the length of the object (Fig. 3)[11].

Fig. 3: Location and directions of overloading beam cracks[29].

B. CONCRETE COLUMN

- Splitting Cracks: There is vertical cracks, short and parallel. Insufficient steel reinforcement, deficient cross-section, or inferior in the concrete quality, and corrosion in the reinforcement are the main causes of the occurrence of splitting cracks. This crack occurs at the maximum load-carrying capacity of the column.

- Diagonal cracks: These cracks run in the diagonal direction, they appear anywhere in the height and have a constant thickness. it accure due to the load carrying capacity and cross-section are insufficient, also, Inadequate steel reinforcement.

- Horizontal Cracks: This initiates at the beam-column junctions. This crack might be because of incorrect design, faulty construction, overloading, corrosion of reinforcement, isolated settlement of the foundation, creep, and shrinkage. Columns with adequate moment resistance capacity, or insufficient reinforcements, or improper disposition of installed reinforcement are prone to horizontal cracking, due to the effect of shear force and direct load and uniaxial bending.

Horizontal crack reduces the column's shear strength and gives rise to failure. This crack develops horizontally at the beam-column junction due to the shear force.

- Corrosion Cracks: corrosion cracks in concrete columns are developed along the line of reinforcements. This type of cracks is commonly is in the width and it widen as the column is ageing. Possible reinforcement corrosion and inadequate bond between concrete and steel bars are the cause of corrosion reinforcement in concrete columns. If such type of cracks is not tackled the corrosion of reinforcement would accelerate considerably [12].
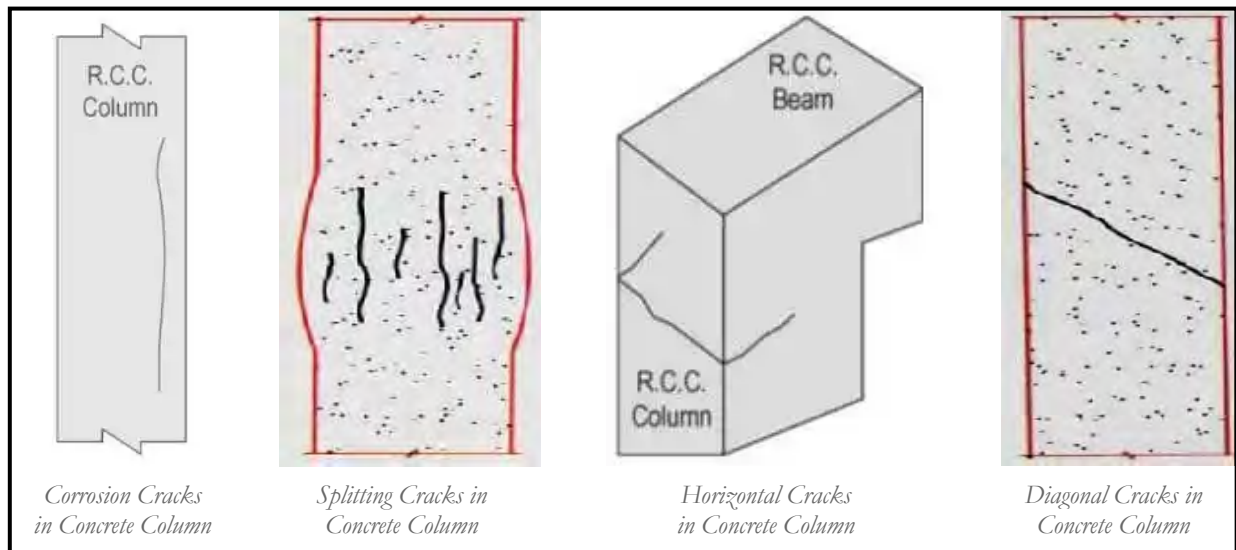

| Corrosion Cracks in Concrete Column | Splitting Cracks in Concrete Column | Horizontal Cracks in Concrete Column | Diagonal Cracks in Concrete Column |

Fig. 4: Column Cracks type[30].

C. SLABS

- Plastic shrinkage cracking: This crack occurs in the concrete in the curing stage and can be reduced or prevented with the use of proper joint placement. This crack appears on the horizontal surface of fresh concrete after placement as shown in (Figure 4). This type of cracks appears due to the rapid drying of the concrete.

Spalling: This crack is due to reinforcement corrosion or reaction between implanted steel bars in the concrete mixture. When the steel bars corrode, the expansion of the rust is ten times the original volume that provokes the formation of tension forces inside the concrete. The problem is, concrete becomes impuissant to hold the tension forces, therefore the pieces between the corroded steel and the surface near to it start breaking off.

Another cause may be:

1. Poor surface finishing or improper curing of the slab reaction between the implanted steel bars in the concrete mixture or due to the bad concrete mixing. The steel exposed by

minor spall leaves it unsafe and gets more corroded shown in (Fig. 5). The more rate of corrosion in steel more will be the spalling, shown in (Fig. 5).

2. Spall in an area can be the first slice of a big problem hidden inside, which may present destruction of the steel by corrosion.

- A wide spall area in a slab is a sign of structural danger. When more concrete has broken down at the bottom of the slab, leaving the reinforcing uncovered, the tension and compressive forces cannot be held due to the absence of concrete resulting in the steel acting as a cage only shown in (Fig. 5).

- Expansion cracks: In hot weather, the reinforced concrete slab expands, as it gets hotter. During its expansion, the stress developed in the concrete slab pushes away any object on its way such as walls or a slab next to it. If the concrete does not have a space to expand, the force will cause a crack in the slab and in the structural element near it as shown in Figure 5.

- Heaving Cracks: Expansion of clay soils causes slab heaving due to the absorption of moisture. Garden irrigation, broken sewer pipes, groundwater, rainwater, and poor surface drainage are some sources of moisture. Roots of trees near reinforced concrete slabs may enter inside the concrete and destroy it by lifting and cracking the concrete[11].
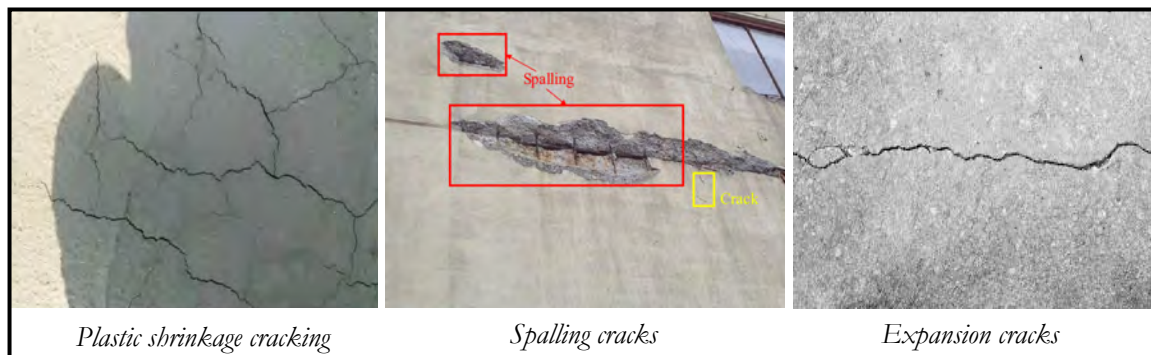

| *Plastic shrinkage cracking* | *Spalling cracks* | *Expansion cracks* |

Fig. 5: Slab Cracks type[11].

NON-STRUCTURAL CRACKS: are generally due to internal forces developed in the building materials due to moisture variation, and temperature changes and suitable remedial measures can be taken to control it[10]. Cracks may appreciably vary in width from very thin hair cracks barely visible to the naked eye to gaping cracks. Depending upon the crack width, the cracks are classified as:

A. Heat shrinkage cracks: occur as a consequence of the exothermic reaction between water and cement, and it takes place during the initial stages of the hardening process. The application of steam curing is a common practice for treating prefabricated materials. The application of this heat treatment results in a significant thermal energy release within the concrete.

B. Plastic shrinkage cracks refer to the formation of cracks in concrete structures during the early stages of the drying process, mostly caused by the rapid evaporation of moisture from the phenomenon that arises due to the swift evaporation of water from the surface of the concrete. Which undergoes a plastic state throughout the setting process. The rate of quick evaporation is contingent upon various elements, with temperature and the angle of direct sunlight being particularly influential. These factors contribute to a higher rate of evaporation compared to the pace at which water remains on the surface of the concrete.

C. Thermal stress disparities: The utilization of precast constructions is susceptible to the impact of temperature variations arising from natural weather fluctuations or heating processes, hence leading to the formation of fractures.

D. Cracks resulting from corrosion: There exist two primary categories of flaws that contribute to the exacerbation of erosion factors on the concrete infrastructure:

- Rebar corrosion: The growth and proliferation of rust occurs in the vicinity of the rebar, leading to the formation of cracks along its longitudinal axis. This phenomenon has the potential to result in the detachment of the concrete, thereby exposing the underlying reinforcement bars. The presence of calcium chlorides in concrete contributes to the manifestation of this fault, together with the presence of moisture saturated with salts in the regions containing calcium chloride.

- Concrete necrosis: Chemical reactions can induce the deterioration of concrete, with one prevalent scenario being the generation of (Ettringite) through the reaction between Sulphur and cement aluminates in the presence of water. The resulting salt exhibits a greater volume than its constituent elements, causing expansion that ultimately leads to the formation of cracks and subsequent detachment of concrete fragments[13].
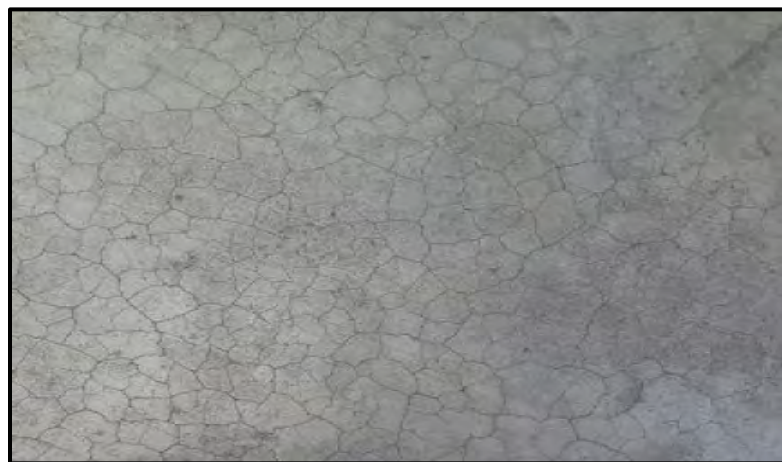

Fig. 6: Hairline Cracks (NON-Structural Cracks)[31].

	TYPE	*ABOUT*
A	**Epoxy Injection**	Epoxy injection is an economical method of repairing non-moving cracks in concrete walls, slabs, columns and piers a sit is capable of restoring the concrete to its pre-cracked strength. The technique generally consists of establishing entry and venting ports at close intervals along the cracks, sealing the crack on exposed surfaces, and injecting the epoxy under pressure.
B	**Gravity Filling**	Low-viscosity monomers and resins can be used to seal cracks with surface widths of 0.001 to 0.08 in. By gravity filling. High molecular weight methacrylate, urethanes, and some low-viscosity epoxies have been used successfully.
C	**Routing And Sealing**	In this method, the crack is made wider at the surface with a saw or grinder, and then the groove is filled with a flexible sealant. This is a common technique for crack treatment, and it is relatively simple in comparison to the procedures and the training required for epoxy injection.
D	**Stitching**	This method is done to provide a permanent structural repairs solution for masonry repairs and cracked wall reinforcement. It is done by drilling holes on both sides of the crack, cleaning the holes and anchoring the legs of the staples in the holes with a non-shrink grout.
E	**Dry Packing**	It is the hand placement of a low water content mortar followed by tamping or ramming of the mortar into place also, helps in producing intimate contact between the mortar and the existing concrete.
F	**Polymer Impregnation**	Monomer systems can be used for effective repair of some cracks. A monomer system is a liquid consisting of monomers which will polymerize into a solid. The most common monomer used for this purpose is methyl methacrylate.
G	**Underpinning**	Whereby the footings of the building are underpinned with either concrete, masonry or piles to carry the load of the building down to a more stable stratum (eg rock or soils below the reactive zone). This solution is usually the costliest, particularly if there are access difficulties or if internal walls require underpinning, which may require lifting internal floors.

Table 1: type of technique to repair cracks[10].

2.2. Example of Al-Bayaddiah Cracks:

Fig. 7: Al-Byaddiah courtyard wall to illustrate the cracks (Photo by Layan).

3. WHY THE BIOMIMCRY?

"We must draw our standards from the natural world. We must honor with the humility of the wise the bounds of that natural world and the mystery which lies beyond them, admitting that there is something in the order of being which evidently exceeds all our competence."

VÁCLAV HAVEL, president of the Czech Republic

The term "biomimicry" derives from the combination of the Greek words "bios," which translates to "life," and "mimesis," which means "to imitate." It can be understood as the act of imitating life. Biomimicry refers to the scholarly investigation of imitating and replicating natural phenomena in order to address human challenges[14]. Biomimicry is an emerging academic subject that focuses on the study of nature's most effective ideas, systems, and processes, with the aim of replicating and applying them to address various challenges and issues[15]. The design process involves designers examining natural species or ecosystems in order to address specific human needs. Through this method, designers aim to translate the behavioral processes observed in nature into design solutions created by humans. Envision it as the amalgamation of biological elements, natural phenomena, and architectural principles converging inside a singular creation. Biomimicry posits that nature,

with its extensive evolutionary history spanning 3.85 billion years, serves as an unparalleled and influential source of innovation for designers. This is due to nature's vast experience in successfully addressing environmental challenges and meeting the needs of its inhabitants. Architects have sought insights from nature to address their intricate inquiries regarding diverse architectural structures and have emulated several natural forms to enhance the efficiency and efficacy of such structures across various architectural contexts[16]. The incorporation of nature imitation has emerged as a prominent strategy in architecture and design, enabling these disciplines to seamlessly integrate with the built environment and effectively communicate innovative concepts to their surrounds[17].
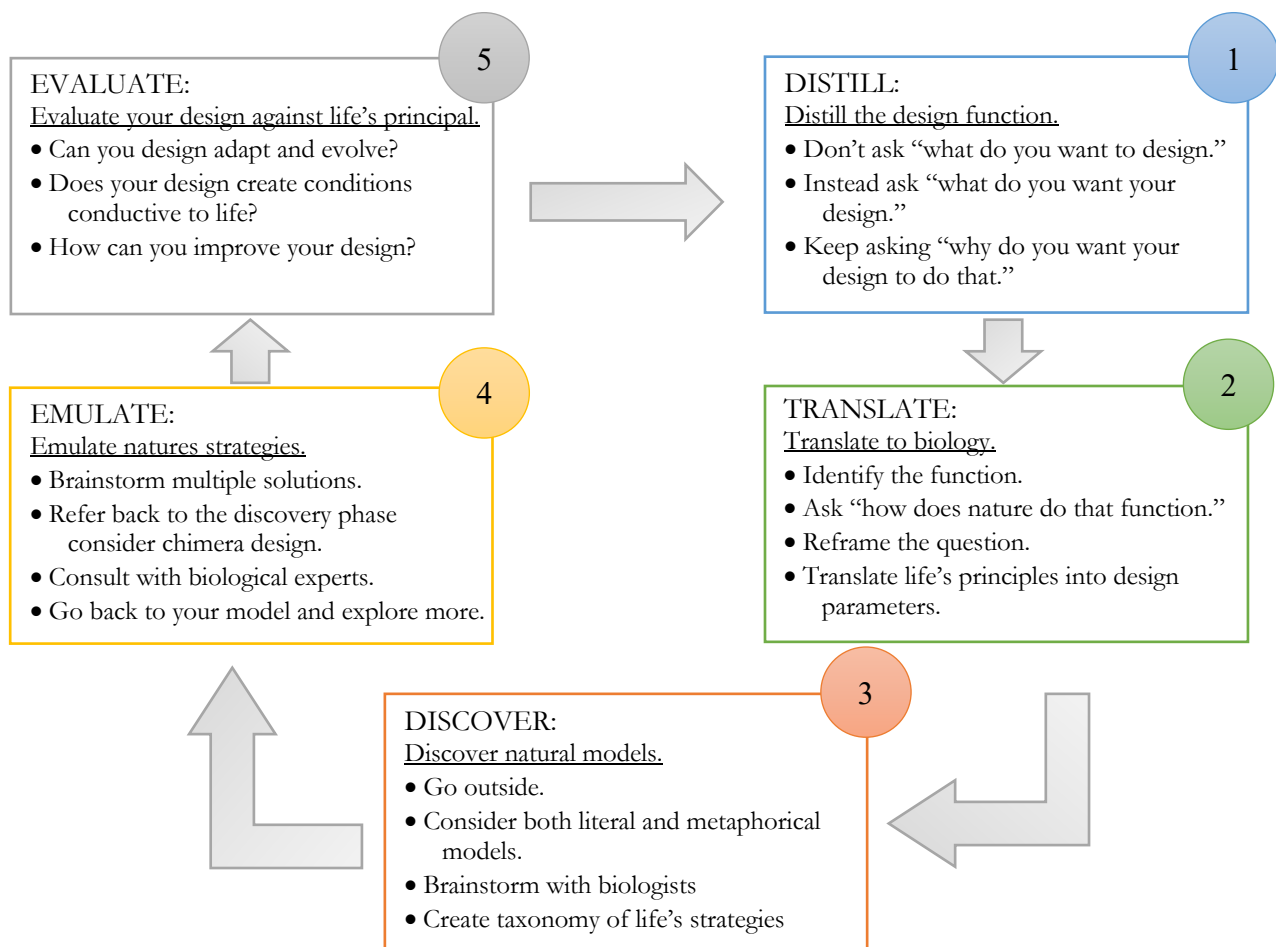

Chart 1: the challenge to biology (design spiral).

Michael Pawlyn once rightly said: *We must draw our standards from the natural world. We must honor with the humility of the wise the bounds of that natural world and "You could look at nature as being like a catalogue of products, and all of those*

have benefited from a 3.8-billion-year research and development period. And given that level of investment, it makes sense to use it.”

Biomimicry is the examination of various species in nature that have successfully resolved their challenges over millions of years. By identifying and using these design traits, biomimicry seeks to incorporate them into practical applications within the fields of architecture and structural engineering[18].

The fundamental tenets of Biomimicry are as follows:

a-   The utilization of energy in nature is limited to its necessary amount.

b-   The structure and design of natural entities are optimized to fulfil their intended purpose.

c-   The recycling of all materials is a fundamental principle in nature.

d-   Nature relies on the presence of diverse elements and organisms to ensure its resilience and stability.

e-   Nature places a strong emphasis on the use of local knowledge and expertise[16].

“The natural world and ecological system are maybe the best picture for what a sustainable world looks and performs like.”

Erin Rovalo, a senior principal of design at the consulting firm Biomimicry

3.1. The Gecko Foots

3.1.1. The adhesive properties of gecko feet.

The origins of biomimicry may be traced back to 1950 when the notion arose that designs influenced by biological creatures might be used to create novel technologies including machinery, materials, and thoughts that would prove advantageous to human beings[19]. This concept has had a substantial influence on the advancement of science and technology, playing a pivotal role in moulding and influencing a multitude of human achievements. In recent decades, scholars have been inspired by geckos to investigate the advancement of synthetic materials inside the domain of living organisms. The foundation for the development of a wide range of industrial adhesives using the fundamental principles of gecko adhesion. Following this, there have been several comprehensive academic inquiries conducted in the field of gecko-inspired adhesives[20,21]. The focus of researchers has mostly been on the manufacture, development, and design elements of these adhesives, to advance adhesive technology that demonstrates enhanced durability and little contamination[22]. The document titled refers to being referred Geckos have an extraordinary capacity to navigate vertical or inverted surfaces that are notably smooth, showcasing their locomotive capability in many climatic conditions, including aquatic settings. Additionally, geckos possess the remarkable ability to swiftly attach and detach their feet in a matter of milliseconds, hence augmenting their adhesive capacities. However, it is important to acknowledge that gecko feet do not cling to surfaces unintentionally; instead, adhesion occurs only when geckos purposefully connect their feet to a surface[26]. The feet of geckos have an impressive capacity to prevent adherence to dirt and tiny particles, so enabling them to retain a high degree of cleanliness regardless of the many surfaces they

come into contact with, without requiring any cleaning treatments[27]. In addition, it is noteworthy that gecko feet exhibit the exceptional capability to stick to surfaces without necessitating substantial pressure. The gecko's adhesive aptitude enables it to adhere to diverse surfaces with ease, even while bearing stresses that exceed its own body weight many times.
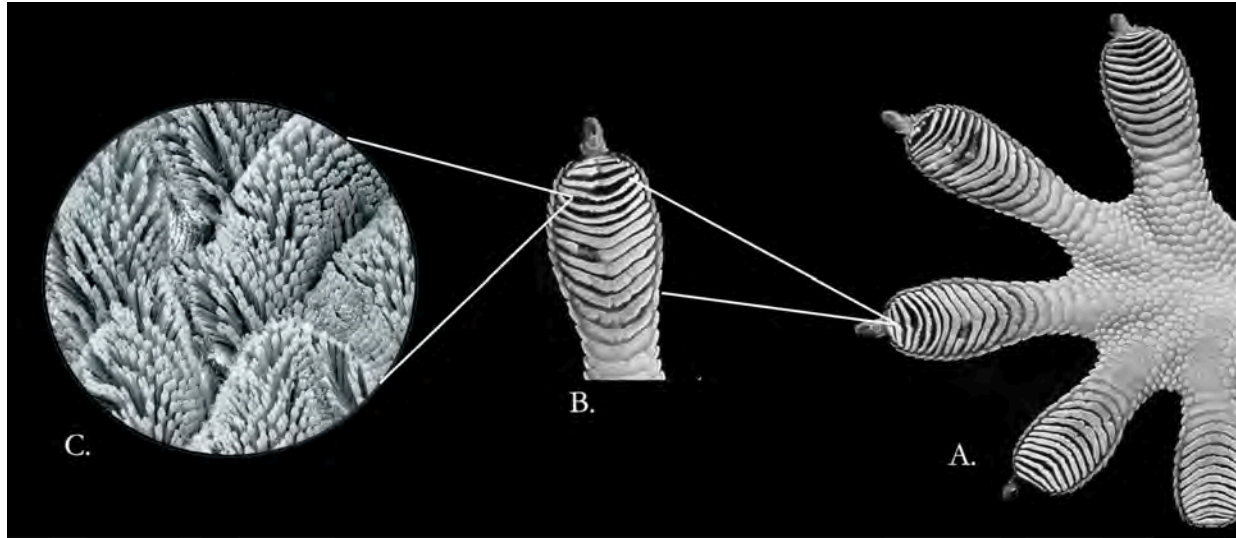

Fig. 8: (a) Macrostructure: A tokay gecko climbing on glass, (b) Mesostructure: View of the foot, with the adhesive lamellae (highlighted by the green oval) on one toe, (c) Microstructure: An array of setae made visible in a SEM image[23].

In the 1950s, after the invention of the electron microscope, researchers observed that the gecko's adhesive system consists of micro-nano multi-scale stratified setae. (Fig. 8) illustrates the multilayer microstructure of the adhesive system found in the Tokay gecko, while (Table. 2) presents comprehensive data on the specific size characteristics of its components. The gecko's setae are composed primarily of keratin, which has a modulus of approximately 1.6 GPA. The presence of hard setae is essential to the adhesive system's self-cleaning and anti-entanglement properties[23].

SCALE	*STRUCTURE*	*DENSITY*	*SIZE*	*ADHESION*
MILLIMETER	Toe	5 per foot	Areas: 227.1 mm2±10.81 mm2	20.04N ±1.33 N
MICRON	Lamella	20row per foot	Length: 400 μm – 600 μm	-
	Seta	14,000setae/mm2	Diameter: 5 μm – 10 μm, length: 30 μm –130 μm	194μN ±25 μN
NANOMETER	Spatula	100–1000 spatula/ seta	Diameter: 100 nm –200 nm, length: 2–5 μm	10 nN
	Spatula tip		Length: 500 nm, width: 200 nm –300 nm, thickness: 10 nm	10 nN

Table 2: The size characteristics of adhesive system of Tokay Gecko[23].

The surface adaptability of the adhesive system is much improved due to the comparatively low equivalent elastic modulus of roughly 80-90 kPa. This characteristic may be ascribed to the layered microstructure of setae[24]. The research undertaken by Autumn et al. (2000) made a major contribution to the comprehension of gecko adherence and laid the groundwork for subsequent extensive investigations into the adhesive mechanism of geckos[24]. The adhesive properties of an individual gecko's seta are first assessed by the use of two separate micro cantilever Micro-Electro-Mechanical Systems (MEMS) sensors. Each sensor is specifically designed to monitor a different kind of motion: parallel dragging and vertical peeling of the seta. In the context of parallel dragging mode, the gecko's seta establishes first contact with the tip surface of the micro-cantilever sensor by applying a predetermined vertical preload. Afterwards, it is drawn or moved in the direction of the contact surface[24]. The piezoresistive sensor devices positioned on the cantilever detect the forces generated by the gecko's seta during vertical preloading and parallel dragging. The capability to decouple and flex in orthogonal directions enables the biaxial micro-cantilever to facilitate this identification. In the vertical peeling mode, a single gecko's seta is first exposed to a vertical preload to establish efficient contact with the surface of the wire sensor. Following this, the seta is removed vertically from the surface of the sensor[23].
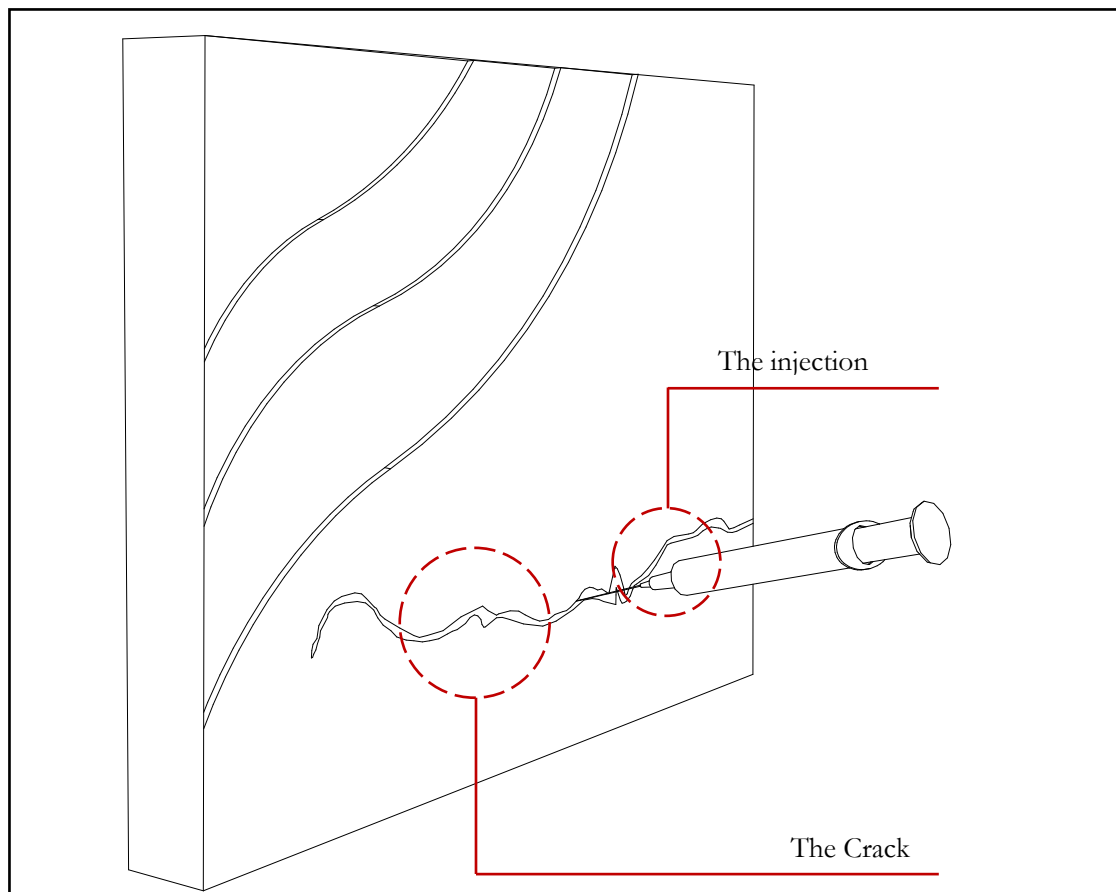

The injection

The Crack

Fig. 9: Sketch how to injection the glue into cracks (Sketch by Layan)

The measurement of the force applied by the seta during the vertical peeling operation is accomplished by observing the deflection of the wire sensor. The process of deflection is thereafter seen by a digital camera and subsequently converted into a measure of adhesion via a calibration procedure[24]. Based on the aforementioned precise measurements of the adhesion demonstrated by an individual gecko's seta, it has been concluded that the adhesion observed during both the parallel dragging and vertical peeling processes aligns with the anticipated range of the Van der Waals force, as described by a fundamental mathematical model. This discovery provides indirect evidence in favor of the theory that gecko adhesion is generated from the Van der Waals force[24]. Furthermore, a study was undertaken to evaluate the adhesive qualities of both the individual gecko toe and the individual gecko seta on surfaces exhibiting hydrophobic and hydrophilic characteristics, using similar testing protocols. Previous research findings indicate that there is no statistically significant difference between the tangential adhesion produced by an individual gecko's toe and the normal adhesion produced by an individual gecko's seta on surfaces that are hydrophobic or hydrophilic[23].

3.2. Previous Studies

1. Examination of gecko-inspired dry adhesives for heritage conservation as an example of iterative design
    and testing process for new adhesives:
    Jacek Olender, Christina Young

This project has demonstrated that GDAs do have a strong potential for applications in heritage conservation. So far, their range of potential use is limited to smooth surfaces. However, there are significant advantages of using the GDAs. When a substrate is receptive to gecko's adhesion, then it will stick to it potentially indefinitely. It was confirmed that a GDA adheres immediately with full strength under only gentle finger pressure. The anisotropic behavior of the GDAs has been confirmed.

2. Gecko-Inspired Adhesive Mechanisms and Adhesives for Robots—A Review:
    Soumya Sikdar, Md Hafizur Rahman, Arpith Siddaiah and Pradeep L. Menezes

This study discussed the methods and the possibility of fabricating gecko-inspired synthetic adhesives. The present study has explained the benefits and limitations of the suction adhesion mechanism. The present study has explained the benefits and limitations of the suction adhesion mechanism. These materials could adhere to different surfaces and environments, generating considerable adhesion force. The importance of water and humidity on the adhesion of geckos was another important focus of this study. This led to the fabrication of synthetic adhesives which could function under real environmental conditions. Inspired by the rapid attachment

and detachment of gecko toe pads, the paper shows cased examples of the recent development of synthetic adhesives.
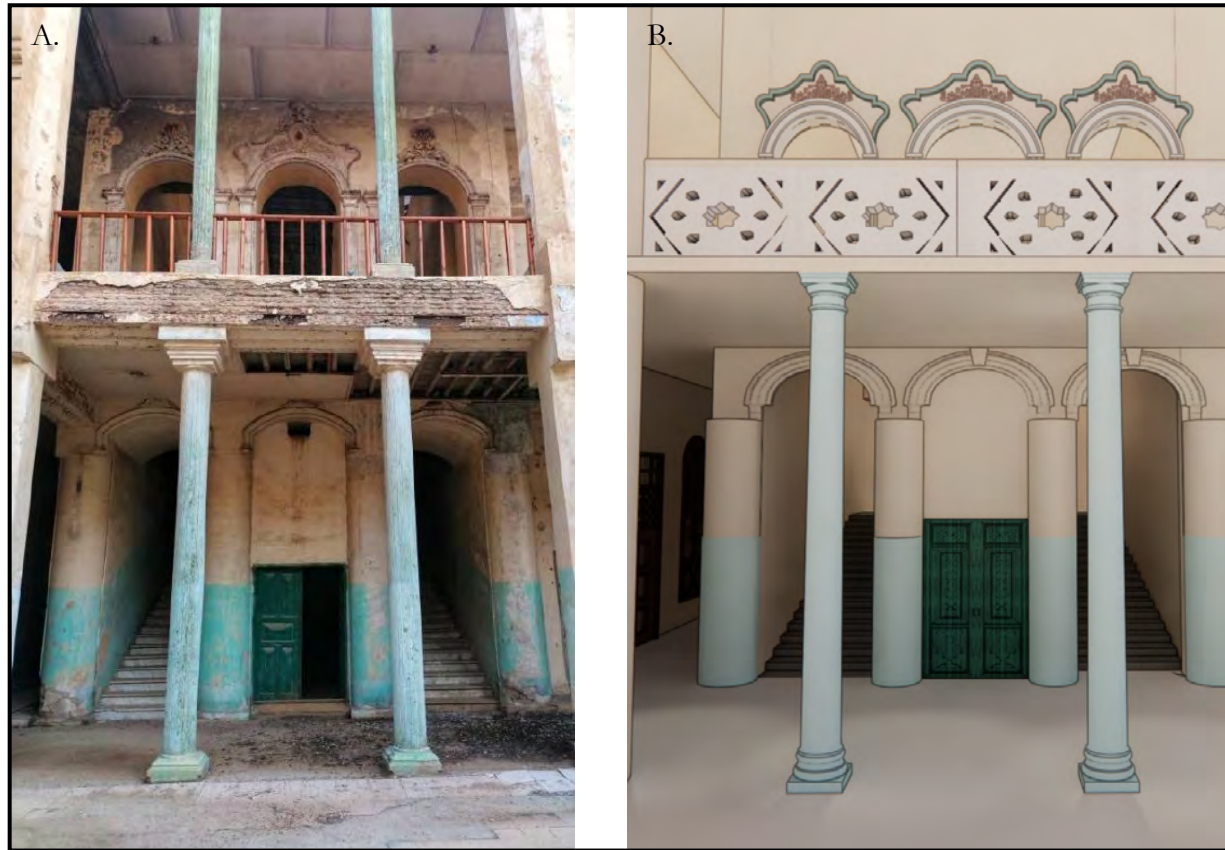
Before and After

Fig. 10: (A) main stair in Al-Byaddiah Palace (31), (B) 3D after repair the cracks in the wall (sketch by Layan).

Fig. 11:(A) Al-Byaddiah Courtyard walls (Photo by Layan), (B) 3D after restoring the courtyard and converting it into a cultural center (3D by Layan)

4. CONCLUSION

The conclusion is that the ancient buildings have a high degree of value due to their historical significance and their previous symbolic significance, especially considering the recent shift in the kingdom's direction. This is due to the fact that the structures formerly represented those entities. In addition, there are potential benefits for the tourism industry and the economy as a whole. The researcher has also demonstrated the necessity of maximizing the building's use of the surrounding natural environment while concurrently enhancing the building's sustainability. Consequently, the gecko adhesive, also known as seta, is actively contributing to this research endeavor, despite the fact that the studies are still being conducted. According to the findings of the study, gecko glue possesses exceptional adhesive properties, making it a viable option for repairing a variety of structural defects. These findings were presented in the context of the potential use of gecko adhesive to repair structural defects. The Al-Byaddiah Palace case study demonstrated that the use of gecko adhesive is an extremely sustainable preservation and restoration technique for historic structures. This was demonstrated by the successful completion of the undertaking. This information was uncovered as a result of the investigation conducted at Al-Byaddiah Palace. In addition, the study provides evidence that gecko adhesive, also known as seta, may play a role in the repair of various types of structural defects.

5. ACKNOWLEDGMENT

NOTES AND REFERENCES

[1] Feary, Sue, Steve Brown, Duncan Marshall, Ian Lilley, Robert McKinnon, Bas Verschuuren, and Robert Wild, " EARTH'S CULTURAL HERITAGE." *In Protected Area Governance and Management*, (2015), pp. 81-116.

[2] Non,"PRESERVING AND RESTORING MONUMENTS AND HISTORIC BUILDING. ", *UNISCO International book year,* (1972), pp. 1-261

[3] Al-Ghabban. Ali, Al-Qarni. Mohsen, Abdel Nour. Hassan, Abu Durman. Ayed, Al-Rashed. Abdullah, Al-Akrash. Khalid, Al-Rasheed. Sultan, Al-Qarni. Mousa and Abulbaqi, Sami, " AL TURATH AL OMRANI AL-SAUDI TANAWI FE ATTAR AL WAHDA.", in General Authority for Tourism and Antiquities book, (2010), pp.1-206

[4] Saudi vision 2030, Leadership Message, https://www.vision2030.gov.sa/ , accessed (October,2023).

[5] Prof. Al-Murahhem, Faredah, " MAKKAH: CITY OF SELF-IDENTITY AND INSPIRATION." *In art, design & communication in higher Education,* (2021), pp.7-28.

[6] Ignaccolo. Carmelo, La Mantia. Costanza, Nimri. Rama, Klen-Amin. Anne, Njuguna. Samuel, El-Hefnawi. Aymen, Tesoriere. Giuseppe, Glass. Elizabeth, Alhowaish. Abdulkarim, Tavera. Mario and karani. Solomon, " FUTURE SAUDI CITIES PROGRAMME CITY PROFILES SERIES: MAKKAH.", *in UN-Habitat,* (2019), pp. 1-137.

[7] Aldahas, Fawaz (Reader in history – Umm al-Qura University). Personal interview with Layan Rayes. (September 29, 2022).

[8] Rayes, Layan, Site visit and data collection. The two visits were accompanied by members from with Ministry of Culture and a construction engineer.(October 30, 2021).

[9] Pise, Nidhi, Meshram, Trupti, Doijad, Yash, Gathe, Rahul, Bobade, Ayush, Kutemate, Anup, Patil, Swapnil, Raut, Pranay and Prof. Gudadhe, Amit, "A BRIEF STUDY ON CAUSES OF CRACKS PREVENTION AND PATTERN OF CRACKS ON CONCRETE. ", *International Journal of Scientific Research in Science, Engineering and Technology*, (2021), pp. 439-443.

[10] Prof.Rajabather, Arvind, " INVESTIGATION OF CRACKS IN BUILDINGS.", *in Conference: Forensic structural engineering,* (2017), pp. 1-10.

[11] Dr Thales, Adje and prof. Sadeghi, Kabir, "CAUSES AND EFFECTS OF STRUCTURAL CRACKS.", *In International Journal for Modern Trends in Science and Technology,* (2022), 8 pp. 64-69.

[12] Non, " TYPES AND REASONS OF CRACKS IN CONCRETE COLUMN. ", *in Company: BRS Building Services Sdn Bhd,* (2021), pp. 1-3.

[13] Al-Hiti, ahmed and Al-Ajbari, ahmed, " DIRASAT INHIARAT W TASHQUQAT AL-ABNIA AL-MUNAFITHA ELAA ALTURAB ALTIYNIAH W TURQ TADEIMHA. ", *in Iraqi Journal of Civil Engineering,* (2007), pp. 89-112.

[14] Elsamadisy, Reem, Sarhan, Alaa, Farghaly, Yasser abd Mamdouh, Amal, "BIOMIMICRY AS A DESIGN APPROACH FOR ADAPTATION. ", *in journal of Al- Azhar university engineering sector*, (2019), pp. 1516- 1533

[15] Jamei, Elmira and **Vrcelj, Zora**, " BIOMIMICRY AND THE BUILT ENVIRONMENT, LEARNING FROM NATURE'S SOLUTIONS. " *In MDPI journal*, (2021), pp. 1-19.

[16] Pathak, Shivi, " BIOMIMICRY: (INNOVATION INSPIRED BY NATURE). "*, in International Journal of New Technology and Research,* (2019), pp. 34-38.

[17] Oguntona, Olusegu and Aigbavboa, Clinton, " NATURE INSPIRATION, IMITATION AND EMULATION: BIOMIMICRY THINKING PATH TO SUSTAINABILITY IN THE CONSTRUCTION INDUSTRY. ", *in Built Environ,* (2023), pp. 1-12

[18] AlAli, Mariam, Mattar, Yara, Alzaim, Mhd and Beheiry, salwa, "APPLICATION OF BIOMIMICRY IN ARCHITECTURE, CONSTRUCTION AND CIVIL ENGINEERING. ", *in Biomimetic,* (2023), pp. 1-22.

[19] Vincent, Julian, Bogatyreva, Olga, Bogatyreva, Nikolaj, Bowyer, Adrian and Pahl, Anja-karina "BIOMIMETICS: ITS PRACTICE AND THEORY. ", *in journal of the royal society*, (2006), pp. 471–482.

[20] Autumn K, Hsieh ST, Dudek DM, Chen J, Chitaphan C and Full RJ. " DYNAMICS OF GECKOS RUNNING VERRTICALLY. ", *in the journal of experimental biology,* (2006), pp.260-272.

[21] utumn K, C. Majidi, R. E. Groff, A. Dittmore and R. Fearing, "EFFECTIVE ELEASTIC MODULUS OF ISOLATED GECKO SETAL ARRAYS. " *In the journal of experimental biology*, (2006), pp. 3558-3568.

22 Sikdar, Soumya, Rahman, Hafizur, Siddaiah, Arpith and Menezes, Pradeep, " GECKO- INSPIRED ADHESIVE MECHANISMS AND ADHESICES FOR ROBOTS-A REVIEW. ", *in Robotics journal,* (2022), pp. 1-42.

23 Wang, Wei, Liu, Yang and Xie, Zongwu, " GECKO-LIKE DRY ADHESIVE SURFACES AND THEIR APPLICATION: A REVIEW. " *In journal of bionic engineering,* (2021), pp. 1011–1044.

24 Autumn, Kellar, Liang, Yiching, Hsieh, Tonia, Zesch, Wolfgang, Pang Chan, Wai, Kenny, Thomas, Fearing, Ronald and j. Full, Robert, " ADHESIVE FORCE OF A SINGLE GECKO FOOT-HAIR. ", *Article in Nature,* (2000), pp.1-16.

25 Al-Murahhem, Faredah, "A NEW INTERPRETATION OF LOCAL BUILT HERITAGE. ", *in Fine Arts Magazine,* (non), pp.1-11.

26 AUTUMN, Kellar, Gravish, Nick, "GECKO ADHESION: EVOLUTIONARY NANOTECHNOLOGY. ", *In philos trans a math phys eng sci,* (2008), pp. 1575-1590.

27 Graham, Sarah. "Scientists Unravel How Geckos Keep Their Sticky Feet Clean." *Scientific American,* Scientific American, 4 Jan. 2005, www.scientificamerican.com/article/scientists-unravel-how-ge/.

28 Al-Byaddiah Façade, https://ar.wikipedia.org/wiki/%D9%82%D8%B5%D8%B1_%D8%A7%D9%84%D8%B3%D9%82%D8%A7%D9%81 ,[Accessed Augest 2023]

29 Location and directions of overloading beam cracks. https://crspgh.com/about-concrete-repair-services/causes-of-concrete-cracks/ ,[Accessed Augest 2023]

30 Column Cracks type. https://theconstructor.org/concrete/types-cracks-concrete-columns/26433/ , [Accessed Augest 2023]

31 Hairline Cracks (NON-Structural Cracks), https://theconstructor.org/concrete/hairline-crack-concrete-cause-repair/27860/ , [Accessed September 2023].

SOCIO-CULTURAL DYNAMICS OF DWELLING IN PERSIAN ARCHITECTURE: A CRITICAL REVIEW OF COMPONENTS OF CULTURE, INTERRELATIONS, AND LAYERS

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SOCIO-CULTURAL DYNAMICS OF DWELLING IN PERSIAN ARCHITECTURE: A CRITICAL REVIEW OF COMPONENTS OF CULTURE, INTERRELATIONS, AND LAYERS

◆ ◆ ◆

This study explores the intricate relationship between culture and dwelling in traditional Iranian societies. It highlights the challenge of dwelling design evolving more rapidly than culture, leading to architectural practices disconnected from their cultural context. To address this issue, the paper emphasizes the need for ongoing research and the adoption of temporal and dismantling approaches. The research focuses on identifying the socio-cultural factors that shaped Persian traditional dwellings through a scoping literature review, shedding light on future directions for understanding the dynamics of culture-housing relationship in Iran.

1. INTRODUCTION

A dwelling is a physical structure people use for living, which affords specific functions and serves as inhabitants' primary anchor. Academic literature has diverse interpretations on the design and spatial characteristics of built environments, especially dwellings. Some suggest that the form and spatial properties of dwellings respond to regional climate and topography, particularly in vernacular settlements[1]. Others highlight the importance of available materials, constructions, and technological techniques[2]. However, it has been well-argued that the form of vernacular dwellings, or any other built environment, are unlikely to be solely determined by physical forces such as climate and technology, but rather influenced by a wide range of socio-cultural factors[3]. The dynamic relationship between culture and built environments, indeed, has been widely acknowledged, leading to the argument that:

> "Given a certain climate, what finally decides the form of a dwelling, moulds the spaces and their relationships is the vision that people have of the ideal environment sought reflects many socio-cultural factors, including religious beliefs, social organization, way of gaining a livelihood, and social relations of individuals."

<div align="right">Amos Rapoport[4].</div>

However, culture is a dynamic system, it evolves and changes over time. Cultural values, practices, and preferences shift due to globalization, social transformations, and urbanization[5]. Many scholars in the field of culture of dwelling observed that these issues are generally more noticeable in the traditional and historic societies with conservative social structures and values, like East Asian, Mediterranean, and Middle Eastern countries[6,7,8]. It is well-established that traditional dwellings in these countries were carefully designed in response to the socio-cultural characteristics of their inhabitants, such as family structure, religious values, and societal norms[7,9,10]. Nevertheless, ongoing changes in the social conditions in these countries, resulting from

globalization, urbanization, modernization, and changing lifestyles, led to the discontinuation of historical traditions in the urban and dwelling forms of these regions[11]. Persian traditional dwellings, representing the traditional architectural style of dwelling in Iran as inward-looking courtyard houses, exemplify one of the traditional settlements that were well-designed in response to the socio-cultural characteristics of their inhabitants[12]. However, despite its unique socio-spatial characteristics, the inward-looking courtyard pattern of dwellings was discontinued in the 20th century. Iranian architectural scholars and historians generally assumed that transition in domestic architecture in Iran occurred because of the reinterpretation of many social and cultural values within Iranian society[13,14]. Nevertheless, from a historical perspective, changes in socio-cultural values and practices are generally much slower than changes in dwellings design and architecture[15]. The lack of a thorough understanding of this dynamic relationship between culture and dwellings can result in architectural practices that are disconnected from their cultural context and lack socio-cultural sustainability. This underscores the significance of ongoing research on the interplay between culture and dwellings to ensure that dwellings function efficiently and are responsive to the socio-cultural needs of a specific region. To address this issue, it is first essential to adopt both temporal[16] and dismantling[17] approaches. The temporal perspective examines the culture of dwelling through a chronological lens, while the dismantling perspective involves deconstructing the broad concept of culture into several components and variables. The first stage of the adoption of these approaches, therefore, requires identifying the variables that shaped the spatial characteristics of traditional dwellings. This paper aims to take the initial step and conduct a scoping literature review, providing a synthesis of different socio-cultural factors that dictated the spatial properties of Persian traditional dwellings. By placing the traditional dwellings under examination, the paper then sparks a dialogue on the dynamic relationship between culture and dwellings in Iran over time. Opening this dialogue is relevant because the form and spatial properties of dwellings in Iran have undergone significant changes throughout the time. Therefore, given the significant socio-cultural characteristics embedded in the spatial properties of Persian traditional dwellings, raising the question of "what and if dwellings can represent as a part of the dynamism of culture in Iran" is relevant. By providing a synthesis of previous research on Persian traditional dwellings, the paper can lighten future research paths for addressing the raised question, the dynamism of culture-dwelling relationship in Iran over time.

2. METHODOLOGY

To effectively conduct a scoping review on the current literature, this paper adopted the five stages of the framework proposed by Arksey and Malley[18]. First, the main keywords related to the research topic were determined and searched in the two main electronic databases, Web of Science, and Google Scholar, in mid-2023 (July 2023 last search). All peer-reviewed articles, conference papers, and book chapters containing the keywords of (culture OR socio-cultural OR cultural OR social) AND (dwelling OR house OR home) AND

(Iran* OR Persia*) in their title/abstract/keywords were identified and selected for further consideration to extract socio-cultural factors embedded in the Persian traditional dwellings. No timespan limitation was imposed. However, the language was restricted to Persian and English. The papers were included for further content analysis only if they explored at least one socio-cultural characteristics of Persian traditional dwellings. That is, publications related to other Persian traditional built environments, such as mosques-schools[19], schools[20], and bazaars[21], were removed. Eventually, 29 relevant publications were selected for further analysis (Table 1).

	AUTHOR(S)	YEAR	TITLE	DISCUSSED SOCIO-CULTURAL FACTOR
1	S. Mazumdar and S. Mazumdar[12]	1994	Societal values and architecture: A socio-physical model of the interrelationships	Family structure, privacy, gender relation, modesty
2	S. Mazumdar and S. Mazumdar[22]	1997	Religious traditions and domestic architecture: A comparative analysis of Zoroastrian and Islamic houses in Iran	Family structure, privacy, gender relation
3	M. Mirmoghtadaee[23]	2009	Process of housing transformation in Iran	Family structure, way of gaining a livelihood
4	M. Gharavi Alkhansari[24]	2015	Analysis of the responsive aspects of the traditional Persian house	Family structure, privacy, gender relation
5	S. R. H. Raviz, A. N. Eteghad, E. U. Guardiola and A. A. Aira[25]	2015	Iranian courtyard housing: The role of social and cultural patterns to reach the spatial formation in the light of an accentuated privacy	Family structure, privacy, gender relation
6	E. Fallah and I. Hojat[26]	2018	Investigating the effect of family structure changes on houses' spatial organization using grounded theory: A case study of the houses of Yazd	Family structure, privacy
7	L. Rajendran, F. Molki, S. Mahdizadeh and A. Mehan[27]	2021	(Re) framing spatiality as a socio-cultural paradigm: examining the Iranian housing culture and processes	Family structure, hospitality, privacy, gender relation
8	A. Khaki Ghasr[28]	2019	Space programs of traditional houses in Yazd in relation to contemporary dwelling	Way of gaining a livelihood, hospitality, gender relation
9	S. Moqadam and L. Nubani[29]	2022	From house to home: exploring the spatial expression of social identity on traditional Shiraz houses	Way of gaining a livelihood, hospitality, privacy, gender relation
10	G. Memarian and F. E. Brown[30]	2003	Climate, culture, and religion: Aspects of the traditional courtyard house in Iran	Hospitality, privacy,
11	M. M. Shabani, M. M. Tahir, H. Shabankareh, H. Arjmandi and F. Mazaheri[31]	2011	Relation of cultural and social attributes in dwelling, responding to privacy in Iranian traditional house	Hospitality, privacy, gender relation

12	M. M. Tehrani and M. Duffy[32]	2015	The sensuous host: practices of ensuring guests feel 'at home' in traditional Iranian houses	Hospitality, privacy
13	M. Golabi and F. C. Bilsel[33]	2020	A Study on the Spatial Organization of Post-Revolutionary Houses in Tabriz (1980s)	Hospitality
14	M. Sadoughianzadeh[34]	2013	Gender Structure and Spatial Organization: Iranian Traditional Spaces	Privacy, gender relation
15	G. H. Memarian and A. M. Ranjbar-Kermani[35]	2011	Privacy of house in Islamic culture: A comparative study of pattern of privacy in houses in Kerman	Privacy, gender relation
16	H. Kamalipour and M. Zaroudi[36]	2014	Sociocultural context and vernacular housing morphology: A case study	Privacy
17	H. Nejadriahi and O. Dincyurek[37]	2015	Identifying Privacy Concerns on the Formation of Courtyards	Privacy
18	S. Alitajer and G. Molavi Nojoumi[38]	2016	Privacy at home: Analysis of behavioral patterns in the spatial configuration of traditional and modern houses in the city of Hamedan based on the notion of space syntax	Privacy
19	R. Askarizad[39]	2018	Influence of Socio-Cultural Factors on the Formation of Architectural Spaces (Case Study: Historical Residential Houses in Iran)	Privacy
20	H. Khosravi[40]	2020	Theology of Form	Privacy
21	H. Kamelnia, P. Hanachi and M. Moayedi[41]	2022	Exploring the spatial structure of Toon historical town courtyard houses: topological characteristics of the courtyard based on a configuration approach	Privacy
22	F. Khozaei Ravari, A. S. Hassan, M. H. Abdul Nasir and M. Mohammad Taheri[13]	2022	The development of residential spatial configuration for visual privacy in Iranian dwellings, a space syntax approach	Privacy, gender relation
23	A. Zabihi and R. Mirzaei[42]	2022	The evolution of privacy in contemporary houses in Iran using space syntax techniques: a case study of Kerman	Privacy
24	A. Shayegani and V. Joklová[43]	2023	Investigating privacy principles' formation in vernacular architecture of arid and semi-arid parts of Iran	Privacy, gender relation
25	M. Valibeigi, S. Maroofi and S. Danay[44]	2022	The Material Cultures of the Iranian Home: Cultural Reading	Privacy, modesty
26	B. Mazinanian, J. Sabernejad, M. Dolati and N. Nikghadam[45]	2022	The influence of culture in the body of traditional courtyards of Hamedan based on data theory	Privacy
27	S. Mazumdar and S. Mazumdar[46]	2001	Rethinking public and private space: Religion and women in Muslim society	Gender relation

| 28 | G. Memarian and A. Sadoughi[47] | 2011 | Application of access graphs and home culture: examining factors relative to climate and privacy in Iranian houses | Gender relation |
| 29 | G. Memarian and F. Brown[48] | 2004 | The shared characteristics of Iranian and Arab courtyard houses | Gender relation |

Table 1: Twenty-nine publications included for review and their discussed socio-cultural factor(s).

3. PERSIAN TRADITIONAL DWELLINGS: SOCIO-SPATIAL CHARACTERISTICS

The socio-cultural factors explored in the domain of Persian dwelling studies are identified and categorized in this section. These socio-cultural factors include family structure, way of gaining a livelihood, hospitality, privacy, gender relation, and modesty. Figure 1 illustrates a schematic morphology of a Perian dwelling and its main components.
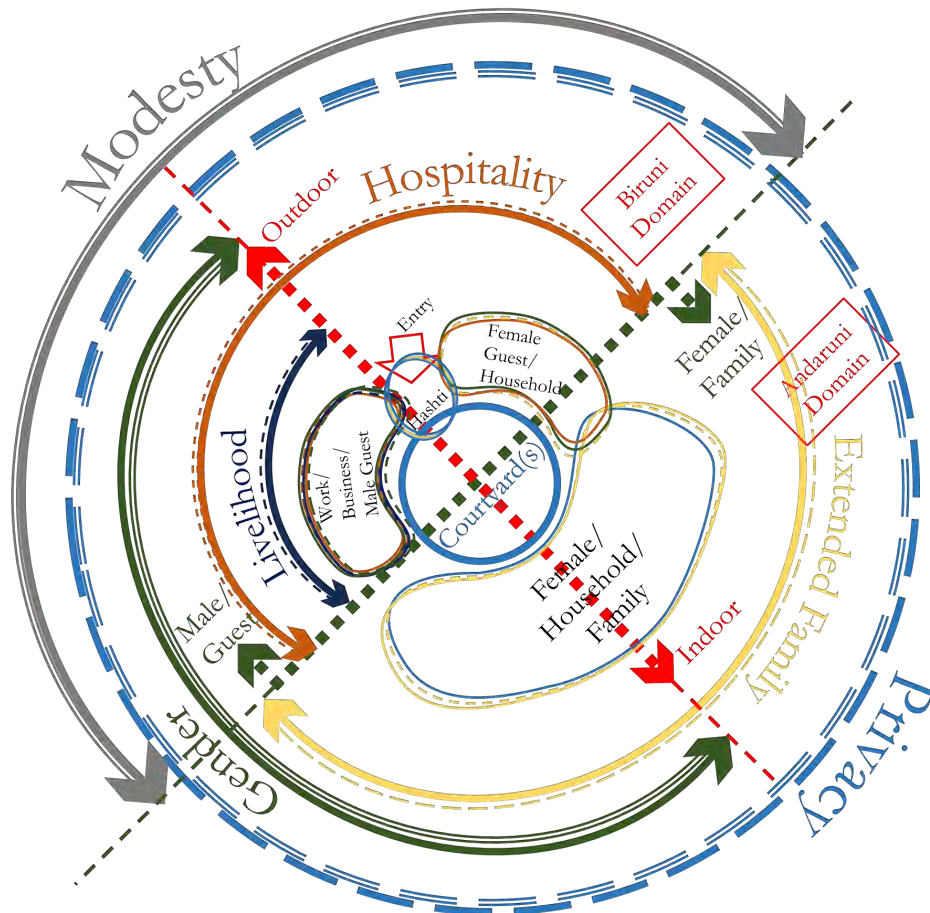

Fig. 1: A schematic morphological diagram of a Persian dwelling.

The definition and certain considerations for each identified socio-cultural factor are summarized in Table 2. The following sections highlight the reasons why these socio-cultural factors are relevant, as well as the design interventions applied in Persian traditional dwellings to address each identified socio-cultural factor.

SOCIO-CULTURAL FACTOR	DEFINITION OR CONSIDERATION FOR THE SOCIO-CULTURAL FACTORS
FAMILY STRUCTURE	It refers to different forms of families and households, such as a polygynous family, a nuclear family, and an extended family, and how they shape the nature of their accommodation[5].
WAY OF GAINING A LIVELIHOOD	The way individuals make a living, particularly whether it is inside or outside the dwelling.
HOSPITALITY	A dwelling that provides chances to offer hospitality to neighbours and extended family members[49].
PRIVACY	A dwelling as a private place for personal and familial sanctuary[49].
GENDER RELATION	A dwelling that accommodates the socially and culturally ways in which men and women are supposed to interact with each other within a particular society[34].
MODESTY	A dwelling NOT as a means of showing off one's wealth[49].

Table 2: The socio-cultural factors affecting the spatial properties of Persian dwellings.

3.1. Family Structure

There is a direct relationship between "family type and cycle" and size and form of Persian traditional dwellings. Due to the prevalence of patrilocality and extended family structure in Iran, multi-courtyard housing was common, with each courtyard cluster designated for an individual family while maintaining connections between them[12,22,23,24]. Maintaining this connection was valued because of the strong kinship bonds among members of the family[25,26,27]. In addition, the family structure resulted in large-scale dwellings where a relatively large number of inhabitants could be accommodated[12,22] (Fig. 2).

3.2. Way of Gaining a Livelihood

In the past, living and working spaces in Iran were frequently integrated. Many wealthy families, including governors, merchants, and businessmen, built multi-courtyard houses, dedicating a separate courtyard and its associated rooms to their business activities[23,28,29]. Figure 2 shows the 19th-century house of Imam Juma in Isfahan, a religious leader, with one courtyard dedicated to working activities.
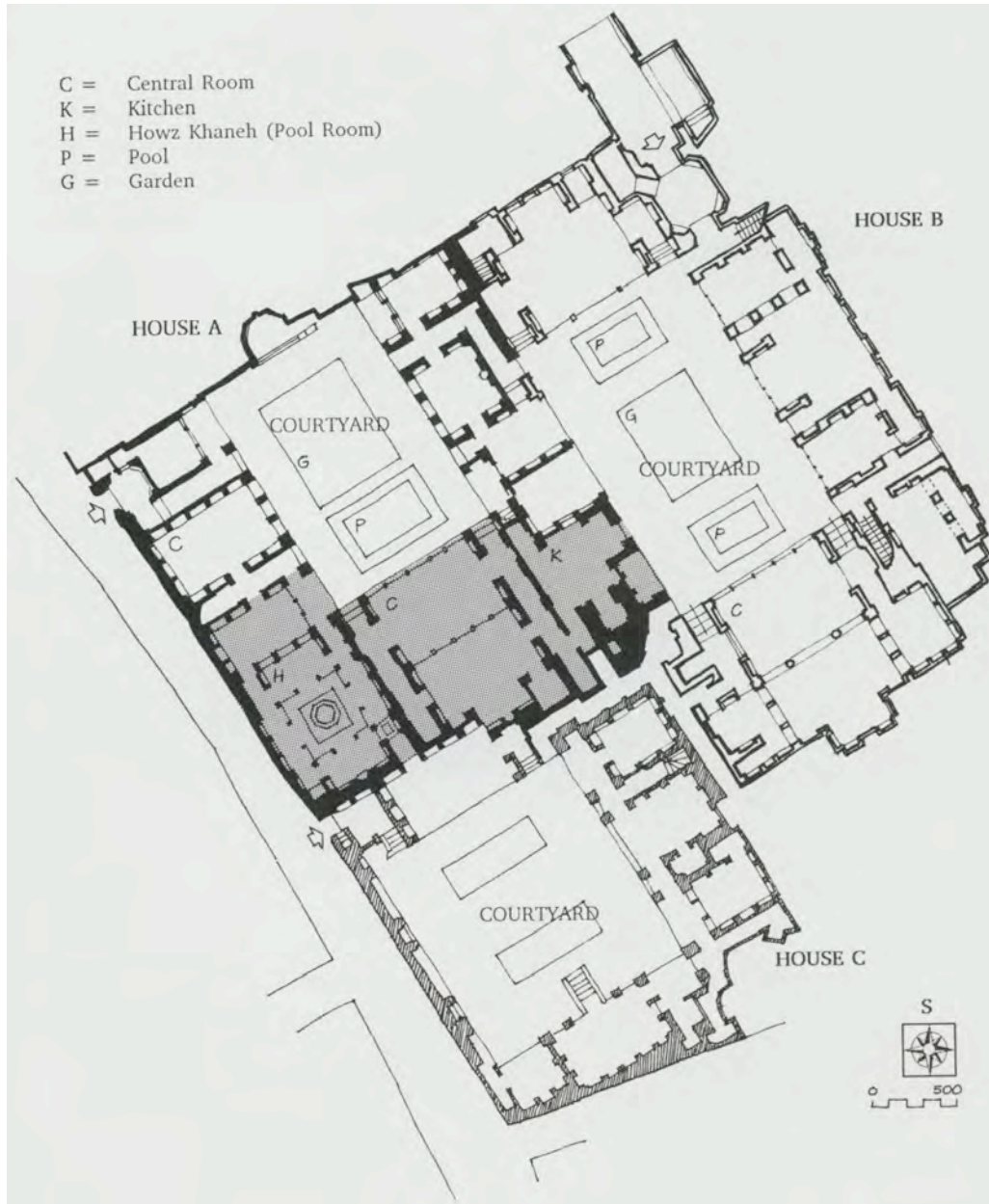
Fig. 2: Imam Juma house: an example of a multi-courtyard house in Isfahan, Iran. (Source: Iran: Ministry of Culture & Arts, 1976, adapted from Sanjoy Mazumdar and Shampa Mazumdar, 1994).

3.3. Hospitality

Resulted from the society's religion, Islam, hospitality is a religious value that affected the spatial organization of Persian traditional dwellings[30,31]. In Islamic culture, hospitality is a deep-rooted teaching that places great emphasis on the friendship, kinship, and social interaction among all members of Islamic society[30]. Based on the Islamic teachings, the act of visiting each other's homes is a way to strengthen the bonds among members of the (Islamic) society and is regarded as a holy deed by Allah (God). This religious value has been

manifested in Persian traditional dwellings through assigning a usually well-decorated, spacious room to guests as a "guest room", parlor or "*mehman-khaneh*" in Persian[27,28,29,30,32,33].

3.4. Privacy

Privacy was another religious value in the Iranian Muslim society, playing a pivotal role in dictating the spatial arrangement and design of Persian traditional dwellings. In fact, privacy in Persian traditional dwellings was based on the teachings of Quran because Islamic teachings place great importance not only on the separation and invisibility of the household realm from the public, but also on the keeping female members out of sight of male strangers while they were not wearing hijab[22,25,26,31]. Several design interventions were employed to achieve a desired level of visual privacy in Persian traditional dwellings. Firstly, the inward-looking courtyard pattern of dwellings ensured that there was an appropriate distance to control view to the inside of dwellings, avoiding the direct visibility into the internal living areas where family daily activities were performed[13,22,24,25,26,27,29,34,35,36,37,38,39,40,41,42] (Fig. 3). This inward-looking courtyard pattern with high walls enclosing the dwelling also minimized or eliminated the need for windows overlooking the street as interior spaces faced the central courtyard to receive sunlight and have a view[12,22,24,25,26,32,34,41,43]. In case windows overlooking the streets were required, they were installed at a considerable height above the line of sight to prevent any direct views into the dwellings[12]. This spatial characteristics, inward-looking courtyard pattern, has also been known as "introvert architecture" that emphasizes hiding what exists inside the dwelling[34,42,44].
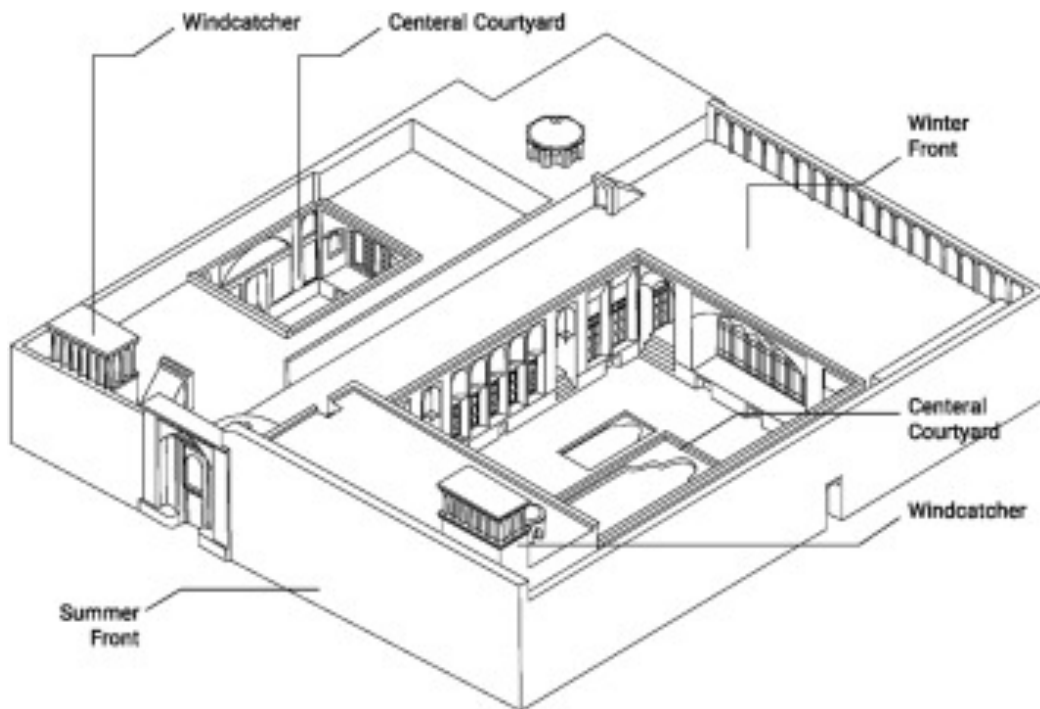

Fig. 3: Rasoulian house: an example of an inward-looking courtyard house with windowless walls fronting the street in Yazd, Iran. (Source: Haji Ghasemi, 1996).

Another design approach to maintaining household and female privacy was the measures taken in the design and location of the entrance areas. Obviously, the entrance doors and areas are a transitional space between the private and public realm. In Persian traditional dwellings, the entrance area had a spatial character that blocked the direct visibility and accessibility to the courtyard and interior spaces of the dwellings. More specifically, the entrance area, which was called "*hashti*", was the only place connected to the street and served to prevent the sacred interior from being visible to strangers[12,24,26,34,37,43,44,45]. This entrance area was usually connected to an L-shape corridor leading to the central courtyard and other parts of the dwelling that ensured the invisibility of the courtyard and interior spaces[24,25,27,30,32] (Fig. 4).
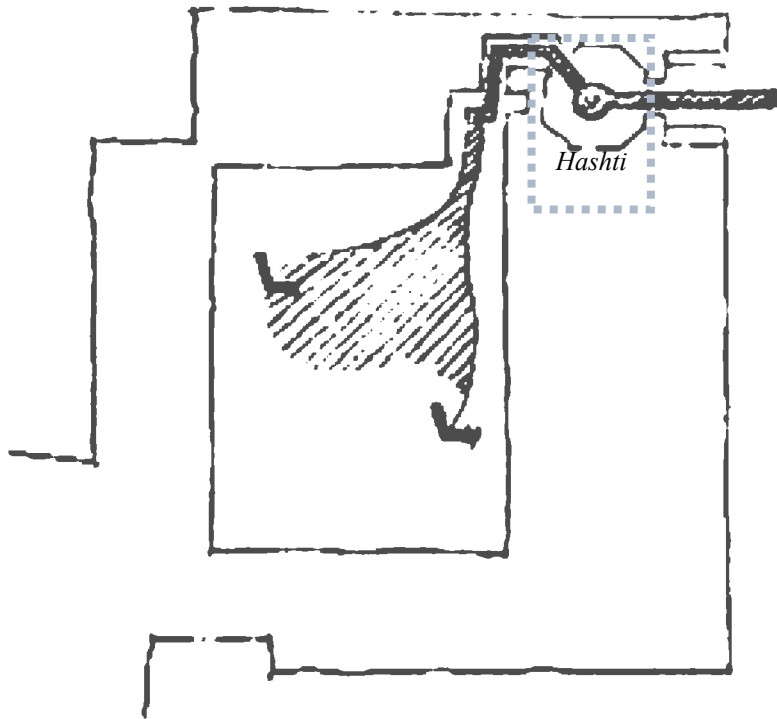

Hashti

Fig. 4: The hierarchy in the entrance area progresses from the outside to the "*hashti*" (highlighted by the rectangle), then to an L-shaped corridor, and finally to the courtyard. (Source: Maryam Gharavi Alkhansari, 2015).

3.5. Gender Relation

Division of male and female spaces, called gender-segregated spaces was another criterion adopted for ensuring gender segregation in Persian traditional dwellings. This gender division resulted from the Islamic teachings that place emphasis on keeping women out of sight of not-blood related and stranger (non-mahram) male. In fact, male and female were accepted to have social relationship only if they were related either through marriage or close blood ties[12,22,25,31,46]. Additionally, Islamic traditions discouraged intense social interactions and relations between not blood-related men and women**Error! Bookmark not defined.**, but encouraged hospitality and hosting neighbors, relatives, and friends[31]. To balance the desire for hospitality

and control gender relations, the effort was made to separate not only the public (male) and private (female) realms of the dwellings, but also the accessibility of the two realms[28,46,47]. Male, and female guests were often entertained separately[12,46]. In Persian traditional dwellings, double or multi-courtyard dwellings were a conventional design approach to separating female private spaces from more public (male) or guest realms of the dwellings. Specifically, many inward-looking courtyard houses in Iran consisted of two main domains and courtyards, named "*andaruni*" (private/female domain) and "*biruni*" (public/male domain)[12,22,25,27,47] (Fig. 5). "*Biruni*" referred to the public part and was either located near the main entrance area, or had a separate entrance area, and traditionally served as a male domain. It was the domain where the household would welcome the male guests. On the other hand, "*andaruni*" was designed for family members, particularly the females, and female guests[13,22,24,25,29]. Nevertheless, not all people could afford constructing multi-courtyard houses to provide gender-segregated courtyards[12,22,34,35]. In these cases, attempt was made to divide public (male guest) and private (family and female guest) realms/ domains of the houses in other ways. For instance, in the Iranian single courtyard houses that dedication of a separate courtyard for male/guests' domains was impossible the male guest room or parlor was usually located next to or very close to the entrance area of the house and was designed in a way that could be entered before reaching the courtyard or private living spaces so that the household and female privacy was maintained[22,25,31,35,43,48].
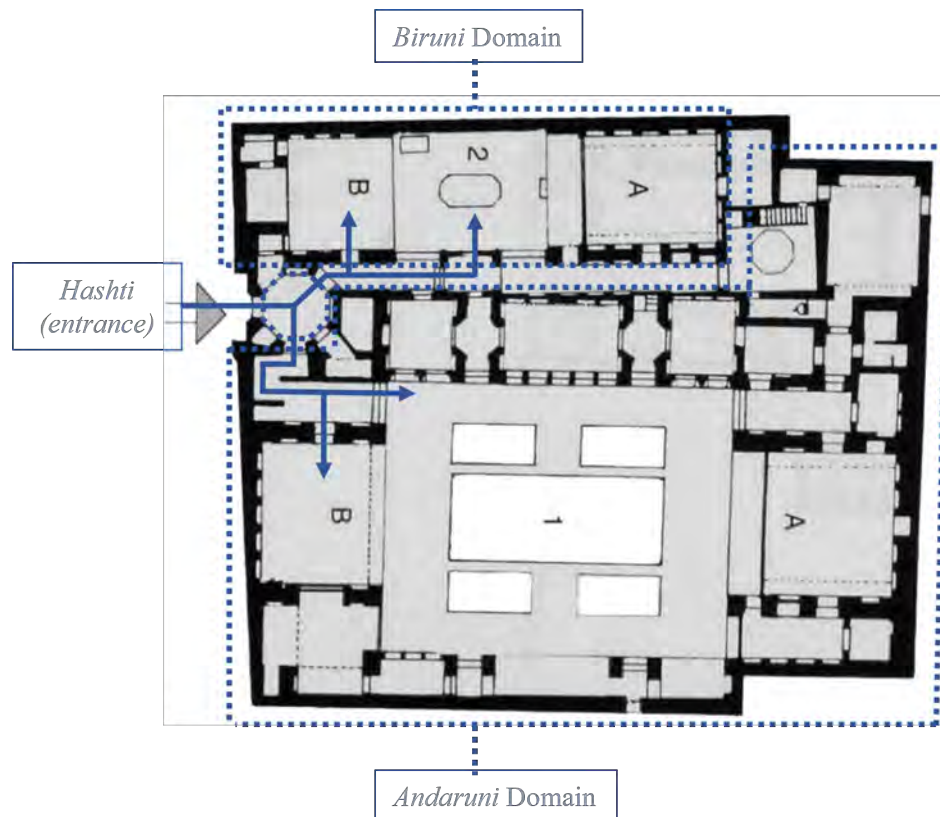

Fig. 5: Rasoulian house: an example of a two-courtyard house with separate public and private domains, as well as separate accessibility for each domain. (Source: Gholamhossein Memarian and Arezou Sadoughi, 2011).

3.6. Modesty

In the Persian traditional society, value was assigned to the simplicity of dwellings than showing wealth and prosperity through one's dwelling. The façade of Persian traditional dwellings, as a result, projected nothing but simple mud walls with the entrance as the only opening[24,44] (Fig. 6). This design approach also stemmed from the traditional Islamic principles and guidelines that emphasized simplicity and modesty in planning and regulating built environments especially dwellings. More specifically, Islamic principles involves prohibiting excessive spending on building the house, particularly external areas, as a means of showing off one's wealth in order not to hurt feelings of the less fortunate and not to arouse the envy of neighbors and passer-byes. This approach has been known as humility and modesty by scholars[44]. However, it should be mentioned that this design approach was mostly adopted in the design of the façade and exterior parts of dwellings that could be observed by strangers and neighbors. This means that while usually having restrained, plain, and simple exteriors, Persian traditional dwellings could be rich and luxurious inside[44]. For instance, traditional wealthy families tended to decorate their inward-looking courtyard houses with colorful luxurious sash-windows, called *orosi*[50].

Fig. 6: Plain, windowless, mud façade of Persian dwellings. (Source: Sanjoy Mazumdar and Shampa Mazumdar, 1994).

4. DYNAMIS OF CULTURE-DWELLING RELATIONSHIPS IN IRAN OVER TIME: CONTEMPORARY EVOLUTION

As detailed in the previous section, the spatial characteristics of Persian traditional dwellings were well-developed in response to the socio-cultural characteristics of their inhabitants, including family structure, way of gaining a livelihood, hospitality, privacy, gender relation norms, and modesty. Although this traditional architectural type of dwelling, inward-looking courtyard pattern of dwelling, predated the Seljuk period (1037-1194) in Iran, it remained consistent over a long period of time and persisted until the second half of the 20th century in Iran[51]. However, despite its unique spatial and cultural characteristics, this courtyard pattern of dwellings was completely discontinued in the 20th century. The transformation of the traditional courtyard houses into other types of housing, such as villas and apartments, was regarded as a major shift in the spatial form of dwelling in Iran[51] (Fig. 7).
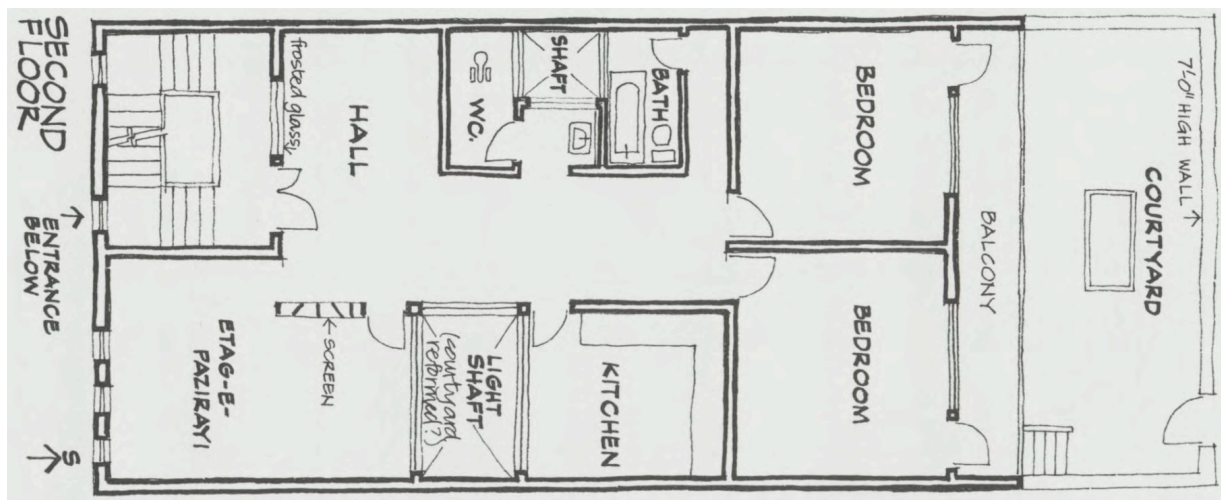

Fig. 7: Plan of a contemporary apartment unit in Tehran, Iran. (Source: Sanjoy Mazumdar and Shampa Mazumdar, 1994).

Scholars on Persian architecture have put diverse interpretations on the reasons behind the significant spatial transformations of dwellings in Iran. Factors that have been presumed to account for the changes in the spatial form of Persian dwellings included modernization[14,27], imitation from the Western architectural patterns because of the authorities' travel to Europe or returning local architects who were sent to Europe to study architecture[52,53], and political changes[33]. These studies also shared the assumption that these factors, modernization, westernization, and political changes, paved the way for re-interpretation of many social and cultural values and lifestyle patterns in Iranian society, leading to transition in domestic architectural patterns[13,14]. Nevertheless, these subjective interpretations on the reasons behind the spatial transformations of dwellings in Iran have been more based on a series of assumptions rather than being relied on empirical

and rigorous testing. In addition, although it is acceptable that socio-cultural values are everchanging, and dwellings can dynamically adapt to new cultural values and practices, from a historical standpoint, shifts in socio-cultural values typically occur at a slower pace compared to changes in dwelling design[15]. Consequently, there is a legitimate reason to question the accuracy of previous subjective interpretations on dwelling transition in Iran, as they lack a strong foundation in specific, in-depth cultural studies. The shared assumption among Iranian scholars that those certain social transformations, such as modernization and Westernization, directly facilitated socio-cultural changes that, in turn, led to shifts in domestic architecture, represents a considerable claim. Spatial transformation of dwellings can be claimed to be a legitimate manifestation of the socio-cultural changes only if the dynamism of the identified socio-cultural factors in scoping review is experimentally studied[16]. This process would entail first-hand cultural analyses, involving a deep and systematic examination of the significance and nature of each socio-cultural factor through time within the context of Iran. Therefore, there is a need for analyzing the networks of spatial and socio-cultural relationships over time in Iran to validate the specific socio-cultural changes that occurred and whether and how they contributed to the spatial transformations of dwellings. As Lawrence proposed, the explanation for these transformations can only be sought by studying the dynamic nature of culture in a society, and its interrelationships with changing spatial forms[16]. Only through these experimental analyses can we uncover what dwellings can truly represent as a part of the dynamism of culture in Iran, mitigating assumptions and subjective interpretations.

In addition, Rapoport, Oliver, and Lawrence, seminal scholars in the field of culture and dwelling, highlight that the relationship between culture and dwelling is dynamic and changeable, as culture includes factors that might evolve over time[4,5,16]. Furthermore, they suggest that a comprehensive examination of the history of dwelling and its socio-cultural background requires the integration of both temporal and dismantling perspectives[16,17]. Adoption of a temporal perspective is important because the dwelling, as a socio-cultural artefact, can only be comprehended when explored over time. This is since the connection between the dwelling and its inhabitants is dynamic and changeable, often involving components that may remain unresolved over an extended period[16]. Thus, a historical perspective is essential for comprehending the way in which alterations occur in both the physical and socio-cultural aspects and how these shifts manifest in the architectural design and utilization of built environments[54]. Moreover, it is necessary to adopt a dismantling approach because culture is a broad concept, encompassing a range of beliefs, values, practices, and social norms[17]. Therefore, for studying the evolving socio-cultural characteristics underlying dwelling form over time, it is necessary to first study the history of the socio-cultural variables or components which formed the design and use of domestic architecture in the historical context. These socio-cultural variables would then serve as a framework to assess how these characteristics have transformed, remained unchanged, or ceased to exist. Accordingly, by placing the traditional dwellings under critical examination in this paper, we took the

initial step for comprehending the dynamic relationship between culture and dwelling in Iran, promoting an understanding of the socio-cultural components invested in the spatial properties of Persian traditional dwellings. In the next step, we hope to dig deeper into how the identified traditions, values, and practices have evolved within the Iranian context, and how they influenced the spatial transformation of dwellings through the course of time.

5. CONCLUSION

 The relationship between culture and dwelling is complex, with socio-cultural values evolving over time. While it is acceptable that socio-cultural values are constantly changing, and dwellings can adjust to new cultural norms, historically, changes in socio-cultural values have tended to happen more slowly than changes in dwellings design. In Iran, domestic architecture has undergone significant transformations, consequently, raising concerns about the socio-cultural sustainability of dwellings. This paper highlighted the need for ongoing research on culture-dwelling relationships while adopting temporal and dismantling approaches. These approaches involved deconstructing the broad concept of culture into more explicit components, identifying the socio-cultural factors that shaped the spatial characteristics of Persian traditional dwellings. Accordingly, a scoping literature review was conducted to synthesize the socio-cultural factors affecting the spatial properties of Persian traditional dwellings, known as inward-looking courtyard houses. The review indicated that six main socio-cultural factors dictated the design and use of traditional dwellings in Iran, with the religion playing the primary role. More specifically, the inward-looking courtyard houses in Iran were carefully designed to suit the socio-cultural characteristics of their inhabitants, including extended family structure, inhabitants' occupation, and the integration of work, and living spaces, the need for hospitality, and religious values and norms towards household privacy, gender relation, and modesty. The paper then sparked a dialogue on the dynamic interplay between culture and dwellings in Iran over time. By placing traditional dwellings under examination, the paper can lighten future research paths for engaging in the opened dialogue.

NOTES AND REFERENCES

[1] Nguyen, Anh-Tuan, Tran Quoc-Bao, Tran Duc-Quang, and Reiter Sigrid, "An investigation on climate responsive design strategies of vernacular housing in Vietnam", *Building and Environment*, 46.10 (2011), p. 2088-2106.

[2] Pardo, José M, "Challenges and Current Research Trends for Vernacular Architecture in a Global World: A Literature Review", *Buildings*, 13.1 (2023).

3 Vellinga, Marcel, ""How Other Peoples Dwell and Build" Erwin Anton Gutkind and the Architecture of the Other", *Journal of the Society of Architectural Historians*, 78.4 (2019), p. 409-421.

4 Rapoport, Amos. *House form and culture*. Engelwood Cliffs: NJ: Prentice-Hall, 1969.

5 Oliver, Paul. *Encyclopedia of vernacular architecture of the world*. Cambridge University Press, 1997.

6 Yangang, Fang, "The modification of North China quadrangles in response to rural social and economic changes in agricultural villages: 1970–2010s", *Land Use Policy*, 39 (2014), p. 266-280.

7 Erdoğan, Nevnihal. "How Do Social Values and Norms Affect Architecture of the Turkish House? ", *Socialization: A Multidimensional Perspective*, 2018.

8 Adebara, Temitope Muyiwa. "Private open space as a reflection of culture: the example of traditional courtyard houses in Nigeria." *Open House International,* 48.3 (2023), p.617-635.

9 Al-Haroun, Yousef, and Mohammed Al-Ajmi. "Understanding socio-cultural spaces between the Hadhar and Badu houses in Kuwait." *Archnet-IJAR: International Journal of Architectural Research,* 12.3 (2018), p. 68.

10 Al-Mohannadi, Asmaa Saleh, and Raffaello Furlan. "Socio-cultural patterns embedded into the built form of Qatari houses: Regenerating architectural identity in Qatar." *Journal of urban regeneration & renewal*, 12. 4 (2019), p. 336-358.

11 Kiet, Anthony. "Arab culture and urban form." *Focus* 8, 1 (2011), p 10.

12 Mazumdar, Sanjoy, and Shampa Mazumdar. "Societal values and architecture: A socio-physical model of the interrelationships." *Journal of Architectural and Planning Research,* (1994), p. 66-90.

13 Khozaei Ravari, Fatemeh, Ahmad Sanusi Hassan, Muhammad Hafeez Abdul Nasir, and Mohsen Mohammad Taheri. "The development of residential spatial configuration for visual privacy in Iranian dwellings, a space syntax approach." *International Journal of Building Pathology and Adaptation,* (2022).

14 Imani, Elnaz, and Maziar Asefi. "INVESTIGATING THE CAUSES OF CHANGE IN IRANIAN ARCHITECTURE." *Traditional Dwellings and Settlements Review,* 30. 1 (2018), p. 54-54.

15 International Association for the Study of Traditional Environments (IASTE), (2023), Accessed October 19, 2023, https://iaste.org/iaste-2024-riyadh/.

16 Lawrence, Roderick J. "The comparative analyses of homes: Research method and application." *Social science information.* 22. 3 (1983), p. 461-485.

17 Rapoport, Amos. "Theory, culture and housing." *Housing, theory and society,* 17. 4 (2000), p. 145-165.

18 Arksey, Hilary, and Lisa O'Malley. "Scoping studies: towards a methodological framework." *International journal of social research methodology,* 8. 1 (2005), p. 19-32.

19 Fallah Tafti, Fatemeh, and Hamid Mirjany Arjanan. "A Comparative Study of the Configuration and Functions of Outdoor and Semi-Outdoor Space in Schools from the Traditional to the Contemporary Period Based on Evaluating the Role of the Governing Educational System." *Sustainability,* 13. 22 (2021), p. 12782.

20 Fallah Tafti, Fatemeh, and Ju Hyun Lee. "Examining Variance, Flexibility, and Centrality in the Spatial Configurations of Yazd Schools: A Longitudinal Analysis." *Buildings,* 12. 12 (2022), p. 2080.

21 Mohammadi Kalan, Arezou, and Eduardo Oliveira. "The sustainable architecture of bazaars and its relation with social, cultural and economic components (Case study: the historic Bazaar of Tabriz)." *International Journal of Architecture and Urban Development* 5, 4 (2015), p. 5-12.

[22] Mazumdar, Sanjoy, and Shampa Mazumdar. "Religious traditions and domestic architecture: A comparative analysis of Zoroastrian and Islamic houses in Iran." *Journal of architectural and Planning Research,* (1997), p. 181-208.

[23] Mirmoghtadaee, Mahta. "Process of Housing Transformation in Iran." *Journal of Construction in developing Countries,* 14. 1 (2009).

[24] Gharavi Alkhansari, Maryam. "Analysis of the responsive aspects of the traditional Persian house." *Journal of Architecture and Urbanism,* 39. 4 (2015), p. 273-289.

[25] Raviz, Seyed Reza Hosseini, Ali Nik Eteghad, Ezequiel Uson Guardiola, and Antonio Armesto Aira. "Iranian courtyard housing: The role of social and cultural patterns to reach the spatial formation in the light of an accentuated privacy." *ACE: Arquitectura, Ciudad y Entorno* (2015).

[26] Fallah, E., and I. Hojat. "Investigating the effect of family structure changes on houses' spatial organization using grounded theory: A case study of the houses of Yazd." *Iran University of Science & Technology,* 28. 2 (2018), p. 149-162.

[27] Rajendran, Lakshmi, Fariba Molki, Sara Mahdizadeh, and Asma Mehan. "(Re) framing spatiality as a socio-cultural paradigm: examining the Iranian housing culture and processes." (2021).

[28] Khaki Ghasr, Azadeh. "Space programs of traditional houses in Yazd in relation to contemporary dwelling." *Journal of Architecture in Hot and Dry Climate,* 6. 8 (2019), p. 23-46.

[29] Moqadam, Sadrodin, and Linda Nubani. "From house to home: exploring the spatial expression of social identity on traditional Shiraz houses." *Archnet-IJAR: International Journal of Architectural Research,* (2022).

[30] Memarian, Gholamhossein, and Frank Edward Brown. "Climate, culture, and religion: Aspects of the traditional courtyard house in Iran." *Journal of architectural and planning research,* (2003), p. 181-198.

[31] Shabani, Mohamad Mahdi, Mazlan Mohd Tahir, Hoda Shabankareh, Honey Arjmandi, and Fereshteh Mazaheri. "Relation of cultural and social attributes in dwelling, responding to privacy in Iranian traditional house." *e-BANGI,* 6. 2 (2011), p. 273.

[32] Tehrani, Melika M., and Michelle Duffy. "The sensuous host: practices of ensuring guests feel 'at home'in traditional Iranian houses." *Journal of South Asian Studies,* 3. 3 (2015), p. 351-361.

[33] Golabi, Maryam, and Fatma Cânâ Bilsel. "A Study on the Spatial Organization of Post-Revolutionary Houses in Tabriz (1980s); Tebriz'de Devrim Sonrası Konutların Mekânsal Organizasyonu Üzerine Bir Araştırma (1980'ler)." (2020).

[34] Sadoughianzadeh, Minoosh. "Gender structure and spatial organization: Iranian traditional spaces." *Sage Open,* 3. 4 (2013), p. 2158244013511258.

[35] Memarian, Gholam Hossein, and Ali Mohammad Ranjbar-Kermani. "Privacy of house in Islamic culture: A comparative study of pattern of privacy in houses in Kerman." *International Journal of Architectural Engineering and Urban Planning,* 21. 2 (2011), p. 69-77.

[36] Kamalipour, Hesam, and Mostafa Zaroudi. "Sociocultural context and vernacular housing morphology: A case study." *Current Urban Studies,* 2. 03 (2014), p 220.

[37] Nejadriahi, Halleh, and Ozgur Dincyurek. "Identifying privacy concerns on the formation of courtyards." *Open House International,* 40. 4 (2015), p. 18-24.

[38] Alitajer, Saeid, and Ghazaleh Molavi Nojoumi. "Privacy at home: Analysis of behavioral patterns in the spatial configuration of traditional and modern houses in the city of Hamedan based on the notion of space syntax." *Frontiers of Architectural Research,* 5. 3 (2016), p. 341-352.

[39] Askarizad, Reza. "Influence of Socio-Cultural Factors on the Formation of Architectural Spaces (Case Study: Historical Residential Houses in Iran)." *Creative City Design,* 1. 1 (2018), p. 29-36.

[40] Khosravi, Hamed. "Theology of a Form." *AA Files,* 77 (2020), p. 180–92.

[41] Kamelnia, Hamed, Pirouz Hanachi, and Mina Moayedi. "Exploring the spatial structure of Toon historical town courtyard houses: Topological characteristics of the courtyard based on a configuration approach." *Journal of Cultural Heritage Management and Sustainable Development,* (2022).

[42] Zabihi, Ali, and Reza Mirzaei. "The evolution of privacy in contemporary houses in Iran using space syntax techniques: a case study of Kerman." *Open House International,* 48. 1 (2023), p. 55-80.

[43] Shayegani, Aida, and Viera Joklová. "Investigating privacy principles' formation in vernacular architecture of arid and semi-arid parts of Iran." *Architecture Papers of the Faculty of Architecture and Design STU,* 28. 1 (2023), p.3-16.

[44] Valibeigi, Mojtaba, Sakineh Maroofi, and Sara Danay. "The Material Cultures of the Iranian Home: Cultural Reading." *Estoa. Revista de la Facultad de Arquitectura y Urbanismo de la Universidad de Cuenca,* 11. 22 (2022), p. 13-32.

[45] Mazinanian, Bahareh, Jaleh Sabernejad, Mohsen Dolati, and Niloufar Nikghadam. "The influence of culture in the body of traditional courtyards of Hamedan based on data theory." *Space Ontology International Journal,* 11. 1 (2022), p. 33-43.

[46] Mazumdar, Shampa, and Sanjoy Mazumdar. "Rethinking public and private space: Religion and women in Muslim society." *Journal of Architectural and Planning Research,* (2001), p. 302-324.

[47] Memarian, Gholamhossein, and Arezou Sadoughi. "Application of access graphs and home culture: examining factors relative to climate and privacy in Iranian houses." *Scientific Research and Essays,* 6. 30 (2011), p. 6350-6363.

[48] Memarian, Gholamhossein, and Frank Brown. "The shared characteristics of Iranian and Arab courtyard houses." *Courtyard housing: Past, present and future,* (2004), p. 21-30.

[49] Othman, Zulkeplee, Rosemary Aird, and Laurie Buys. "Privacy, modesty, hospitality, and the design of Muslim homes: A literature review." *Frontiers of Architectural Research,* 4. 1 (2015), p. 12-23.

[50] Faghihi, Parinaz, Fernando Quintas, and Teresa Almeida. "Architectural glass in the 18th to 20th centuries in Iran." *Glass science in art conservation,* (2017). P. 43-45.

[51] Zolfagharkhani, Mina, and Michael J. Ostwald. "The spatial structure of yazd courtyard houses: A space syntax analysis of the topological characteristics of the courtyard." *Buildings,* 11. 6 (2021), p. 262.

[52] Bani-Masoud, A. "Iranian Contemporary Architecture, the Struggle between Tradition and Modernity." (2011).

[53] ALALHESABI, MEHRAN, and NAIEMEH KORRANI. "The factors affecting housing evolution from the past to the future." *Journal of Housing and Rural Environment,* 32. 141 (2013), p. 19-36.

[54] Lawrence, Roderick J. "The interpretation of vernacular architecture." *Vernacular Architecture,* 14. 1 (1983), p. 19-28.

AL-FAQIR FORT PRESERVATION: ANALYZING AND DOCUMENTING WITH IMAGE-BASED AND UAV PHOTOGRAMMETRY 3D RECONSTRUCTION DATA - A CASE STUDY OF AL-ULA, SAUDI ARABIA

Wajdi Ali Atwah

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Saudi Arabia is known for its modern towers, but it also has a rich heritage that is at risk due to economic modernization. The World Heritage System helps preserve historical sites, but it requires local support. Preserving and developing historic sites in Saudi Arabia lacks knowledge, expertise, skilled personnel, and proper intervention approaches. It is important for governments, organizations, and people to work together to protect the nation's unique history.Photographic documentation is crucial for conserving cultural heritage, and digital photography has provided new opportunities in this field. Image-based 3D reconstruction, specifically through photogrammetry, is a valuable tool for analyzing and interpreting cultural heritage sites. These innovative methods produce complete and user-friendly 3D data that can be used for future plans and studies.The paper focuses on the utilization of image-based survey methods and UAV photogrammetry for architectural studies, using the Al-Faqir Fort in the Al-'Ula region of Saudi Arabia as a case study. This fort, which was recently destroyed by severe weather conditions, is an 18th-century landmark that played a vital role in guarding trade routes between Egypt, Syria, and Iraq. Its destruction highlights the importance of proactive measures to protect cultural heritage.Overall, preserving Saudi Arabia's heritage requires collaboration and support from various stakeholders. Utilizing advanced technologies like photogrammetry can enhance the analysis and interpretation of cultural heritage sites. The case study of Al-Faqir Fort emphasizes the value of safeguarding shared cultural heritage for future generations.

1. INTRODUCTION

The Kingdom of Saudi Arabia has a diverse architectural landscape, characterized by the presence of contemporary high-rise buildings, which symbolize its position as a global hub. Additionally, the nation possesses a significant historical inheritance, representing one of the first civilizations in human history. Tragically, the Kingdom faces the risk of compromising its cultural history, a matter of significant importance for both Arab culture and the global community, as it pursues economic modernization. The preservation of Saudi Arabia's cultural heritage primarily relies on the implementation of the World Heritage System (WHC) established in 1972[1].The 1972 World Heritage Convention aims to save historically significant places, although its effectiveness is conditional upon the level of domestic backing it receives. The protection of heritage is important for both national and international communities, given its distinct significance[2].

In recent years, there has been a significant expansion of historic preservation efforts in Saudi Arabia, resulting in several benefits such as increased tourism and investment opportunities. Additionally, these preservation initiatives play a crucial role in safeguarding the cultural identity and history of the country's historic monuments. The expansion seen may be defined to the enhanced recognition of the need to preserve and engage in constructive measures, such as restoration, especially by governmental entities, after the establishment of the Saudi Commission for Tourism and Antiques (SCTA) in 2000[3]. With the SCTA's renewed emphasis on the tourist and heritage industries, the enormous untapped potential of heritage tourism in historical areas is being squandered due to a lack of knowledge, expertise, professionals, and

implementation of effective intervention strategies. According to Jukka Jokilehto [4],many international groups have made significant contributions to the preservation of built heritage around the world. These groups include the United Nations Educational, Scientific, and Cultural Organisation (UNESCO), the International Council on Monuments and Sites (ICOMOS), the Aga Khan Foundation, English Heritage, the International Centre for the Study of the Preservation and Restoration of Cultural Property (ICSPRCP), and the Getty Centre Institute. Therefore, the Saudi Arabian government is responding to a growing international commitment by devoting considerable funds and employees to preservation.

In this regard assets of historical, cultural, or anthropological worth that are bound to any and all human activity and expression that have been passed down, acquired, or inherited from previous generations are what compose our cultural heritage. These assets might be physical or intangible such as material heritage encompasses several elements, including architectural heritage. Architectural heritage refers to any physical structures that have been used for the purpose of creating and enclosing space. Examples of architectural heritage include historical monuments, buildings, archaeological sites and excavations, landscapes, ancient towns and villages, as well as undersea archaeological sites, among others. Consequently, the documentation of historical settings is the first and crucial stage in the evaluation of Cultural Heritage, as well as the study or implementation of Archaeology or its associated disciplines.

The documentation of heritage sites has gained significant importance nowadays, with a special emphasis on sites that are at risk of being lost. The need for comprehensive three-dimensional (3D) reconstruction of heritage objects is caused by the need to promote in-depth research and interpretation, as well as to support subsequent physical reconstruction efforts [5]. In contemporary times, there has been a persistent and increasing need for the preservation and documentation of cultural heritage [6' 7' 8]. Corresponding to Tsiafaki and Michailidou [9], the adoption of 3D digital technology in the field of archaeology has become a prominent aspect of the archaeological process. In fact, some scholars argue that it has emerged as the primary concern within this process, specifically referring to the use of 3D techniques for recording, processing, visualizing, representing, and reconstructing archaeological and historical sites. The use of image-based reconstruction techniques has been shown to be very advantageous in the preservation of both geometric and textural information, all while maintaining a low cost-effective approach. Consequently, this method has emerged as a fundamental tool in the field of heritage documentation [10' 11]. Within the scope of cultural heritage, three-dimensional (3D) models serve as a powerful tool for the purposes of documentation and interactive visualization. They enable the creation of virtual reality settings and the recreation of things that have been damaged.

This paper will present and analyze various aspects of utilizing (image-based photogrammetry with (Digital Camera) survey methods and (UAV) photogrammetry) 3D data for architectural studies. The combination of

both techniques is a method for planning paths that can safely and automatically complete the image asset. This is achieved through an efficient 3D reconstruction of a building, which is presented in this paper are based on the experience gained from a specific selected buildings in the Al-'Ula region in Saudi Arabia which is namely (Al-Faqir Fort) as a case study. This building holds significant value as it was recently destroyed by severe weather conditions. It is a captivating 18th-century fort that sits atop a small hill in the southern region of modern-day Al-'Ula, along the Levantine pilgrimage route. With its towering walls and intricate architecture, this historic landmark serves as a tangible reminder of the rich cultural heritage within this part of Saudi Arabia. The fort was constructed during an era when caravan trade routes were thriving between Egypt, Syria, and Iraq. It played an essential role in guarding these trade routes from potential attacks by bandits and raiders who sought to plunder precious goods being transported across these lands. Thereby highlighting the value of taking proactive measures to safeguard our shared cultural heritage.

2. SAUDI ARABIA BACKGROUND AND HISTORY

Saudi Arabia is recognized for its distinctive monuments, including the Arabian Peninsula and ancient fortified settlements dating back to the Islamic era [12]. Preserving Saudi Arabia's pre-Islamic heritage is one of the country's top priorities for cultural preservation [13]. Due of its cultural connection with the first human civilizations in the Middle East. The Arabian Peninsula, as seen in (Fig 1), has a significant historical background characterized by pre-Islamic civilizations. This region includes a variety of ancient cultures, such as Sheba, the Himyarite Kingdom, the Kingdom of Awsane, the Kingdom of Main, and the Sabao Kingdom, which may be traced back to a remarkable antiquity of 20,000 years. The majority of these civilizations inhabited the southern region of the Arabian Peninsula.

Fig 1: Arabian Peninsula and surrounding countries (Sources: Industrious.info.com, 2019) [14]

As a consequence, it is worth noting that the southern Arab Peninsula was habitat to several civilizations. Examples of ancient civilizations on the Arabian Peninsula include the Kingdom of Thamud, the Kingdom of Dedan, the Kingdom of Lahyan, the Ma'in culture, and the Kingdom of the Nabateans. The preservation of pre-Islamic and non-Islamic culture in Saudi Arabia has historically faced opposition from religious extremism, primarily due to the influence of the official religion's branch of Conventional Islam. According to Exell and Rico[15], there has been an overall decrease in the importance of culture as a formal authority strategy. On the other hand, the heritage of monuments that were believed to be harmful to the national identity interests of Saudi Arabia was destroyed. The most well-known example of this is the demolition of a site linked with the Ottoman Empire in 2002 [16]. Since 1925, almost 98% of the historical and religious sites that formerly existed in Saudi Arabia have been destroyed[17]. Based on Joseph [18], Both the preservation and the destruction of Saudi Arabia's heritage of culture are intricately connected to the nation's long and historical past, as well as to the nationalist ideals and interests that are actively supported by the Kingdom of Saudi Arabia. However, the fact that the nationalistic image rather than an exemplary universal value needs to be harmonised with the heritage interest, which is a criterion that is used by the World Heritage Commission, demonstrates the need for developments in this field in terms of the requirements and values associated with the conservation of heritage in Saudi Arabia. Thankfully, the recent addition of a Pre-Islamic site to the World Heritage List signifies a notable departure from the detrimental practises previously used by the state [19].

2.1. The Heritage Sites of Saudi Arabia

In Saudi Arabia, there are thousands of historical antiques and architectural structures that date back to that period of time. Some examples of these monuments are forts, wells, and castles. According to[20],the UNESCO World Heritage List is a highly important list that reflects a cultural conversation that takes place on a global scale. There are an astonishing six sites in Saudi Arabia that have been designated as UNESCO World Heritage sites. These sites show both the extensive and varied history of the nation as well as the efforts that have been made to conserve this past. The names of the aforementioned sites include the Al-Hijr Archaeological Site (2008), the At-Turaif District in ad-Dir'iyah (2010), Historic Jeddah, the Gate to Makkah (2014), Rock Art in the Hail (2015), Al-Ahsa Oasis, an Evolving Cultural Landscape (2018), and the Ḥimā Cultural Area (2021) see (Fig 2).

In addition, vernacular architecture in Saudi Arabia was described by Babsail and Al-Qawasmi[21], who highlighted how the styles of this building type evolved over time to create a comfortable community in response to factors including the region's culture, climate, economy, and availability of building materials. Hans, Ishteeaque and Al-Said[22] provide a comprehensive overview of the primary classifications of vernacular architecture in Saudi Arabia, along with their fundamental building techniques, which are categorized into four distinct areas see (Fig 3). Furthermore, Saudi Arabia's vision 2030 emphasizes promoting its rich Arabic

culture and social traditions, Vision 2030 outlines various areas where Saudi Arabia might gain from investment and public engagement. The plan is to highlights the need to foster the country's rich Arabic culture and social heritage in order to establish a dynamic society and expanding economy [23].
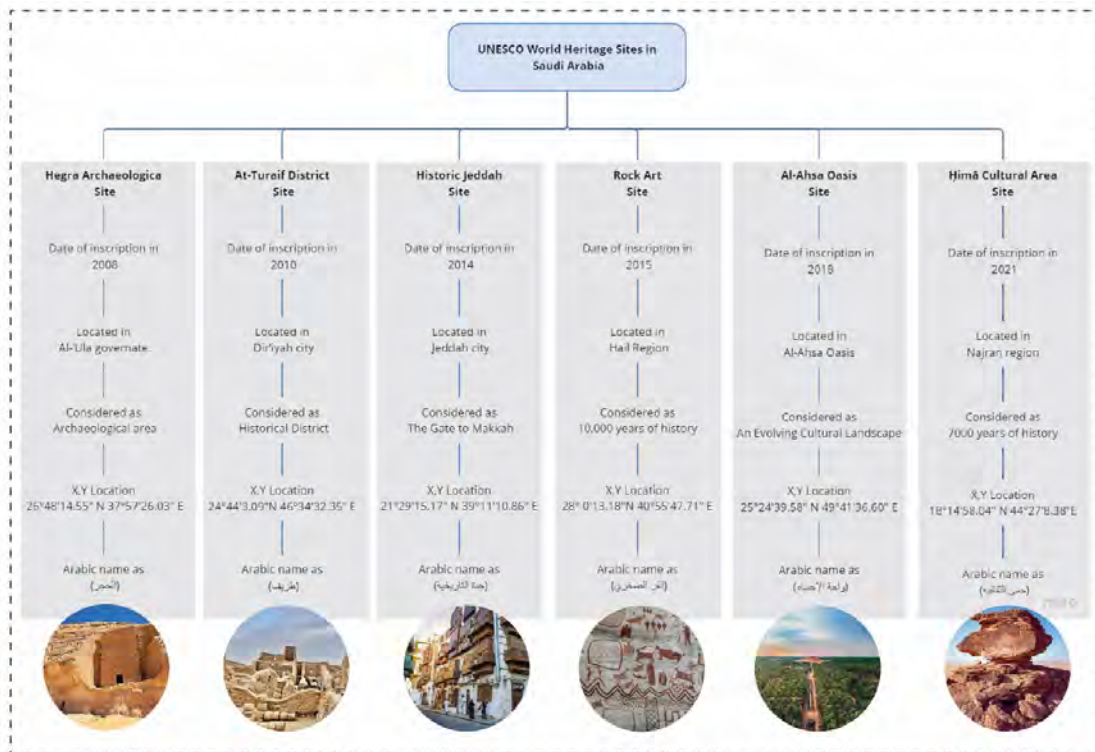

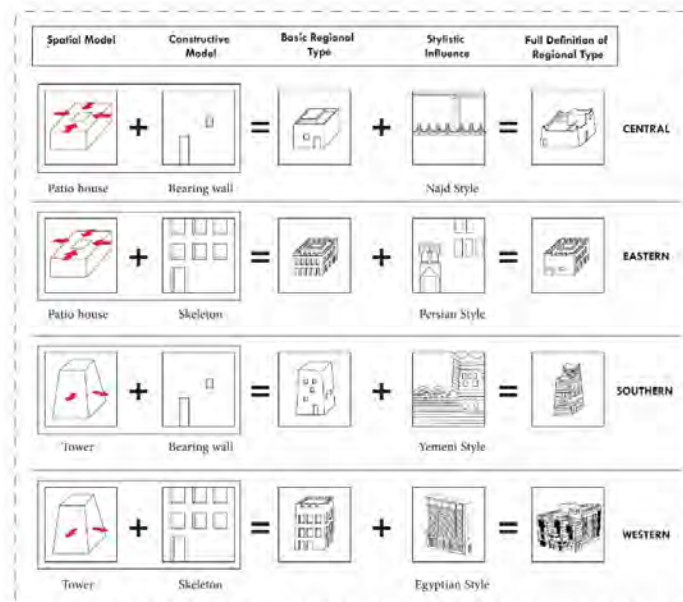Fig 2: Arabian Peninsula and surrounding countries (Aldosari 2023)

Fig 3: The Basic Equations for Regional Architecture in Saudi Arabia (Source: Ishteeaque & Al-Said 2008)

2.2. Al-'Ula Possesses a Rich Historical Background

Al-'Ula is the treasured asset of the governorate of the same name, which is a part of the Madinah province, which is found in the far northwestern region of Saudi Arabia. (see Fig 4), where mountains may be seen in all directions, including to the east and west. These mountains are made of limestone, which over the course of millions of years has eroded into extraordinarily beautiful shapes. In addition, the valley has the potential to
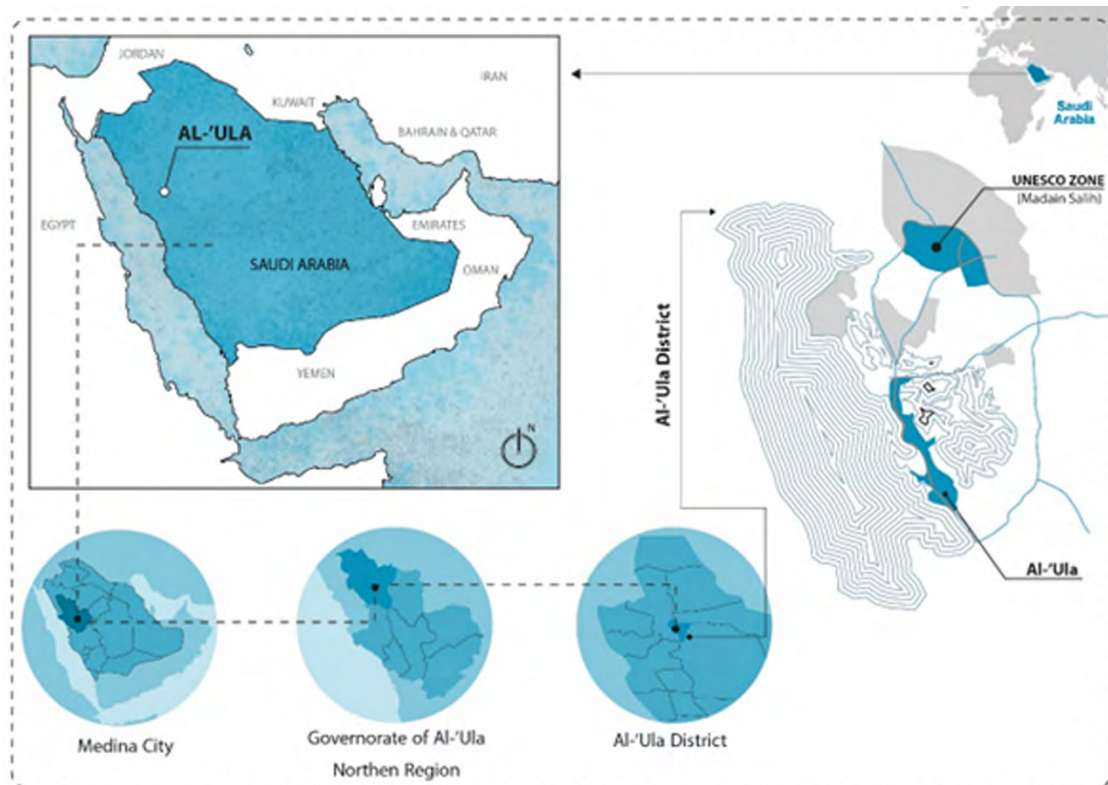
get water from a number of the mountain streams (SATG, 2019).

Fig 4: The location of Al-'Ula in Saudi Arabia and where is located within the Medina City from the north side (Author, 2023)

Arab geographers have historically referred to Al-'Ula as Wadi Al-Qura, which refers to "Valley of Villages," as stated by Power [24]. Al-Muqaddasi had described the place as "the second largest town in the Hijaz at the present time after Makkah," which he also pointed out. According to Tabari [25], it was noted that Prophet Mohammed personally commanded the military operation up to the Tabuk region, during which there was concern over potential involvement by the Byzantine army. The Prophet stayed at 'Wadi Al-Qura' for a duration of three days, actively contributing to the recovery of the oasis's economic significance, which is situated around 20 km to the south see (Fig 5). During the Islamic era begun by the Prophet Mohammed, multiple military expeditions took place in this valley, making it an important part of Arab Peninsula history.

Zaid ibn Haritha's expedition (Wadi al-Qura) and the Second Expedition of Wadi al-Qura were two such examples; in the former, Muhammad dispatched Zayd ibn Haritha to investigate the area and keep track on his enemies, while in the latter case, he ordered a raid on the locals as a form of vengeance for the deaths of several Muslims during an earlier expedition. At the close of the Muhammad period, the Jews of Wadi al-Qura were the target of the Third Wadi al Qura Expedition's invasion and conquest [26].

Fig 5: The Muslim conquest of Arabia (Source: explorethemed.com)

Following the Muslim conquest, Wadi Al-Qura served as a stop along the pilgrimage route from Damascus to Makkah, known variously as the Syrian Way or the Incense Way. In addition, Pilgrim caravans often stopped in the Valley to restock on food and water (SATG, 2019).

2.3. A Fundamental City for Pilgrims

From a historical perspective, the Arabian Peninsula was not located on the periphery of the ancient world but rather close to the middle of a vast commerce and pilgrimage network that extended from India and China to the Mediterranean via Egypt, Yemen, and East Africa all the way to Syria, Iran, and Mesopotamia. It is made very clear that early Arabs, although drawing ideas and concepts from the many kingdoms and empires that were located in their immediate environment, established their own unique styles of clay work, jewellery making, painting, and sculpting [27] see (Fig 6).
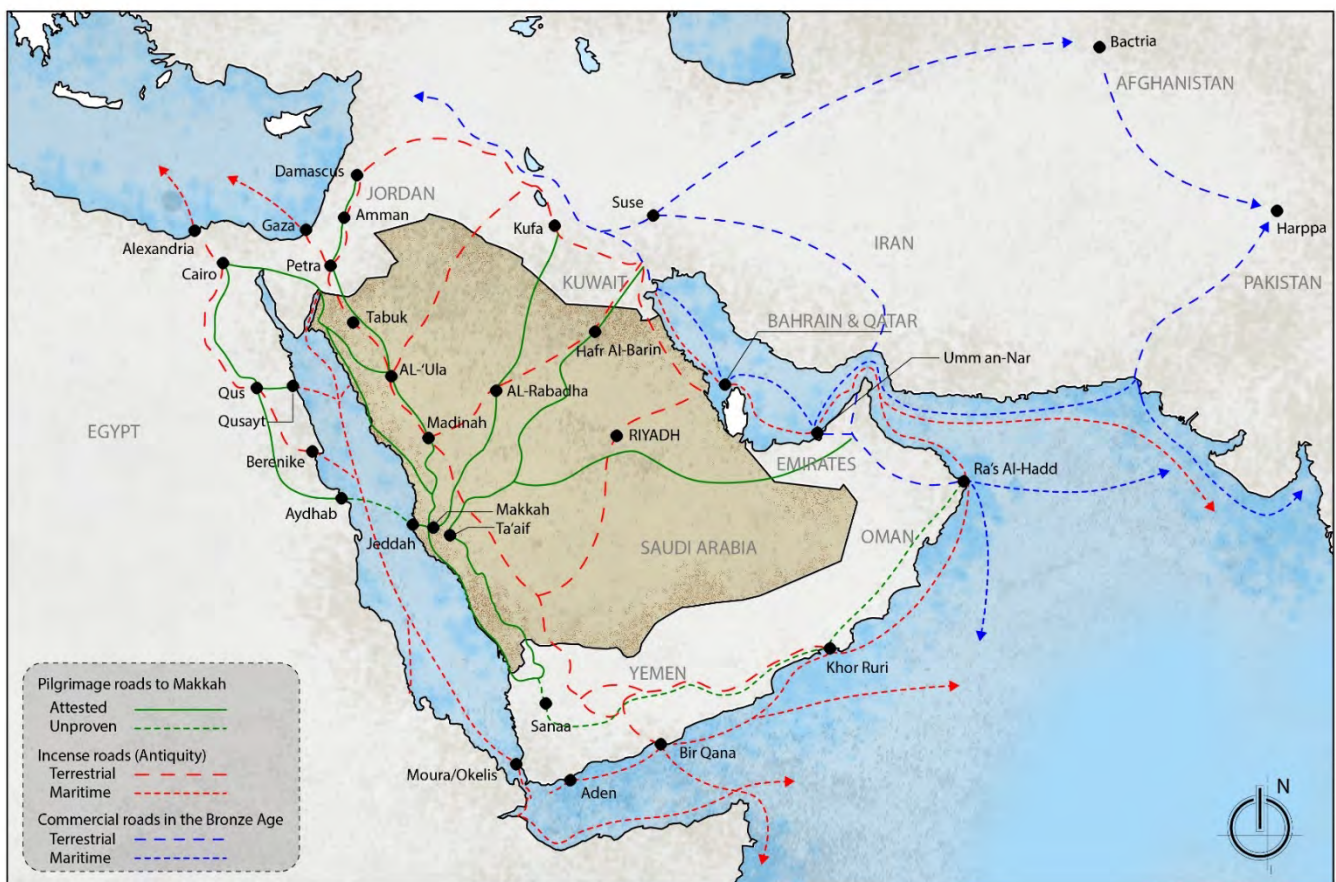
Fig 6: Arabian Peninsula trade and travel lines that connect to each other. ways to get around the Arabian Peninsula (Source: billyknight33.com, Redrawn by Author, 2023)

The provided figure illustrates the network of the Arabian Peninsula, specifically highlighting the commerce routes and pilgrimage trails. It showcases three distinct paths, with the initial focus on the green lines symbolising the commercial routes during the 3rd millennium BCE. Subsequently, the incense trade routes

throughout the first millennium BCE are shown by the red lines. The purple lines seen in the illustration symbolise the historical pilgrimage routes leading to Makkah, which were traversed from the inception of Islam until the 19th century.

Muslim pilgrims have historically accessed the most holy towns of Makkah and Medina over many primary routes before the establishment of modern roadways. Travellers originating from Yemen and the Horn of Africa traverse the Yemeni road, which extends from the southwestern region of Arabia to Damascus. From there, they continue their journey southward to Makkah, where they meet the Syrian road, originating from the northwest. According to ROA[28], the road in Damascus passed through via Al-'Ula, which was situated along the historical commerce route.

Binkovitz (2012) asserts that Al-'Ula served as a prominent trade route during the pre-Islamic era, functioning as a caravan road or incense road. This route facilitated the production of frankincense and the transportation of myrrh from southern Arabia to the Mediterranean region in southern Arabia. In the subsequent era of Islam, it is notable that Prophet Muhammad undertook the migration from Makkah to Medina in the year 622 CE [29]. Additionally, he introduced the principal pilgrimage known as Hajj, which has since become one of the fundamental tenets, or 'five pillars', of Islam and a central obligation for all adherents [30].Moreover, the Hajj is a quintessential five-day pilgrimage of Arabic origin that takes place in close proximity to the sacred regions of Saudi Arabia. The annual occurrence of this event necessitates the Muslims' pilgrimage to the location, therefore infusing the commerce route with a sense of vitality. Muslims commemorate a significant occasion that occurs in the last month of the Islamic lunar calendar. It is worth noting that the lunar calendar consists of 354 days, which is 11 days less than the standard 365-day calendar year.Consequently, the occurrence of Hajj is postponed by a period of twelve months with each successive iteration. During the duration of the five-day sacred pilgrimage, adherents of Islam engage in a series of prescribed rites, serving as a manifestation of their collective solidarity and as an act of reverence towards the divine being. During the last three days of the Hajj pilgrimage, Muslims partake in a festival of sacrifice, commemorating a significant event in their religious tradition, and engage in festivities to commemorate their holiday. Following that, pilgrims are given the opportunity to go to Medina in order to perpetuate their religious observances by visiting the revered mosque and the grave of the esteemed Prophet Muhammad. Following this, they proceed to explore the historical sites for recreational purposes, as outlined by Ascoura (2013).

An further significant event that occurred at the Al-'Ula site, pertaining to the pilgrimage during the late Ottoman Empire and the early 20th century, is referred to as the Hejaz Railway (see to Fig 7). The project, spanning over 1,900 kilometres from Damascus to Medina, is regarded as very captivating [31]. Maunsell [32] claims that the Hejaz Railway has several distinctive characteristics that distinguish it from other railway systems. The primary aim is to provide pious Muslims an enhanced level of ease in doing their pilgrimages to the sacred sites of Makkah and Medina.
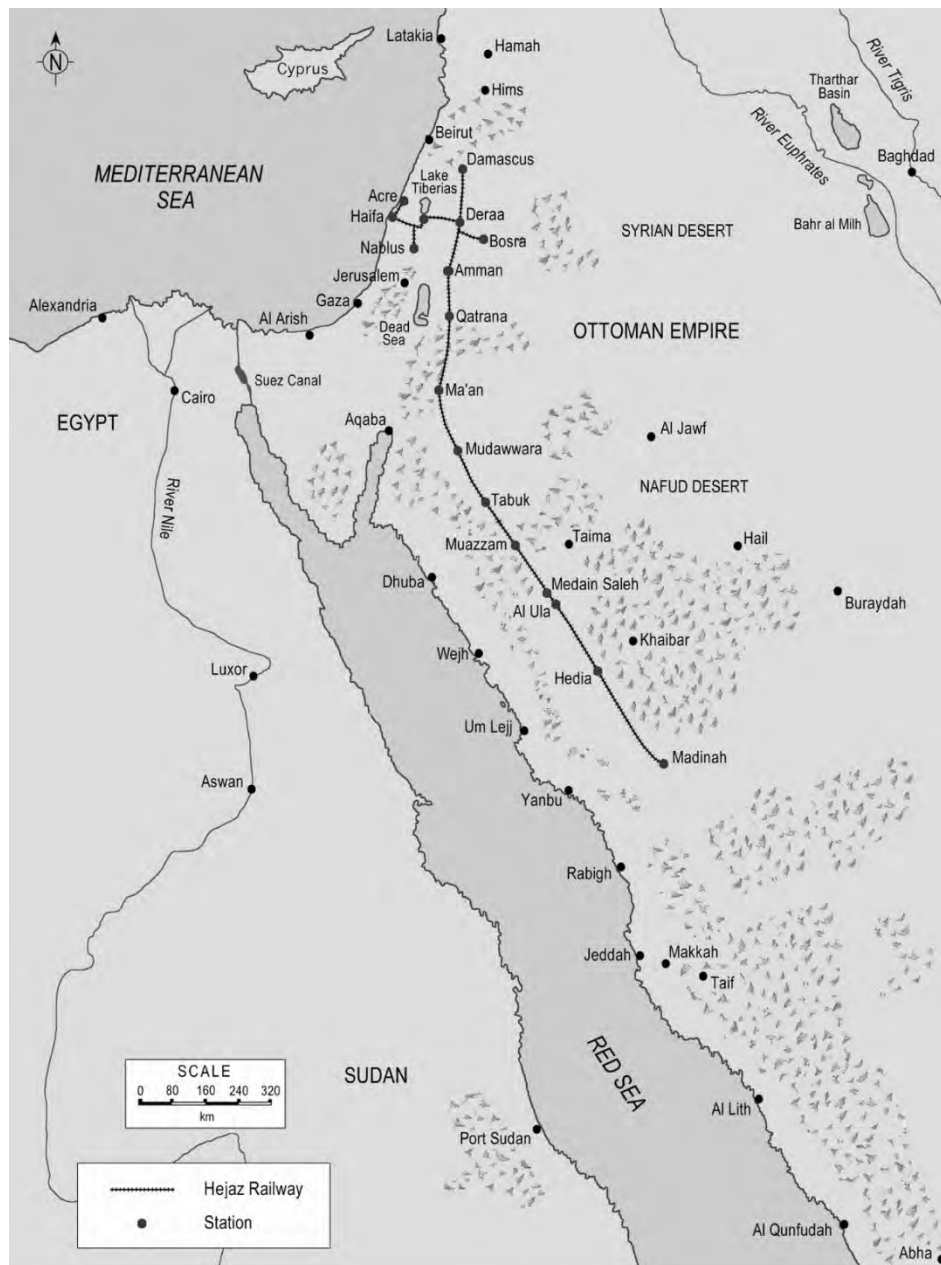

Fig 7: The primary stations along the route of the Hejaz Railway (Source : Nicholson, 2006:321)

In the year 1864, Dr. Charles Zimpel, an engineer of American origin, put out the first proposal for the establishment of a railway system connecting the cities of Damascus and Medina. However, a significant advocate of the concept was Izzat Pasha al Abid, an Arabian individual who served as the second secretary of the Ottoman Empire under the Sultan and had a position of close advisory. According to Nicholson [33], the mainline was established in the year 1900 and subsequently completed in 1908. In addition, it is worth noting that an extension line was established up to the year 1918. This extension line served as the foundation for many infrastructure elements, including telegraph roads, military outposts, station buildings, trains, and wells. These elements were meticulously planned and implemented during this era, enhancing the aesthetic appeal of the surrounding desert and mountainous landscapes [34]see (Fig 8).
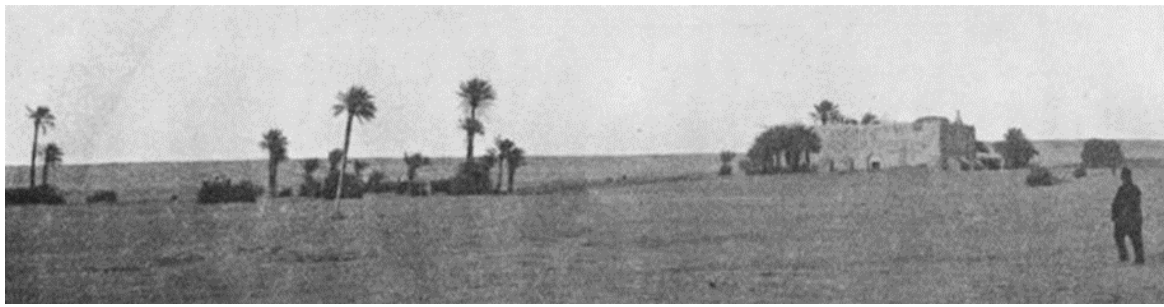
Pilgrims route to Makkah
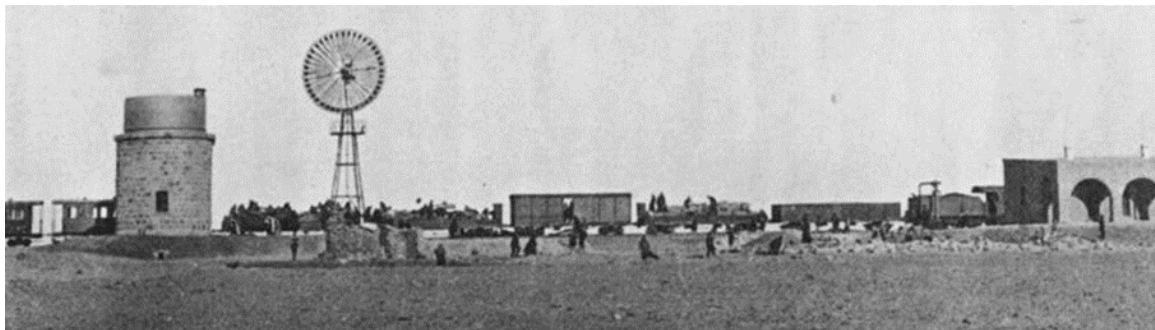
Hejaz Railway: At Mudawwara Station

Fig. 8: Demonstrates how things have changed since the decision to build the Railway was made (Source : Maunsell, 1908) [35]

3. THE SYRIAN HAJJ ROAD

As I mentioned earlier regrading pilgrimage network in the Arabian Peninsula and their routes and pilgrimage trails. The history of the Syrian Hajj route is a truly fascinating one, stretching all the way back to ancient times and continuing to influence the region today. In many respects, the link between Bilad al-Sham (Greater Syria) and Arabia may be understood via the history of the Syrian Hajj route and its pre-Islamic past generations. The Via Nova Traiana was established by Roman Emperor Trajan in the first century AD, after decades of use by the Nabateans for commerce in the first and second centuries BC [36, 37]. After Muhammad's death, the road served as the primary route for the Arab invasion of Syria and Palestine in the 7th century. This route had previously been utilized by pre-Islamic Arabs for trade with the Byzantine towns of Syria[38]. Damascus, a highly developed type of lslamic urban civilization, and the Holy Cities of Mecca and Medina, repository of original Islam, were linked directly via this route throughout the early Islamic era. It's worth mentioning here that the prophet Muhammad went to Bosra in Syria on the trader and that he probably used the road that is now known as the Darb al-Hajj al-Shami. The fact that Syria was the first area outside of the Arabian Peninsula to be absorbed into the Islamic world (Dar al-Islam) demonstrates the country's intimate link to the early years of Islam. The road expanded during the Umayyads to become an important historical and cultural route for lslamic civilization. The Umayyad palaces along the road, such as Qasr Mashatta, Khan al-Zebib, and Qastal, are excellent examples of Islamic design and architectural style [39, 40].

The Syrian Road shaped early Islamic politics and culture. The entity started the Abbasid revolution and spread designs quickly. The discovery of Persian/Sassanian coins in Umayyad deposits at Humeima indicates that pilgrims from several nations used the trail [41, 42]. Despite the concentration of authority in Baghdad and the renovation of the pilgrimage route from Iraq to Mecca under the Abbasids, the Syrian route was used from the 9th to 11th century. There is evidence that pilgrims utilising this path may have grown at this time[43].

The Crusader invasion and occupation of Palestine, Jordan, and Syria in the 12th and 13th centuries weakened the Syrian route. The Syrian Hajj was delayed for years due to Crusader fortifications along the path. After the Crusaders left and Mamluk Sultan Baybars took over, things improved. The fall of the Abbasid caliphate drove pilgrims from Iraq, Persia, and Khurasan to pass through Damascus, benefiting the Hajj route through Syria. After safety improvements, the Egyptian overland route via Ayla (Aqaba) has been restored [44].

The Mamluks made Cairo and Damascus significant pilgrimage destinations for Muslims worldwide. The Mamluk ruler or his deputy sanctioned the Egyptian and Syrian caravans and chose Amir al Hajj to lead them. The Egyptian caravan was prioritized over the Syrian caravan because Amir al-Hajj wanted to succeed the Sharif of Mecca or Medina. The Egyptian caravan carried the Ka'ba's Kiswah and was prioritized in Hajj ceremonies. Mamluk Sultan Barsbay forced merchants to follow the Egyptian caravan to monopolize the

Indian market. Mahmal, a silk-embroidered camel litter, was a Mamluk invention. It was initially reported during Sultan Baybars' 1266 journey and symbolized an influential individual. Besides the Syrian Hajj caravan, Aleppo and Karak semi-official caravans adopted the mahmal [45, 46, 47].

In overall, the Syrian route was very important to the early Islamic political system, cultural exchange, and pilgrimage. It served as a link between different areas and facilitated the flow of information and trade. It was still an essential path for Muslims all across the globe to use while making the pilgrimage to Mecca.

4. THE CHRONICLE OF FORTS, ALONGSIDE SYRIA, JORDAN AND SAUDI ARABIA

The historical pathway between Syria and Mecca has significant antiquity and may be traced back to pre-Islamic trading networks. According to Tresse [48], it is noted that throughout Classical times, this particular route served as the primary spice trade route between the Mediterranean and the Indian Ocean. Ibn Battuta's pilgrimage itinerary determined a document of the Hajj route in Syria during the 14th century. Forts on the Darb al-Hajj date back to before the 16th century, as seen in the following (Table 1) from the work of Ibn Battuta as reported by Defremery and Sanguinetti[49].

The forts on Darb al-Hajj before the sixteenth century recorded by Ibn Battuta				
1- Damascus	6- Al-Lajjun	11- Dhat al-Hajj	16- Al-Htdjr	21- Al-Saffah
2- Al-Kiswa	7- Al-Karak	12- Baldah	17- Al-Ula.	22- Al-Badr
3- Zar'a	8- Al-Thailiya	13- Tabuk	18- Al-Althos	23- Al-Usfayn
4- Bosra	9- Ma'an	14- Al-Ahzar	19- Al-Hadiya	24- Batn-Marr.
5- Ziza	10- Aqaba ai-Sawan	15- Al-M.u'azzam	20- Al-Madina	25- Makkah

Table 1: Pilgrimage Route decomentaion stations fort from lbn Battuta (Defremery and Sanguinetti 1858)

In Ottoman Syria, the Hajj was an integral part of daily life. From the time of Sultan Selim's captivate of Damascus in 1516 until the end of Ottoman authority in the early 1900s, providing for the pilgrims who travelled from Syria to Mecca was the primary concern [50]. Therefore, the rulers had issued instructions for the building of fortified structures at Sanamayn, Muzayrib, and Tell Far'un (Mafraq), all situated within a radius of 60 km from Damascus. Within the 1570s, the network expansion reached significant depths throughout the Hijaz region, marked by the establishment of forts at strategic locations such Qatrana, 'Unaiza, Ma'an, Dhat al-Hajj, Tabuk, Ukhaydhir, al-'Ula, and Hadiyya [51]. Every fort constructed during the 16th century was strategically positioned next to a notable water source, carefully situated outside the fortification boundaries. The second significant stage of fortification development occurred throughout the 18th century. During this particular era, many fortifications were constructed, such as Qal 'at al-Balqa (Dab'a), Qal 'at al-Hasa, Qal'at al Fassu'a ('Aqabat al-Hijaziyya), Qal'at Mudawwara, and Medain Saleh see (Fig.9). Furthermore, during the

construction of the forts, a road and bridge were constructed at Qal'at al-Hasa, while significant renovations were undertaken at Hadiyya[52],see (Fig.10).

According to Heyd [53], from architectural perspective, hajj forts are unique in appearance compared to other fortifications in the area. In example, the layout of a typical Ottoman Hajj fort differs from that of an identical Mamluk fort. The Ottoman Hajj forts different primarily in that they are laid out around a courtyard and have thinner walls than their Mediaeval predecessors. Zerka's Qasr Shebib and Zizia (Jize)'s fort are good examples of moderately sized Mediaeval forts. Both include a single big, vaulted room on the ground floor, with walls that are over 2 metres in thickness and a stairway set into the wall itself to reach the upper stories. A classic Ottoman Hajj fort, on the other hand, has two open-air stairs leading to the higher stories, and the ground level is made up of a number of small domed living quarters arranged around a square central courtyard.

Fig. 9: Qal 'at al-Balqa (Dab'a), by Jaussen and Savignac (courtesy of the Ecole Biblique) (Team 2022)
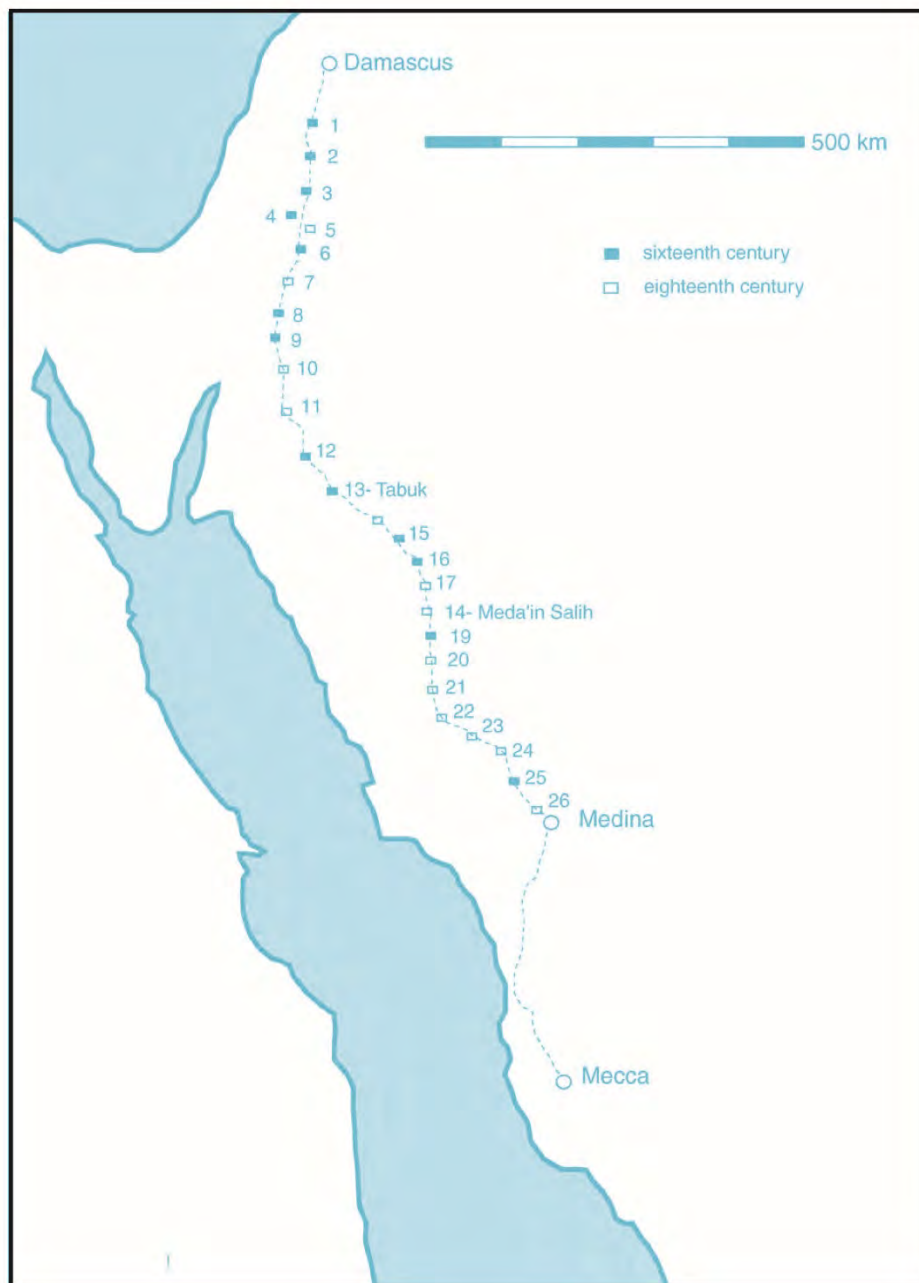
Fig. 10: Fortifications along the Hajj route, as seen on a map from the 18th century. 1) Muzayrib, 2) Mafraq, 3) Zerka (Qasr Shebib), 4) Zizia (Birkat Zizia), 5) Balqa Dab'a, 6) Qatrana, 7) Hasa, 8) 'Unaiza, 9) Ma'an, 10) Fassu'a ('Aqaba al-Hijaziyya), 11) Mudawwara, 12) Dhat al-Hajj, 13) Tabuk, 14) al-Qalandariyya, 15) 'Ukhaydhir, 16) Qal 'at al- Mu 'azzam, 17) Dar al-Hamra, 18) Mada 'in Salih, 19) al- 'Ula, 20) Bir al-Ghannam, 21) Zummurud, 22) Sawrah (Bir Jedid, Valide Kuyusu), 23) Hadiyya/Antar, 24) Nakhlatayn (Fahletein, lstabel Antar, Shajwa), 25) Wadi al-Qura (Biar Naszeif), 26) Hafira, (Adapted and enhanced from: G1BB, 1958) [54].

The architectural style being exhibits notable similarities to Mediaeval khans and caravanserais, as noted by Lee, Raso, and Hillenbrand[55]. However, a fascinating new theory suggests that these structures may have originated from wooden forts used during military battles in the Balkans, as proposed by Nicolle and McBride [56]. The dimensions of each Hajj fort are usually 20 metres per side, with a minimum of 15 metres and a maximum of 29 metres. These forts have a rectangular centre courtyard, which typically occupies around 20% of the ground floor exterior. The courtyard's size may vary between a minimum of 15% and a maximum of 36%. The majority of the forts have a three-storey structure, with a ground floor, first level, and an upper story with a parapet. However, it should be noted that several forts, like Mafraq, depart from this pattern and possess only two stories. The fortifications were constructed using locally sourced materials such as limestone and flint cobbles, consequently providing them with a unique aesthetic in contrast to alternative fortifications that use different materials for construction. Mostly of them build simple and visual, except for the decorations positioned above the entrance, such as the three spheres decorating the entrance of Qatrana. See (Fig.11&Fig.12) Numerous Fortifications can be found alongside Syria, Jordan, and Saudi Arabia.

Fig.11: Qal 'at al-Mu 'azzam, in 1907, by Jaussen and Savignac (courtesy of the Ecole Biblique) (Team 2022) [57].

Mafraq fort, exterior with entrance to right.

Ziziafortfrom the south-east (1986)

Qal 'at Dab 'a, exterior from West in 1898, by Rudolf⊠Ernst Bri.in-now (courtesy of Princeton University).

Qal 'at Qatrana,fort and cistern from east in 1898, by Rudolf-Ernst Briinnow (courtesy of Princeton University)

Qal'at Mudawwara, south side (1986).

Dhat al-Hajj, from south-west in 1907, by Jaussen and Savignac (courtesy of the Ecole Biblique)

Tabuk, exterior of fort with entrance in 1907, by Jaussen and Savignac (courtesy of the Ecole Biblique).

Fig.12: Forts along the borders of Syria, Jordan, and Saudi Arabia (Team 2022)

5. THE HISTORY OF AL-FAQIR FORT (Abyar al-Ghanum)

There are a few descriptions of this Fort location between al-'Ula and Qal'at Zumurrud, but almost nothing is known about its history or what kinds of infrastructure may be found there. There is no recent description of the location and no indication of the fort's style, or its current condition; yet the site has been marked as a fort on contemporary maps of Saudi Arabia as (Al-Faqir Fort).

According to Gibb [58], that Ibn Battuta travelled from the 14th century, talks about a camping spot one day's trip south of al-'Ula on the Syrian Hajj route. This may be the first reference of the location as part of the Hajj route. Ibn Battuta calls it Wadi al-'ltas and describes it "a place of violent heat," telling the account of how the deadly Samoom wind wiped off most of the pilgrims there in the year of the Amir al-Jaliqi.i. In addition, Gibb, who translated this passage from Ibn Battuta, identifies Amir al-Jaliq as Gaza's ruler by noting that Qutlughtimur al-Nasiri, Amir al-Jaliq's son-in-law, led the Syrian Hajj in 1309 AD (708 AH). However, neither the place as well as the catastrophe are mentioned again in the mediaeval period, and it is unclear to determine whether this is the same location as Abyar Ghanam, which appears in later Ottoman archives. The distance of 50 km between al-'Ula and Abyar Ghanam is consistent with the site's location, which is a one-day travel away.
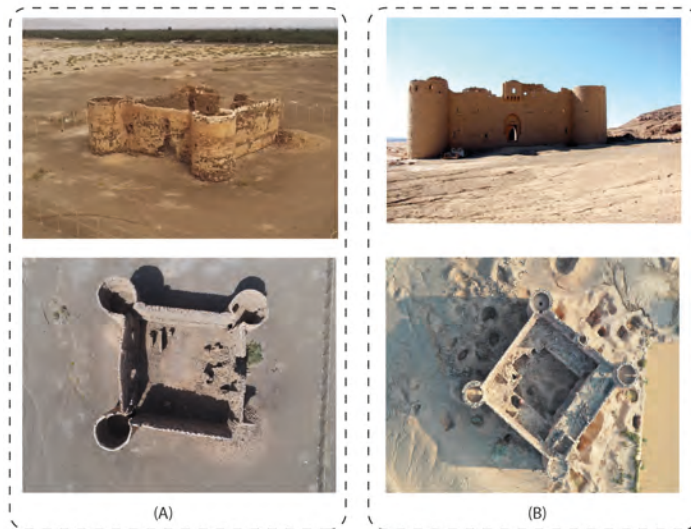
Fig.13: (A) Abyar Ghanum Fort by (Author, 2023), (B) Al-Mu'adham Fort (Team 2022)

Furthermore, Evliya Çelebi refers to a fortress located at a distance of forty-five hours from al-'Ula. It is possible that this fortress fits the description of Abyar Ghanum, despite the fact that there is a fifty-kilometer distance between the two locations which would indicate a trip of approximately 10 hours. According to Celebi, the fort was situated on a prominent rocky formation within a steep valley. It was constructed by Mu 'izz al-Din, the Fatimid caliph, in the year 358 AH [59][60]. There is a possibility that the Celebi mentioned might be referring to a different fort, such as the citadel located at Khaybar, which is situated to the northeast of Qal 'at Zumurrud. This interpretation is supported by the work of Pierard and Legros [61]. Based on my

investigation into the historical background of the forts, it is evident that the architectural layout of the fort of Abyar Ghanum has the closest resemblance to that of Al-Mu'adham fort, as shown in (Fig.13)

According to Barbir (1980), the earliest documented mention of a fort at the present location can be traced back to an official directive issued on March 26, 1722. This directive outlines the allocation of garrison duties at Medain Saleh and Abyar Ghanam to 300 Jannisaries from the local (Damascus) region, with a rotation cycle of four years. As well, the combined effort of these garrisons would have resulted in a total manpower of 75 individuals. Adding to that, the writings of Mehmed Edib, on 18th-century pilgrim, provide an extensive description of the site and fort, offering a more intricate understanding of its historical significance in (Table.2).

Name	Distance from preceding fort	Date of construction/repair and person responsible
Şanamayn	17 hrs. from Damascus	Early 16th cent.—Sultan Selim I
Muzayrīb	7 hrs.	Early 16th cent.—Sultan Selim I
Tall Far'ūn	11 hrs.	Early 16th cent.—Sultan Selim I
'Ayn Zarqā	12 hrs.	Either pre-Ottoman or 16th cent.[a]
Balqā	18 hrs.	Either pre-Ottoman or 16th cent.[b]
Qaṭrāna	16 hrs.	Mid-16th cent.—Sultan Süleyman I
Ẓahr 'Unayza	29 hrs.	Late 16th cent.—Süleyman Paşa(?)
Ma'ān	12 hrs.	Mid-16th cent.—Sultan Süleyman I
Ẓahr al-'Aqaba	13 hrs.	Mid-18th cent.—Gürcü Osman Paşa
Jughaymān	15 hrs.	1730-33—Aydınlı Abdullah Paşa
Dhāt Ḥajj	14 hrs.	Mid-16th cent.—Sultan Süleyman I,
Tabūk	25 hrs.	Mid-16th cent.—Sultan Süleyman I, repaired 1654
Maghāyir al-Qalandariyya	13 hrs.	Mid-18th cent.—Gürcü Osman Paşa
Ukhayḍir (Ḥaydar)	12 hrs.	1531—Sultan Süleyman I
al-Mu'aẓẓam	17 hrs.	Ayyūbid: al-Malik al-Mu'aẓẓam Sharaf al-Dīn 'Isā (1218-1227)
Dār al-Ḥamrā'	18 hrs.	1753-1754—Gürcü Osman Paşa
Madā'in Ṣāliḥ	19 hrs.	Mid-18th cent.—Esat Paşa (al-'Aẓm) or Gürcü Osman Paşa
'Ulā	9 hrs.	Mid-16th cent.—Sultan Süleyman I
Abyār Ghanam	10 hrs.	Unknown[c]
Zumurrud (off the main road)	10 hrs.	Late 18th cent.—Mehmed Paşa ('Aẓm)
Valide Kuyusu	8 hrs.	Early 17th cent. waterhole Mid-18th cent. fort—Gürcü Osman Paşa
Hadiyya	12 hrs.	Late 16th cent.—Süyleyman Paşa(?) Early 18th cent.—repaired by Nasuh
'Antar (near Hadiyya)		Mid-18th cent.—Gürcü Osman Paşa
Nakhlatayn	16 hrs. from Hadiyya	Mid-18th cent.—Gürcü Osman Paşa
Wādī al-Qurā	15 hrs.	Unknown[d]

[a] See Kâtip Çelebi, *Cihannümâ*, p. 539.
[b] Ibid.
[c] Mehmed Edib reports that a fort existed here; no information available on founder.
[d] Mehmed Edib reports a ruined fort here in 1779-1780.

Table 2: The network of pilgrimage fortresses between Damascus and Medina.by Mehmed Edib (Barbir, 2014: appendix VII)

According to Edib [62], the place is recognized by many names such as Bir Ghanum, Tavamir, Matran, and Khifa al-Zir. The author characterizes the environment as a desert adorned with little black stones, next to an expansive plain, encircled by deep valleys. One section of the route through a dense forest filled with Tamarisk trees, while the other section opens across mountainous terrain [63]. Also he further asserts that in the event of water scarcity at the location, it will be supplied by the accompanying Hajj caravan. Ultimately, he believes that this particular station is among the most challenging on the whole of the Hajj pilgrimage route. Furthermore, regarding the location fort that Burckhardt is the only European author to mention Biar el-Ghanam; he only included it in his trips as the 20st stop and notes that the town has many of freshwater wells [64].

The lack of references and mystery surrounding the name of this place may be attributed to the existence of two distinct paths used during the Hajj pilgrimage between Medain Saleh and Zumurrud. One of the routes followed a path via al-'Ula, while the other route proceeded straight to Zumurrud, using the Sahel al-Matran route [65]. In this scenario, Abyar al-Ghanum would have been avoided. The precise date of the fort's construction remains uncertain; nevertheless, it is certain that it predates 1722, as shown in the aforementioned official records. There is also a possibility that its origins may be traced back as far as the 10th century (3rd century AH), if indeed it is the same fort referenced by Evliya Celebi.

6. HISTORICAL BACKGROUND FOR USING UNMANNED AERIAL VEHICLES (UAV) AND CLOSE-RANGE PHOTOGRAPHY(CRP) TO RECORD ARCHITECTURAL HERITAGE

Protecting historical sites is a priority for nations of every sort. For effective conservation measures, Saudi Arabia, like other nations, must finish its documentation and inventory of cultural treasures as soon as practical. Presently the methodologies employed for the generation of physical structure models, including three-dimensional representations of architectural structures, leverage contemporary advancements in technology. These include state- high-tech total stations, progressively enhanced laser scanners, and photogrammetric software designed for automated image data processing. In the last few years, there has been a remarkable increase in the use of non-metric cameras within the context of conducting a photogrammetric inventory of monuments. The rapid development and widespread adoption of high-tech solutions may be attributed to the advancement of technology and its growing accessibility [66, 67]. Furthermore, the use of aerial oblique photographs for constructing 3D models has garnered significant attention from the scientific community and software developers, as shown by the works of Höhle [68] and Gerke[69].According to Szelinski [70], the approach was implemented and tested during the period of 2008-2009. However, the system's capabilities have been significantly enhanced by the recent integration of computer vision algorithms into widely used software tools.

The use of dense image matching in 3D modelling enables the incorporation of detailed descriptions of building facades and accurate representations of building footprints throughout the models. This enhances the visualisation of Structure from Motion method (SfM) by transitioning from a single perspective to more intricate 3D models. This expanded representation offers potential benefits for more outstanding research across several domains such as energy regulations, urban planning, and city administration. According to Meijer[71], the approach known as Structure from Motion has gained popularity due to its ability to generate very accurate and comprehensive 3D models without the need of external landmarks. Moreover, the use of this technology enables the efficient acquisition of comprehensive and intricate data within a limited timeframe, hence providing a significant advantage for the purposes of mapping and documenting. This shows that SfM can get outstanding results without 4-6 objectives for accuracy and metric information extraction. The point cloud SfM creates from numerous images represents the environment's surfaces and attributes. By linking these points, a 3D mesh may be constructed that is an exact replica of reality down to the textures. This state-of-the-art technique has a wide range of potential applications, from construction and archaeology and even virtual reality. Morgan[72], said that,

> "Results from this study suggest that SfM provides topographic data of similar accuracy to TLS, at higher resolution and lower cost."

<div align="right">Jacob A. Morgan, Daniel J. Brogan, and Peter Nelson.</div>

It's competitive with other approaches in terms of precision and provides greater resolution data at a lower price. Students and researchers like me, who may be working with a tight budget yet need access to high-quality data for our studies, might benefit much from this.

The choice of an appropriate approach depends upon many aspects. The process involves a methodical analysis and interpretation of project needs, then aligning these objectives with the most suitable methodologies, benefits, and possibilities. A wide range of approaches has been developed, as shown by the works of (Boehler, W., & Marbs, 2004;Remondino et al., 2005;Kadobayashi et al., 2004;Grussenmeyer et al., 2008) [73,74, 75, 76].Additionally, Beraldin [77], Sabry F. El-Hakim [78], Lambers [79], and Guidi [80] have contributed to the combination of these methodologies.

Models of structures may be generated using just digital two-dimensional photographs thanks to tools like Agisoft Metashape, Reality capture, Autodesk ReCap, and many others (some of which are free). In addition, this technology is now within reach because of applications designed for handheld devices. Similar to the shift from analogue to digital photography, the advancement of software based on photogrammetry has facilitated the ability to acquire a uniquely built digital model from advanced software. These technologies provide major assistance to a variety of professionals, including architects, conservators, and archaeologists.

The objective of this study is to explore the potential of using Unmanned Aerial Vehicles (UAVs) and Close-Range Photography (CRP)techniques for the recording of architectural heritage building of Al-Faqir Fort. This article provides an in-depth analysis of the process involved in creating 3D models of significant religious structures and massive fortresses. Furthermore, the paper examines the practicality of these models in the context of historical building inventory.

7. THE METHODOLOGY FOR DOCUMENTING AL-FAQIR FORT

7.1. The Case Study of Al-Faqir Fort

The previously mentioned building see (Fig.14) holds significant value as it was recently destroyed by severe weather conditions, it is a captivating 18th-century fort as we have explained earlier. The sites sit atop a small hill in the southern region of modern-day Al-'Ula, along the Levantine pilgrimage route see (Fig.15). With its towering walls and intricate architecture, this historic landmark serves as a tangible reminder of the rich cultural heritage within this part of Saudi Arabia. The fort was constructed during an era when caravan trade routes were thriving between Syria, and Makkah. It played an essential role in guarding these trade routes from potential attacks by bandits and raiders who sought to plunder precious goods being transported across these lands for pilgrimage Hajj. In (Fig. 16) presents the results of the observation survey carried out inside the site preparation.

Al-Faqir Fort
(Abyar al-Ghanum)

A notable observation, accompanied by a detailed sketch, effectively highlights the positioning of the component and emphasizes the grand entrance of the fortress.

The Grand Entrance

Fig.14: The Study of Al-Faqir fort-(Abyar al-Ghanum) as a case study (Author, 2023)

Fig.15: The geographical placement of the historical structure known as Al-Faqir Fort (Author, 2023)

AL-FAQIR FORT
(Abyar al-Ghanum)

The archaeological site is situated on a hilly terrain in the southern part of contemporary times Al-'Ula, along the historic pilgrimage route of the Levant.

An aerial image showcasing the fort from various perspectives.

Aerial imagery reveals the interior architecture of the structure.

(A)   (B)   (C)   (D)

Multiple perspectives on the building's structure

(A)   The entrance of the fortress

(B)   The fort's corners are configured in a manner that results in the formation of four circular walls.

(C)   The fortification's perimeter wall shows partial collapse.

(D)   The fort reveals full destruction in one of its corners.

In order to gather data from locations outside the construction area, it is essential to ensure that the necessary instruments are properly set up. Additionally, it is of vital importance to pay attention to the safety protocols and site safety procedures established by the Royal Commission for AlUla Governorate.

Fig.16: Provides data from an observational study conducted throughout the construction of the site (Author, 2023)

The precision of a photogrammetric model of a building or other structure depends on a number of factors, including simply not limited to: image registration; camera parameters; proper calibration and rectification; the overlay of consecutive images in blocks; the shape of the metering network; and the number of checkpoints[81].

To analyze a huge quantities of metric and non-metric digital photos, most popular software nowadays relies on automated image matching algorithms [82]. The article makes use of the Agisoft Metashape programme, which is based on automated image-matching techniques. In order to identify local characteristics in a picture, the software employs techniques based on the SIFT (Scale-Invariant Feature Transform) algorithm, which performs pixel-by-pixel analysis and comparison of parameters to generate image descriptors. Next, these identifiers are set to use in order to identify duplicate features among photos that make up the same block[83]. In order obtaining a representation of the complete model of a structure and assigning metrics to it are common reasons for using a model built using photogrammetric techniques in the context of Al-Faqir Fort documentation. This article discusses how architectural models may be used in drafting software. (Fig.17) lays out the steps required to create a model of an architectural structure in the previously mentioned setting. The models used in this research were developed using two distinct approaches of (UAV) and Close-Range Photography (Camera) that made use of various picture data sets. The two techniques were combined in terms of how useful they would be in gathering information for building plans and parameters. Data collected from the Interior by (UVA)and exterior by (CRP)of the Fort building was the major focus of the analytic procedure.

7.2. General Workflow

During the process of analyzing data collected from field work, there are four different steps that comprise the workflow:

1-The selection of the site was determined by many variables, including the dimensions of the structure, the architectural characteristics, the materials used in the building, and the level of accessibility.

2-Fieldwork was conducted utilizing three distinct methodologies, namely the traditional survey, close-range photogrammetry (CRP), and Unmanned Aerial Vehicles (UAV).

3-The data acquired through these methods was subsequently employed to generate mesh model, High Dynamic Range photographs, and 3D Point Clouds.

4-A comprehensive evaluation and comparison of each method was performed to assess their respective efficacy and performance.
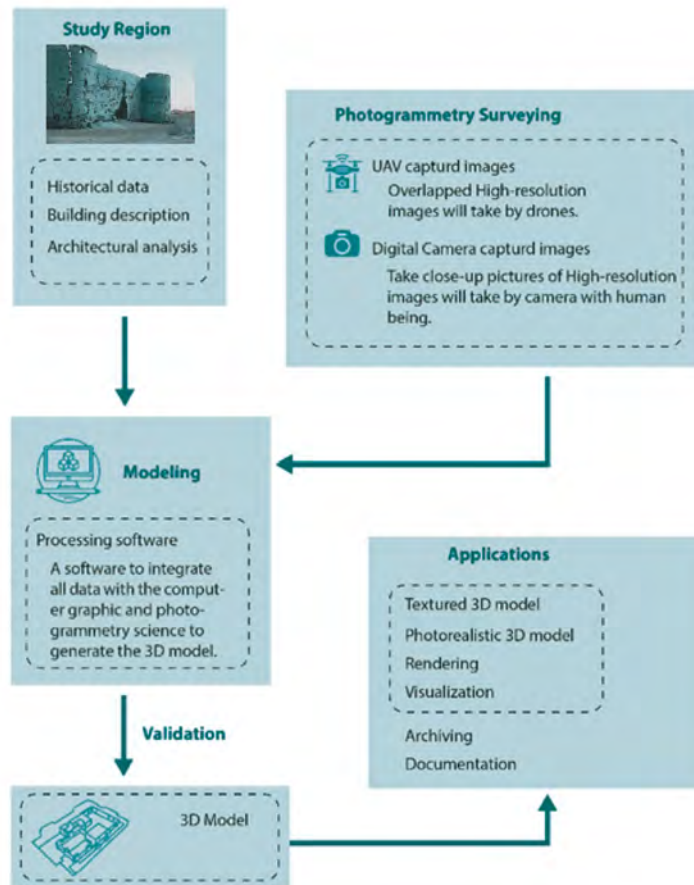
Fig.17: Flowchart of the methodology of photogrammetry process (Author, 2023)

7.3. Photogrammetric Data-Processing

The data collection process included the use of two distinct instruments: a Canon EOS 450D camera and an Anafi Parrot remote control Drone see (Table.3). The photographs were captured using two separate methods under my observation as the one responsible for monitoring both approaches. Regarding the second approach, a specific application (Pix4D control integrated with Anafi Parrot application) was used to effectively manage the drone and facilitate the guidance of photogrammetry data gathering in accordance with the instructions provided by the user see (Fig.18).

The data was gathered on location via a comprehensive survey using both ground-based and aerial photography techniques see (Fig.19). The ground survey included capturing sequential photos in a circular pattern at two specific dimensions of the fortress. The first dimension spanned from 18 to 20 meters, while the second dimension ranged from 28 to 30 meters. The aerial survey was conducted in two dimensions, with the first dimension representing altitude (30m height above ground level) in a circular path with a radius of 40

and the second dimension likewise representing altitude (the same height above sea level) in a circular path with a radius of 20. Data were obtained using ground photogrammetry survey, which included capturing a series of photographs (138 images), as well as through an aerial survey, which also involved capturing a series of images (72 images).
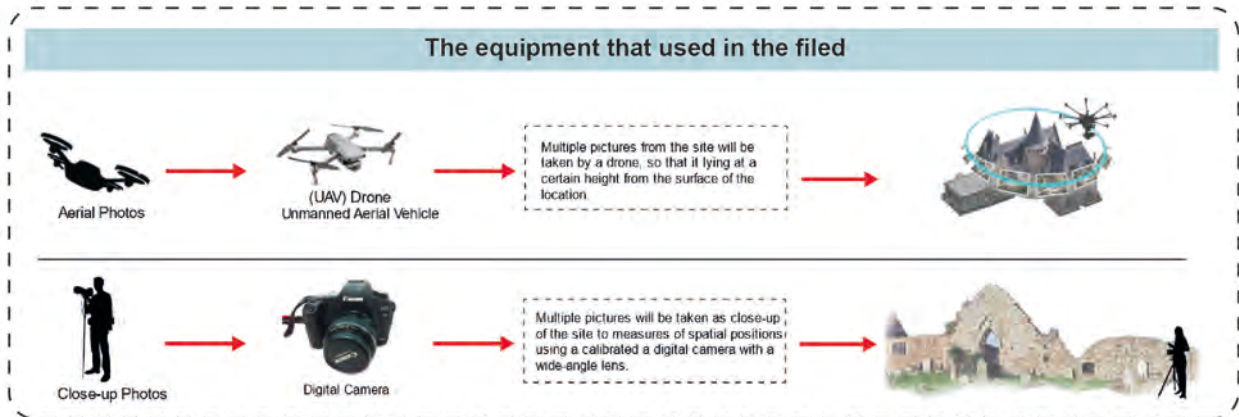

Table 3: The data was collected using a Canon 4500 camera and an Anafi Parrot drone (Author, 2023)

Fig 18: The integration of the Pix4D control with the Anafi Parrot application (Author, 2023)
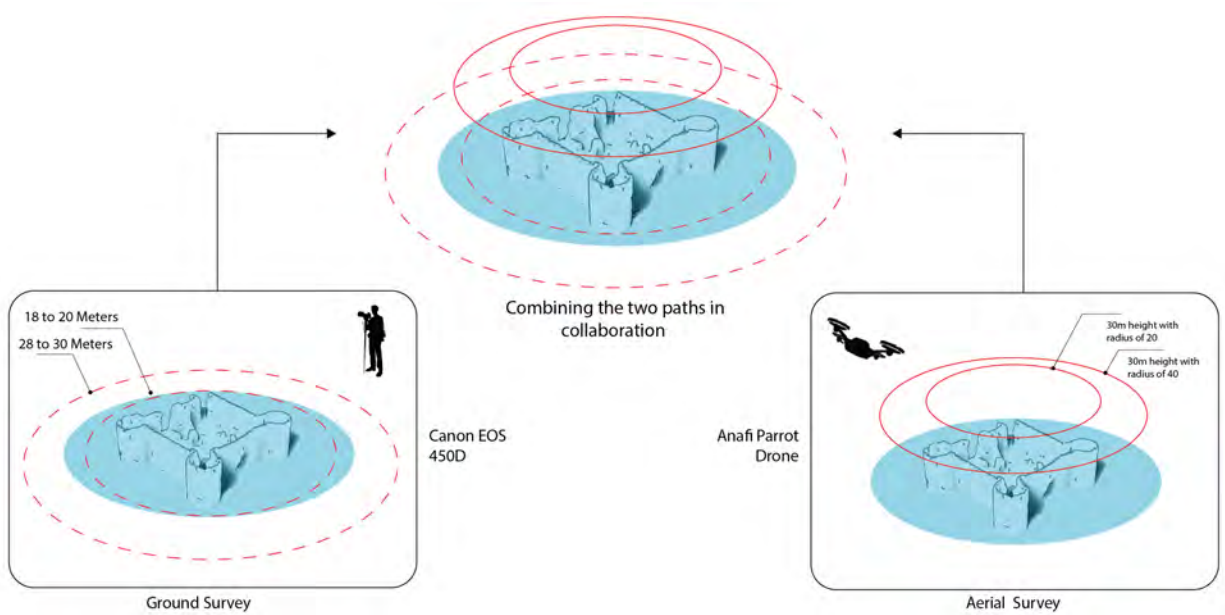
Fig.19: The geographical placement of the historical structure known as Al-Faqir Fort (Author, 2023)

7.4. Calibration Data Processing in Images

Calibration of the camera is a crucial part of collecting photogrammetric data. Calibration of a camera is performed so that its characteristics, including focus length and lens distortion, can be calculated accurately. Two different approaches to picture calibration were tested in this investigation utilizing Agisoft Metashape for field calibration see (Fig. 20).
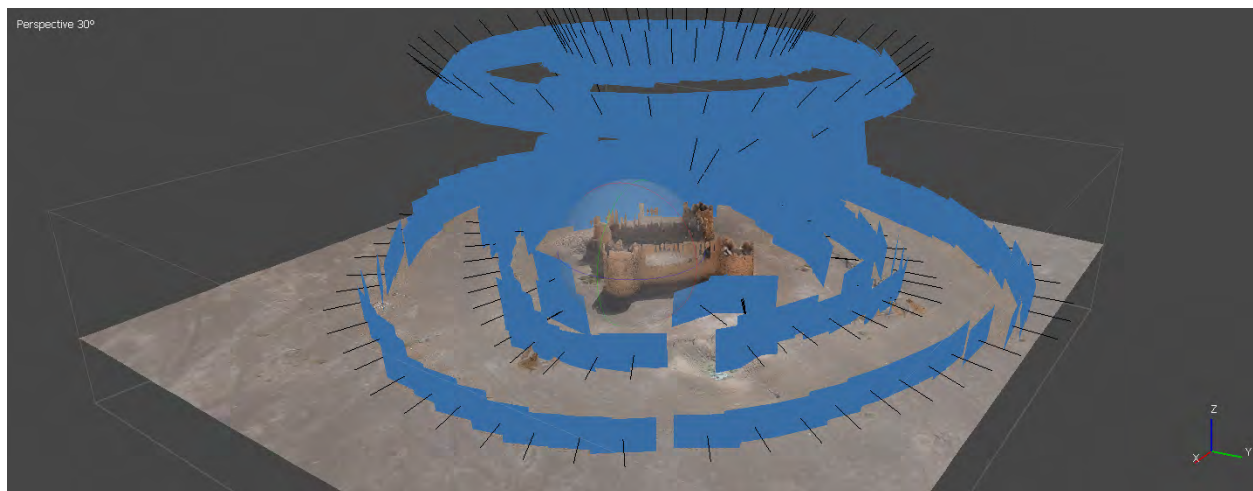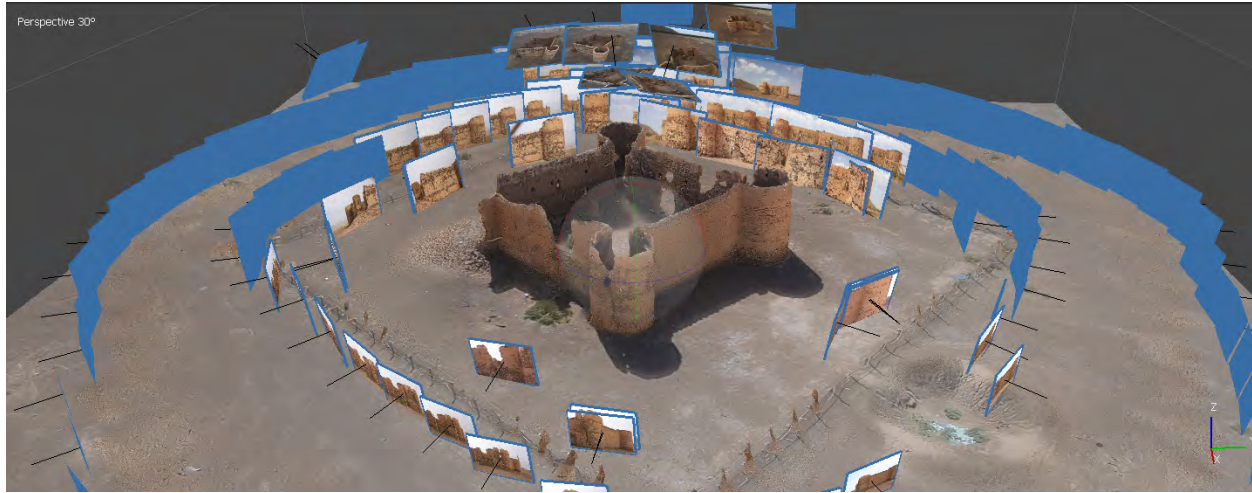
Fig 20: Image calibration data processing (Author, 2023)

In field calibration, which involves fine-tuning the cameras in the field. When precision is crucial, there are conditions that must be met for reliable field calibration. For instance, 1) Maintain constant zoom and focus settings on the camera throughout the shot; 2) the camera positions should cover a wide range of angles; 3) It is important to provide a high level of redundancy in the points shown in photographs, capturing them from several viewpoints and it is important to ensure that all photos are uniformly and comprehensively addressed.

7.5. Results

As a result, the experiment produced a remarkable points cloud, as depicted in (Fig. 21). These indicators were subsequently employed to generate a highly detailed point cloud consisting of an impressive 141,656 points. This intricate point cloud was then utilized to construct a mesh model, as illustrated in (Fig. 22). Furthermore, the mesh model was further enhanced to produce a visually appealing shaded colored model, . and the textured model, exemplified in (Fig. 23), was carefully constructed using the aforementioned indications, resulting in a comprehensive representation of the subject matter. The model's dimensions, meticulously crafted within the confines of the local coordinate system, were derived from precise field measurements obtained directly from the object itself.

Photogrammetry is an incredibly potent method that empowers the extraction of plans and sections with extraordinary levels of accuracy and effectiveness. By harnessing the capabilities of photogrammetry technology, there has been a noticeable amplification in efficiency and precision when it comes to extracting intricate details from models. Furthermore, this advanced technique ensures that high standards of quality and complexity are upheld throughout the process. Overall, photogrammetry has revolutionized the way plans and sections are obtained, providing a remarkable tool for achieving unparalleled results in terms of precision and efficiency see (Fig. 24).

Fig 21: The present study examines the distribution of points cloud utilized in the process of arrangement adjustment (Author, 2023)
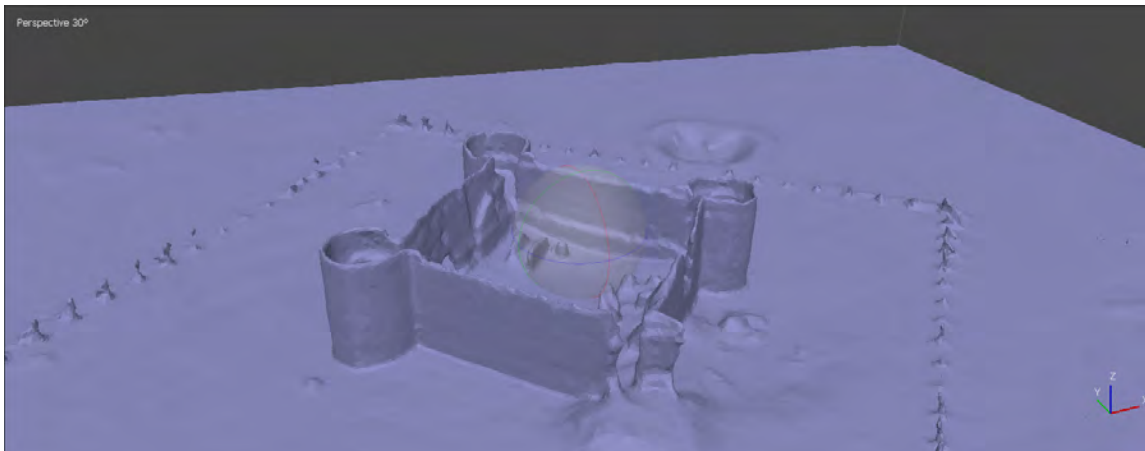

Fig 22: The data was collected using a Canon 4500 camera and an Anafi Parrot drone (Author, 2023)

Fig 23: Shaded colored model, Textured model and section prospective (Author, 2023)

Extracting plans from a photogrammetry model

Photogrammetry is a powerful technique that enables the extraction of plans and sections with exceptional levels of precision and efficiency. In general, the use of photogrammetry technology has significantly enhanced the efficiency and precision of extracting details from models, while maintaining high standards of quality and complexity.

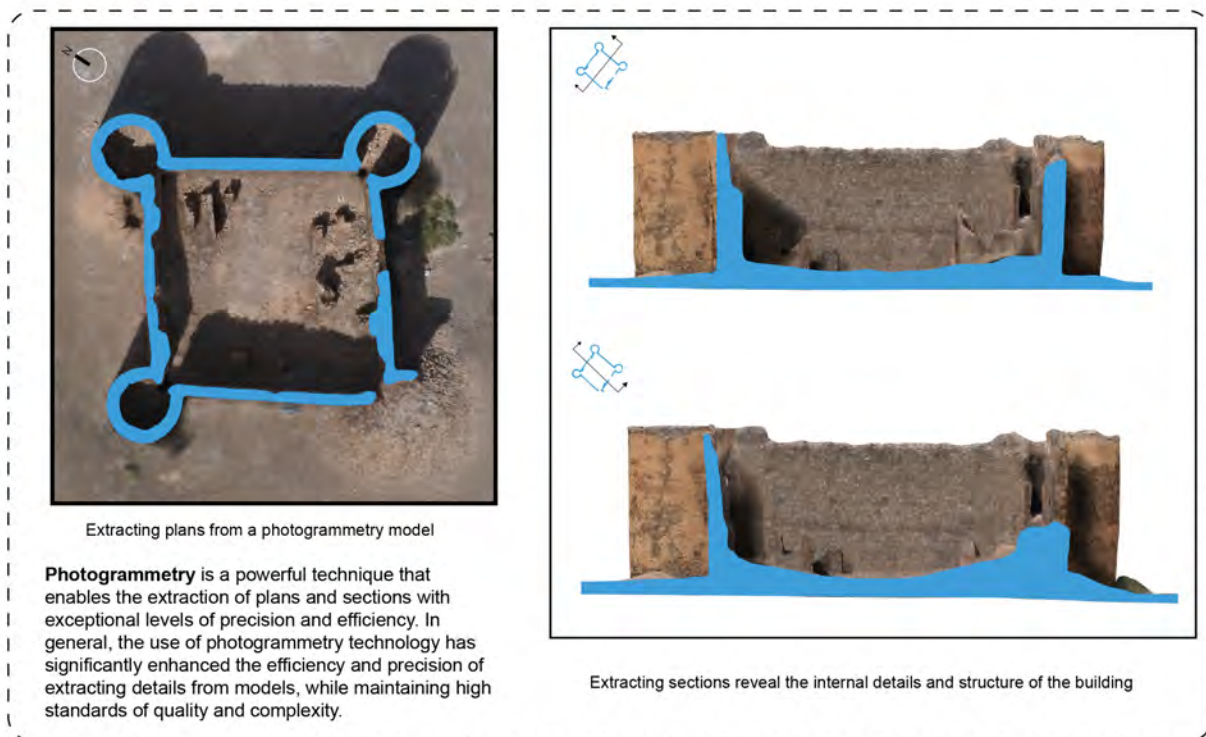Extracting sections reveal the internal details and structure of the building

Fig 24: The Extraction of plan and sections reveal the internal details and structure of the building (Author, 2023)

8. CONCLUSION

This study has provided background on the importance of preserving cultural heritage in Saudi Arabia and challenges in doing so. Besides highlight the importance of preserving its cultural heritage. It reveals the World Heritage System and the role of the Saudi Commission for Tourism and Antiques in heritage preservation. Furthermore, the history and significance of the Syrian Hajj route, which has been a major pilgrimage route for Muslims traveling from Syria to Mecca. The route has ancient origins, dating back to pre-Islamic times, and has played a crucial role in Islamic politics, culture, and trade. Also covered the forts along the route, which were built to provide protection and infrastructure for the pilgrims. The forts were strategically located near water sources and were constructed using local materials. Moreover, explored the historical background of Al-Faqir Fort and its importance along the pilgrimage route. Additionally, emphasizes the need for documentation and 3D reconstruction of heritage sites, using photogrammetry techniques to document and analyze the architectural heritage.

The utilization of a non-metric camera in photogrammetric documentation presents an efficient and cost-effective approach to capturing the condition of a structure during different phases of construction. This principle is equally applicable to architectural formations that are meticulously documented and recorded during archaeological excavations. The utilisation of Unmanned Aerial Vehicle (UAV) systems has witnessed a rise in popularity within the realm of archaeological research, owing to its substantial capacity in terms of expeditiousness, cost-effectiveness, and precision.

The documenting of historic structures may be accomplished using conventional means, but the use of current technology, such as terrestrial photogrammetry and unmanned aerial vehicles (UAVs) equipped with non-metric cameras, has significant value in conducting an inventory of architectural monuments. Recent advancements in technology have facilitated the rapid and precise development of a three-dimensional model of a monument or its component elevations. This process serves as a solid foundation for the creation of vector pictures depicting the structure. One of the key concerns pertaining to the inventory of large-scale historic monuments is the examination of architecturally intricate features situated at significant heights, as well as the measurement of pieces that are difficult to reach. The use of Unmanned Aerial Vehicles (UAVs) allows for the exploration of previously inaccessible locations, hence eliminating the need for scaffoldings or aerial platforms in several instances [84].

Some potential outcomes derived from captured pictures that might be valuable for historical recording include: a point cloud representation of an examined structure, a mesh model, an orthoimage representing elevation, or a digital model of the surrounding area of a monument. Furthermore, the programme known as Agisoft Metashape is extensively used for the purpose of modelling architectural features and individual

components of building facades [85]. Hence, virtual models may be seen as representations that closely resemble the original and provide pertinent information to researchers and other interested parties.

REFERENCES

[1] SCTA. Management Guidelines,Presentation of the new Municipality and SCTA strategy in the Old City. *Hist. JEDDAH, GATE TO MAKKAH* **2**, 1–127 (2012).

[2] Alzahrani, D. A. The Adoption of a Standard Definition of Cultural Heritage. *Int. J. Soc. Sci. Humanit.* **3**, 9-12.(p.10) (2013).

[3] Aas, C., Ladkin, A. & Fletcher, J. Stakeholder collaboration and heritage management. *Ann. Tour. Res.* **32**, 28-48.(p.44) (2005).

[4] Jokilehto, J. A History of Architectural Conservation. *J. Am. Inst. Conserv.* **40**, 150 (2002).

[5] Barsanti, S. G., Remondino, F., Fenández-Palacios, B. J. & Visintini, D. Critical Factors and Guidelines for 3D Surveying and Modelling in Cultural Heritage. *Int. J. Herit. Digit. Era* **3**, 141–158 (2014).

[6] Aicardi, I., Chiabrando, F., Maria Lingua, A. & Noardo, F. Recent trends in cultural heritage 3D survey: The photogrammetric computer vision approach. *J. Cult. Herit.* **32**, 257–266 (2018).

[7] Gomes, L., Regina Pereira Bellon, O. & Silva, L. 3D reconstruction methods for digital preservation of cultural heritage: A survey. *Pattern Recognit. Lett.* **50**, 3–14 (2014).

[8] Murtiyoso, A. & Grussenmeyer, P. Documentation of heritage buildings using close-range UAV images: dense matching issues, comparison and case studies. *Photogramm. Rec.* **32**, 206–229 (2017).

[9] Tsiafaki, D. & Michailidou, N. Benefits and Problems Through the Application of 3D Technologies in Archaeology: Recording, Visualisation, Representation and Reconstruction. *Sci. Cult. Tsiafaki Michailidou Sci. Cult.* **1**, 37–45 (2015).

[10] El-Hakim, S. F., Beraldin, J. A., Picard, M. & Godin, G. Detailed 3D reconstruction of large-scale heritage sites with integrated techniques. *IEEE Comput. Graph. Appl.* **24**, 21–29 (2004).

[11] Liu, X. *et al.* an Object-Oriented Uav 3D Path Planning Method Applied in Cultural Heritage Documentation. *ISPRS Ann. Photogramm. Remote Sens. Spat. Inf. Sci.* **5**, 33–40 (2022).

[12] Yusuf, N. Empowering Economic Development by Promoting Saudi Arabia's Cultural Heritage. **10**, 1–5 (2019).

[13] Maisel, S. & Shoup, J. A. Saudi Arabia and the Gulf Arab states today: an encyclopedia of life in the Arab states. (2009).

[14] Industrious.info. ARABIAN PENINSULA OUTLINE MAP. (2019).

[15] Exell, K. & Rico, T. Cultural heritage in the Arabian peninsula: Debates, discourses and practices. Pp.152 (2016).

[16] Aygen, Z. *International Heritage and Historic Building Conservation.* (Routledge, 2013).

[17] Power, C. Saudi Arabia Bulldozes over its Heritage. (2014).

[18] Joseph, A. Reforming the Judiciary in Saudi Arabia. *TI The influence of gender* (2019).

[19] Alzahrani, D. A. Heritage, Conservation and Good Governance Case Study: Saudi Arabia Heritage. 73–96 (2012).

[20] Aldosari, A. A. Geographic Names and UNESCO World Heritage sites in Saudi Arabia. *United Nations Gr. Expert. Geogr. Names* 1–11 (2023).

[21] Babsail, M. O. & Al-Qawasmi, J. Vernacular architecture in Saudi Arabia: Revival of displaced traditions. *Vernac. Archit. Towar. a Sustain. Futur.* 99–104 (2015) doi:10.1201/b17393.

[22] Ishteeaque, E. & Al-Said, F. The Native Architecture of Saudi Arabia: Architecture and Identity. (2008).

[23] Yusuf, N. Empowering Economic Development by Promoting Saudi Arabia's Cultural Heritage. **10**, 1–5 (2019).

[24] Power, T. The Red Sea from Byzantium to the Caliphate: AD 500-1000. (2012).

[25] Tabari. The Last Years of the Prophet: The Formation of the State AD 630-632/AH. 8–11 (2015).

[26] Alchetron. Wadi al-Qura. (2019).

[27] Covington, R. Roads of Arabia. (2011).

[28] Roads of Arabia (ROA). Makkah and Pilgrimage. *Saudi Aramco World* vol. 62 (2019).

[29] Marom, R. Approaches to the Research of Early Islam: The Hijrah in Western Historiography. (2017).

[30] Hadromi-Allouche, Z. S. Fazlur Rehman Shaikh, Chronology of Prophetic Events. (2002).

[31] Aksoy, Ö. C. Framing the Primordial: Islamic Heritage and Saudi Arabia. (2017).

[32] Maunsell, F. R. The Hejaz Railway. (1908).

[33] Nicholson, J. The hejaz railway. (2006).

[34] Aksoy, Ö. C. Framing the Primordial: Islamic Heritage and Saudi Arabia. (2017).

[35] Maunsell, F. R. The Hejaz Railway. (1908).

[36] Bowersock, G. W. Roman Arabia. *Harvard University Press.* 224 (1983) doi:10.4000/books.ifpo.4903.

[37] Borstad, K. A. History from geography: The initial route of the Via Nova Traiana in Jordan. *Levant* **40**, 55–70 (2008).

[38] Groom, N. Frankincense and Myrrh. *Longman: London.* (1981).

[39] Creswell, K. a. . & Allan, J. W. Early Muslim Architecture: Umayyads, Early Abbasids and Tulunids. Scolar Press. pp.435 (1989).

[40] Genequand, D. Ma'an, an Early Islamic Settlement in Southern Jordan: Preliminary Report on a Survey in 2002. *Annual of the Department of Antiquities of Jordan (Adaj)* vol. 47 25–35 (2003).

[41] Foote, R. M. Frescoes and carved ivory from the Abbasid family homestead at Humeima. Journal of Roman Archaeology, 12. 423–428 (1999).

[42] Oleson, J. P. *et al.* Preliminary report of the al-Ḥumayma excavation project, 1995, 1996, 1998. Annual of the Department of Antiquities of Jordan/Hashemite Kingdom of Jordan, 43,. 411-450. (1999).

[43] Al-Wohaibi, A. The Northern Hijaz in the writings of the Arab geographers, 800-1150. *Univ. London, Sch. Orient. African Stud. (United Kingdom).* (1969).

[44] Peters, F. E. *The Hajj: The Muslim pilgrimage to Mecca and the holy places. Princeton University Press. BMJ (Online)* vol. 343 (1996).

[45] Jomier, J. Le Maḥmal et la caravane égyptienne des pèlerins de La Mecque (XIIIe-XXe siècles). (1953).

46 Ankawi, A. The pilgrimage to Mecca in Mamluk times. Arabian Studies, 1,. 146–170 (1974).

47 Bakhit, M. A. The Ottoman Province of Damascus in the Sixteenth Century. *Libr. du Liban.* (1982).

48 Tresse, R. Le Pelerinage Syrien Aux Vil/es &intes de /'Islam. *(Paris).* (1937).

49 Defremery, C. & Sanguinetti, B. R. Voyages d'lbn Battuta (Paris). 282 (1858).

50 Issawi, C. *The Fertile Crescent, 1800-1914: A Documentary Economic History.Oxford University Press. The Economic History Review* vol. 42 (1988).

51 Bakhit, M. A. The Ottoman Province of Damascus in the Sixteenth Century. *Libr. du Liban.* (1982).

52 Barbir, K. K. Ottoman rule in Damascus, 1708-1758. *Princet. Univ. Press.* 282 (2014).

53 Heyd, U. Ottoman Documents on Palestine 1552-1615. A Study of the Firman according to the Muhimme Defteri. *Oriens* vol. 17 247 (1964).

54 G1BB, H, A, R. The Travels of Ibn Battuta, AD 1325-1354.Trans. with revisions and notes by H.A.R. Gibb. Vol. I. *Hakluyt Soc. Cambridge Univ. Press Cambridge* **1**, (1958).

55 Lee, M., Raso, C. & Hillenbrand, R. Mamluk caravansarais in galilee. *Levant* **24**, 55–94 (1992).

56 Nicolle, D. & McBridge, A. Armies of the Ottoman Turks 1300-1774. (1983).

57 Team, T. D. Levantine Hajj Trail (6): Al-Mu'adham Castle - Miss Castles. Desert team. (2022).

58 G1BB, H, A, R. The Travels of Ibn Battuta, AD 1325-1354.Trans. with revisions and notes by H.A.R. Gibb. Vol. I. *Hakluyt Soc. Cambridge Univ. Press Cambridge* **1**, (1958).

59 ÇELEBİ, E. *EVLİYÂ ÇELEBİ SEYAHATNÂMESİ. IX vol. Yapi Kredi Yayinlari Ltd.* (1999).

60 Bilge, M. Bilge, M. (1979). Arabia in the work of Awliya Chalaby (TheXVIIth century Turkish Muslim Traveller). Pp 213–27 in al-Ansary, Abdalla, Mortel and al-Sakkar (1979 eds). (1979).

61 Pierard, P., & Legros, P. Off-road in the Hejaz. Motivate publishing. pp.96 (1998).

62 Edib, M. Itinéraire de Constantinople à la Mecque: extrait de l'ouvrage turc intitulé: Kitab menassik el-hadj (livre des prières et des cérémonies relatives au pélerinage) . pp.82 (1816).

63 Bianchi, T. X. & Edib, M. Menasik-I hacc-i !jerif. Istanbul.Translated by M. Bianchi. Itineraire de Constantinople a la Mecque. Paris. (1840).

64 Burckhardt, J. L. Travels in Syria and the Holy Land.The Hadj Route from Damascus to Mekka.Appendix. No. III. *Assoc. Promot. Discov. Inter. PARTS AFRICA.* (1822) doi:10.5040/9780755604326.ch-019.

65 Bianchi, T. X. & Edib, M. Menasik-I hacc-i !jerif. Istanbul.Translated by M. Bianchi. Itineraire de Constantinople a la Mecque. Paris. (1840).

66 A. Boroń, Rzonca, A. & Wróbel, A. Metody fotogrametrii cyfrowej i skanowania laserowego w inwentaryzacji zabytków. *Rocz. Geomatyki-Annals Geomatics,* **5**, 129–140 (2007).

67 Markiewicz, J. S. & Zawieska, D. Terrestrial scanning or digital images in inventory of monumental objects? - Case study. *Int. Arch. Photogramm. Remote Sens. Spat. Inf. Sci. - ISPRS Arch.* **40**, 395–400 (2014).

68 Höhle, J. Photogrammetric measurements in oblique aerial images. *Photogramm. Fernerkundung, Geoinf.* **1**, 7–14 (2008).

69 Gerke, M. Dense Matching in High Resolution Oblique Airborne Images. *C. IAPRS, Vol. XXXVIII, Part 3/W4* **XXXVIII**, 77–82 (2009).

70 Szeliski, R. Computer vision: algorithms and applications. Springer Nature. *Choice Rev. Online* (2022) doi:10.5860/choice.48-5140.

71 Meijer, E. Structure from Motion as documentation technique for Rock Art. *Adoranten. Int. Rock Art Mag.* 66–73 (2015).

72 Morgan, J. A., Brogan, D. J. & Nelson, P. A. Application of Structure-from-Motion photogrammetry in laboratory flumes. *Geomorphology* **276**, 125–143 (2017).

73 Boehler, W., & Marbs, A. 3D scanning and photogrammetry for heritage recording: A comparison.Proceedings of the 12th International Conference on Geoinformatics,. 291-298. (2004).

74 Remondino, F., Guarnieri, A. & Vettore, A. 3D modeling of close-range objects: photogrammetry or laser scanning?. *Videometrics VIII* **5665**, 216–225 (2005).

75 Kadobayashi, R., Kochi, N., Otani, H. & Furukawa, R. Comparison and evaluation of laser scanning and photogrammetry and their combined use for digital recording of cultural heritage. *Int. Arch. Photogramm. Remote Sens. Spat. Inf. Sci.* **35 (5)**, 401–406 (2004).

76 Grussenmeyer, P., Landes, T., Voegtle, T. & Ringle, K. Comparison methods of terrestrial laser scanning, photogrammetry and tacheometry data for recording of cultural heritage buildings. *Int. Arch. Photogramm. Remote Sens. Spat. Inf. Sci. - ISPRS Arch.* **37**, 213–218 (2008).

77 Beraldin, J. A. Integration of Laser Scanning and Close-Range Photogrammetry – the Last Decade and Beyond. *Most* **35**, Part B pp. 12-23 (2004).

78 El-Hakim, S. F., Beraldin, J. A., Picard, M. & Godin, G. Detailed 3D reconstruction of large-scale heritage sites with integrated techniques. *IEEE Comput. Graph. Appl.* **24**, 21–29 (2004).

79 Lambers, K. *et al.* Combining photogrammetry and laser scanning for the recording and modelling of the Late Intermediate Period site of Pinchango Alto, Palpa, Peru. *J. Archaeol. Sci.* **34**, 1702–1712 (2007).

80 Guidi, G. *et al.* A Multi-Resolution Methodology for the 3D Modeling of Large and Complex Archeological Areas. *Int. J. Archit. Comput.* **7**, 39–55 (2009).

81 Jaud, M. *et al.* Assessing the accuracy of high resolution digital surface models computed by PhotoScan® and MicMac® in sub-optimal survey conditions. Remote Sensing. **8**, 465 (2016).

82 Preuss, R. Automatyzacja procesu przetwarzania danych obrazowych. Archiwum Fotogrametrii, Kartografii i Teledetekcji,. **26**, 119–127 (2014).

83 LLC, A. Algorithms used in Photoscan, http://www.agisoft.com/forum/index.php?topic=89, Retrieved Oct 29, 2023. (2018).

84 Brutto, M. Lo, Borruso, A. & D'Argenio, A. Uav Systems for Photogrammetric Data Acquisition of Archaeological Sites. *Int. J. Herit. Digit. Era* **1**, 7–13 (2012).

85 Robleda, P. G. & Pérez, R. A. Modeling and accuracy assessment for 3D-virtual reconstruction in cultural heritage using low-cost photogrammetry: Surveying of the 'santa maría azogue' church's front. *Int. Arch. Photogramm. Remote Sens. Spat. Inf. Sci. - ISPRS Arch.* **40**, 263–270 (2015)

THE INFLUENCE OF TRADITIONAL ARCHITECTURE ON MODERN ARCHITECTURAL HERITAGE OF IRAN

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THE INFLUENCE OF TRADITIONAL ARCHITECTURE ON MODERN ARCHITECTURAL HERITAGE OF IRAN

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Iran has a rich architectural heritage that dates back thousands of years. Traditional Iranian architecture is characterized by a unique blend of aesthetics and practicality, which has influenced modern architecture in Iran. In this essay, we will explore the influence of traditional Iranian architecture on modern architectural heritage in Iran. One of the most significant influences of traditional Iranian architecture on modern architectural heritage in Iran is the use of natural materials. Traditional Iranian buildings were constructed using materials such as mud, clay, and straw. These materials were readily available and were used to create buildings that were well-insulated and could withstand the harsh climatic conditions in Iran. Modern architects in Iran have continued to use these materials, but they have also incorporated other materials such as concrete and steel. Another important influence of traditional Iranian architecture on modern architecture in Iran is the use of geometric patterns and motifs. Traditional Iranian buildings were adorned with intricate geometric patterns, which were often repeated throughout the building. These patterns were not only decorative but also served functional purposes, such as helping to cool the interior of the building.

Modern architects in Iran have continued to use these patterns in their designs, but they have also incorporated other motifs and designs that reflect modern aesthetics. Traditional Iranian architecture also influenced the layout and design of modern buildings in Iran. Traditional Iranian buildings were often arranged around a central courtyard, which served as the focal point of the building. Modern architects in Iran have continued to use this layout in their designs, but they have also incorporated other elements such as open floor plans and modular design. The use of natural light is another significant influence of traditional Iranian architecture on modern architectural heritage in Iran. Traditional Iranian buildings were designed to maximize natural light, and they often had large windows and skylights. Modern architects in Iran have continued to use natural light in their designs, but they have also incorporated other elements such as energy-efficient lighting and shading systems. In conclusion, the influence of traditional Iranian architecture on modern architectural heritage in Iran is significant. The use of natural materials, geometric patterns, water features, layout and design, and natural light are just a few examples of how traditional Iranian architecture has influenced modern architecture in Iran. Modern architects in Iran have continued to incorporate these elements into their designs, but they have also added their own unique twist to create a modern architectural heritage that is both innovative and respectful of Iran's rich architectural heritage.

1. INTRODUCTION

1.1. Background

Traditional Iranian architecture is a testament to the rich history and cultural heritage of Iran. The fusion of aesthetics and practicality in traditional Iranian buildings has had a profound influence on the evolution of modern architectural heritage in Iran. This influence not only preserves cultural identity but also contributes to a more sustainable and contextually sensitive approach to contemporary construction. By drawing on centuries-old techniques and aesthetics, modern architects in Iran showcase a harmonious fusion of tradition and innovation, offering valuable lessons to the global architectural community on the importance of preserving and adapting cultural heritage in the pursuit of architectural excellence. This influence exemplifies how architecture can be a bridge between the past and the future, enriching the built environment with a sense of cultural continuity and resonance. This essay aims to delve into the various aspects of this influence and analyse how the traditions of the past continue to shape contemporary architectural designs in the country.

The essence of Iranian traditional architecture encompasses art, architectural forms, family values, expertise, and wisdom. These elements were passed down through generations, taught by family or community members, and perpetually adapted by the community in response to their surroundings and history. As a result, tradition is evident in how spaces are utilized, and the enduring values of Iranian tradition are prominently reflected in their historical architectural structures, such as houses. [1]Iranian traditional architecture incorporates sustainable systems designed by traditional architects to address the diverse climatic zones and regions in the country[2]. These sustainable systems aim to provide solutions for human comfort and the preservation of natural energies. [3] The architectural styles of Iran that are rooted in tradition are known for their inventive construction methods, ornate details, and effective functionality in harsh desert conditions. The main construction material is mud, often complemented by glazed brick tiles. Traditional structures employ techniques like qanat irrigation systems and sunken courtyards with water features and trees. These architectural traditions are well-documented in desert towns such as Yazd, Kashan, and Kerman. In these places, the buildings are specifically designed to improve the local climate[4].

The historical architecture of Iranian houses distinctly reflects traditional values like privacy and hospitality. Typically, traditional Iranian houses feature an internal layout, where rooms are arranged around a central courtyard, providing the sole access to the open space. Furthermore, key elements of traditional Iranian architecture such as construction materials, structural styles, mechanical elements, and decorative features have been integrated into present-day buildings. This highlights how traditional materials have been adapted and incorporated into modern architectural practices. This architectural design is shaped by the cultural practices of the inhabitants, with a strong emphasis on maintaining privacy and extending hospitality. Iranian architects have consistently prioritized key aspects of architecture, including logic, structural principles, technical and scientific considerations, human scale, and the utilization of local materials. Throughout Iran's historical architectural periods, a strong emphasis on geometry and precise drafting was prevalent. Mastery of mathematical principles and geometry was a fundamental requirement for architects, setting the foundation for competition and distinction within the field. [5]

Both Iranian and Western architects have endeavored to integrate these cultural values into modern architectural designs, blending traditional principles with innovative technology and contemporary forms. [1] The progress of technology and the introduction of fresh innovations have enabled the incorporation of arch-shaped structures along with innovative materials and designs. This underscores how traditional architectural elements have been modernized and integrated into contemporary construction practices. [6] These adaptations demonstrate the integration of traditional materials and design principles into modern architecture in Iran.

Modern architectural heritage encompasses the safeguarding and upkeep of buildings and structures originating from the 20th-century modernist movement [7]. These constructions, possessing noteworthy historical and cultural significance, may necessitate restoration or adaptation to accommodate evolving needs and purposes[8]. Preserving modern architectural heritage involves employing digital methods for documentation and examination, enabling enduring archiving and broader accessibility [9]. This is deemed a paramount national concern in countries like Ukraine, where safeguarding architectural cultural heritage is viewed as a strategic imperative [10]. The preservation and utilization of modern architectural heritage should be guided by a multi-objective optimization approach, considering factors like energy usage and indoor comfort [11]. The transition from traditional to modern housing in Iran involved adapting cultural values and architectural elements to new technologies and forms.

Iranian architects, such as Amir Hushang Seyhoun, Kamran Diba, and Nader Ardalan, along with Western architects like Andre Godard, emphasized the importance of incorporating cultural values into modern architecture. In summary, modern architectural heritage assumes a pivotal role in conserving the constructed environment and contributing to cultural sustainability, education, and tourism.

1.2. Objectives

The primary objective of this essay is to explore and analyze the influence of traditional Iranian architecture on modern architectural heritage in Iran is a captivating exploration of how centuries-old design principles continue to shape contemporary building practices of the time. Understanding this influence offers a profound glimpse into the evolution of Iranian architectural identity, showcasing a cultural legacy that thrives amidst the demands of a rapidly changing world.

1.3. Methodology

The study initiates with an extensive review of existing literature on traditional Iranian architecture, modern architectural practices in Iran, and the integration of traditional elements into contemporary designs. This literature review serves as the foundational framework for understanding the historical, cultural, and architectural context. We will analyze a wide range of academic sources, scholarly articles, books, and case studies to provide a comprehensive overview of this subject. Through this method, we aim to offer a well-researched and structured exploration of the topic. Archival research is conducted to access historical documents, photographs, and architectural plans that provide insights into the evolution of architectural practices in Iran. This archival data aids in tracing the development and adaptation of traditional elements in modern architectural heritage.

2. THE USE OF NATURAL MATERIALS

2.1. Introduction to Traditional Materials

Traditional Iranian architecture employs materials like mud, clay, and straw, selected for their suitability to Iran's climate. The integration of natural energy is a fundamental aspect of traditional Iranian house design, considering both climate and geography [12]. The focus on sustainable architecture in Iran's traditional constructions aims to cater to the needs of the inhabitants while adapting to the hot and arid summers [13]. In historic Iranian structures, wood serves as a structural component, and stress wave non-destructive testing is employed to assess the condition of wooden beams [14]. Furthermore, Certain traditional materials hold cultural significance and symbolism in Iranian society. For example, the use of turquoise tiles is a hallmark of Persian architecture and is often associated with spiritual and historical significance. Turquoise stone holds a unique and prominent place in Iranian culture, this is evident in the prevalent sky-blue color seen on mosque domes, created by Iranians through techniques like Kashikari.[15.] The material culture of Iranian household's underscores values like privacy, cooperation, purification, contentment, obedience, submission, and humility. These align with architectural patterns when combined with values of privacy and feminine principles [16].

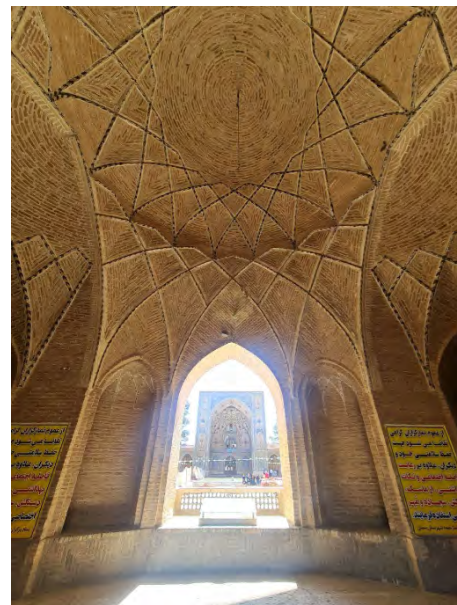Fig. 1: Blue tiles Jameh Mosque of Yazd. (Source: author)

Fig. 2.Brick walls in Imam Mosque of Semnan. (Source: author)

2.2. Contemporary Application of Traditional Materials

However, In the early 20th century, the introduction of European architectural concepts in Iran marked a significant shift in the country's architectural landscape. Reza Shah's modernization policies, initiated after establishing the Pahlavi dynasty in 1926, brought about a profound transformation in architectural practice. Notably, Reza Shah's construction projects, particularly the building of railway stations, played a crucial role in ushering in modern architecture in Iran. These stations, constructed with the collaboration of Western-trained architects and European companies, served as early examples of modern Iranian architectural style. Additionally, the construction of railway stations introduced modern materials like reinforced concrete to Iran, influencing the development of construction technology in the 1930s [17].

For generations, Iranian architecture has relied on traditional materials such as adobe, brick, stone, and wood. When integrated into contemporary designs, these materials offer a seamless aesthetic link to the nation's longstanding architectural heritage. with the advent of modernization and technological advancements, there has been a notable shift towards incorporating materials like concrete and steel [2]. The use of concrete and steel in modern Iranian architecture had a significant impact on both the structural integrity and aesthetics of the buildings. Concrete provided a strong and durable material for construction, allowing for the creation of larger and more complex structures Steel, on the other hand, offered flexibility in design and allowed for the construction of taller buildings with open and spacious interiors.

Fig. 4: integration of concrete material and bricks (Source: author)

Fig. 3: use of Turquoise blue with wight marble for the façade to remind of Persian traditional architecture (Source: author)

3. GEOMETRIC PATTERNS AND MOTIFS
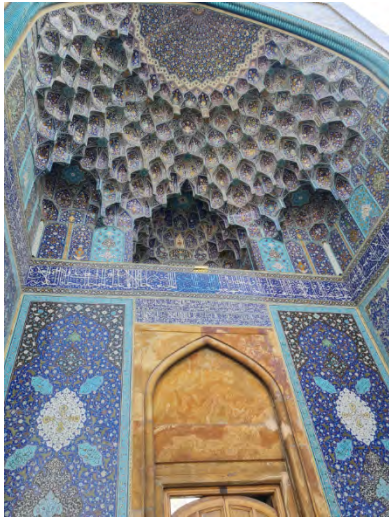
3.1. Traditional Ornamentation

Fig. 5: Imam Mosque Isfahan,
Patterns (Source: author)

Fig. 6: Khaju bridge, Isfahan (Source: author)

In traditional Iranian architecture, geometric patterns and motifs carry both functional and aesthetic importance. These designs are not just visually pleasing but also play a practical role in architectural structure. They are employed to establish a sense of balance, harmony, and overall order in building compositions. These elaborate geometric patterns are frequently rooted in mathematical principles and proportions, including considerations like human scale and modularization, which enhance the architectural beauty and coherence. [18]. As an illustration, a hexagonal shape is employed to determine the best alignment of the structure and to create a sharp clover arch in Persian architectural design. [19]Geometrical patterns in Persian architecture serve as a visual representation of the Sufi tradition, reflecting the belief in the interconnectedness of all things. [20]

3.2. Contemporary Utilization of Geometric Patterns

In the early Pahlavi era, modern Iranian architects employed a diverse range of motifs and patterns in their designs. During the initial Pahlavi period, three distinct architectural trends emerged: a push towards European-influenced modernism, a mixed approach incorporating both Western and pre-Islamic Iranian elements, and a revival of eclectic Iranian styles [21]. Persian architects of this era aimed to emulate Western architectural styles while also integrating traditional Iranian elements [22]. In the Qajar period, motif usage in architecture involved a degree of abstraction and drew inspiration from the surroundings. However, an overabundance of motifs often resulted in overcrowded and monotonous building designs [23]. In present-day Iranian architecture, there has been a notable shift towards a more sophisticated appreciation of the nation's cultural heritage. This has led to a renewed interest in historical architectural styles and a focus on capturing the essence of Iran's unique identity [24]However, the use of computer modeling and computer-

aided design has further facilitated the application of these geometric patterns in architectural and urban planning[25].
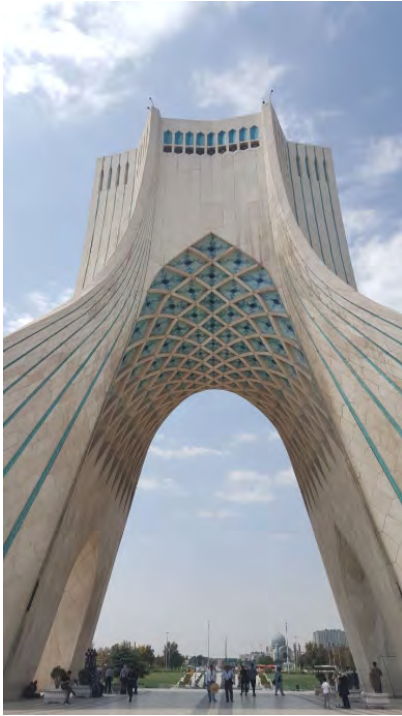

Fig. 8:Azadi tower of Tehran, geometric patterns and motifs (Source: author)

Fig. 7:Azadi tower of Tehran, geometric patterns and motifs (Source: author)

4. LAYOUT AND DESIGN

4.1. Traditional Layouts and Courtyards

Courtyards are an integral part of Persian architecture, often serving as central spaces within buildings. They are typically enclosed by walls or buildings, creating a private and secluded space, Often, they incorporate elements like gardens, fountains, and other facets of nature, elevating the visual charm and establishing a tranquil ambiance [23]. It is designed to incorporate and reflect the local lifestyle and cultural conditions, with a complex of open, semi-enclosed, and enclosed spaces [26]. Numerous research aimed to determine the ideal dimensions of central courtyards, considering various shapes like circular, polygonal, square, and rectangular, tailored to different climates and geographical locations. It was observed that altering the proportions of the central courtyard affects shading levels and direct sunlight exposure [27].

Furthermore, in a traditional house, rooms were typically organized around the central courtyard, creating a division between the private (Andarouni) and public (Birouni) spaces to uphold familial privacy, The elevated walls along the street provide limited visibility into the interior of the house[1].

Fig. 9: Molabashi house,Isfahan, central courtyard(Source: author)

4.2. Modern Architectural Layouts

Modern architects are blending traditional layouts with contemporary design elements in their work. For instance, In some modern houses, the central hall replaced the yard as the center, connecting public and private spaces and providing a circulation between them. This integration of central courtyards in modern architecture allowed for the preservation of cultural values and the creation of a sense of identity and continuity in Iranian housing [1]. They are introducing open floor plans and modular design concepts to create more flexible and adaptable spaces.

Fig. 10: central courtyard in national library of Iran,Tehran(Source: author)

Overall, the integration of traditional layouts with contemporary design elements is a way for architects to create spaces that are both functional and visually appealing in the modern world.

5. THE USE OF NATURAL LIGHT

5.1. Natural Light in Traditional Iranian Architecture

Persian architecture places significant emphasis on natural light, integrating windows and openings to create interplays of light and shadow. This enhances the visual allure of architectural details and patterns. Additionally, it fosters a seamless connection between indoor and outdoor spaces. Beyond aesthetics, natural light holds symbolic importance, symbolizing spiritual enlightenment and divine illumination in Persian design. [20] Deliberate attention is given to the dimensions, direction, and positioning of these openings to optimize both the quality and quantity of natural light [28]. Furthermore, the spatial arrangement of traditional Iranian structures, such as organizing rooms around a central courtyard, aids in effectively distributing natural light throughout the living spaces [29].
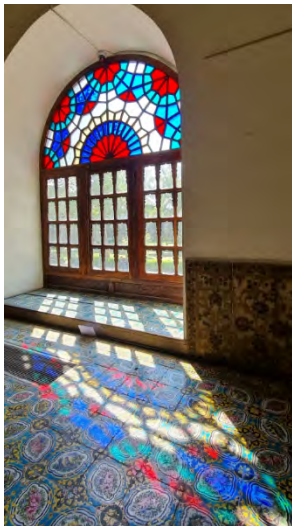

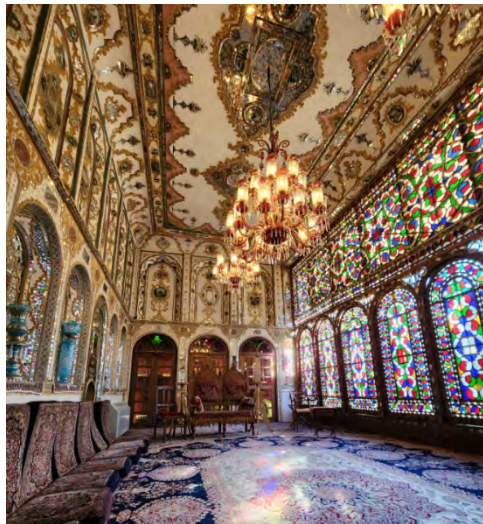Fig. 11: Golestan palace, use of natural light (Source: author)

Fig. 12. Molabashi house in Isfahan, large windows and colorful glasses (Source: author)

5.2. Modern Adaptations of Natural Light

Modern Iranian architects maintain the emphasis on natural light while integrating new technologies. They incorporate elements of traditional Iranian-Islamic architecture, such as the use of natural light, as one of the most important reasons for the formation of contemporary Iranian architecture. Recently, a shift towards community-oriented architecture, emphasizing identity, transparency, and user-centric design, has become pivotal in architectural development. This evolution has allowed for the meaningful representation of historical elements within modern Iranian architecture, with spaces designed to facilitate community interactions, dialogue, and democratic engagement[30].

Fig. 14: inside Azadi tower of Tehran, use of natural light (Source: author)

Fig. 13:contemporary arts museum of Tehran, natural lightning (Source: author)

6. ENVIRONMENTAL SUSTAINABILITY

Traditional Iranian architecture offers sustainable practices for contemporary buildings through a range of elements and strategies. These encompass employing time-tested techniques to ensure thermal comfort and energy efficiency. By incorporating cultural, climatic, and environmental considerations into the design process, it becomes possible to optimize energy consumption patterns[31]. Moreover, adhering to traditional Iranian architectural principles, such as the use of natural materials and the integration of features like courtyards and natural ventilation, contributes to energy conservation and the adoption of renewable energy sources[30]. The astute application of architectural technologies in historical structures attests to the sustainability of traditional buildings [32]. Overall, the influence of traditional Iranian architecture on modern buildings promotes sustainability through the use of natural materials, climate-responsive design, efficient space planning, and cultural sensitivity. This integration of heritage-based practices contributes to environmentally responsible and culturally meaningful contemporary architecture.

7. CULTURAL IDENTITY, PRESERVATION AND CHALLENGES

Modern architects in Iran are finding ways to honor the country's architectural heritage while embracing innovation. They acknowledge the significance of preserving and mirroring the cultural and historical foundations of Iranian architecture within modern edifices [33]. By melding Iranian and Islamic architectural influences, architects successfully uphold the essence of Iranian architectural identity while infusing contemporary design elements [23]. They derive inspiration from the enduring tenets of Iranian architecture, including authentic and sustainable patterns, and ingeniously incorporate them into their creations [34]. Architects often infuse their designs with cultural symbolism, drawing on historical references and traditional motifs. This not only strengthens the connection to Iran's cultural identity but also adds depth and meaning to the architectural expression. Through these approaches, contemporary architects in Iran pay homage to the nation's architectural heritage while pushing the boundaries of inventive design.

However, incorporating traditional elements into modern architecture in Iran is a complex endeavor fraught with challenges. The clash of aesthetics between traditional and modern styles, technical disparities, and budget constraints pose significant obstacles. Finding authentic materials, addressing cultural sensitivities, and balancing sustainability concerns further complicate the process. Regulatory approval and client preferences, along with the need for specialized maintenance and expertise, add layers of complexity to the integration of traditional elements into contemporary designs. To successfully navigate these challenges, a collaborative, multidisciplinary approach is essential, with architects, designers, historians, and builders working together to ensure the seamless and authentic incorporation of traditional features in modern architectural creations.

8. CONCLUSION

The influence of traditional Iranian architecture on modern architectural heritage in Iran is profound and multifaceted. It is evident in the continued use of natural materials, the integration of geometric patterns and motifs, the thoughtful layout and design of spaces, and the emphasis on harnessing natural light. This fusion of tradition and innovation showcases a dynamic architectural landscape that pays homage to Iran's rich cultural heritage while embracing the demands of contemporary design.

Through a careful balance of old and new, architects in Iran have succeeded in creating a modern architectural identity that is rooted in tradition. The incorporation of traditional elements not only adds aesthetic depth but also enhances the sustainability and functionality of contemporary buildings. By drawing on centuries-old wisdom and practices, architects in Iran exemplify a forward-thinking approach to sustainable architecture that resonates with inhabitants and promotes a sense of cultural continuity.

Modern architects in Iran are embracing the challenge of honoring their country's architectural heritage while pushing the boundaries of innovation. They do so by drawing on traditional principles, incorporating cultural symbolism, and maintaining a deep connection to Iran's architectural identity. However, this endeavor is not without its challenges, as the clash of aesthetics, technical disparities, budget constraints, and cultural sensitivities create complexities that require a collaborative, multidisciplinary approach.

Aspect	Influence of Traditional Iranian Architecture on Modern Architecture
Use of Natural Materials	Incorporation of mud, clay, and straw for low embodied energy and insulation. Adoption of concrete and steel.
Geometric Patterns	Integration of intricate patterns for both aesthetic and functional purposes. Incorporation of modern motifs.
Layout and Design	Emphasis on central courtyards for natural ventilation and light. Introduction of open floor plans and modular design.
Use of Natural Light	Maximizing natural light through large windows and openings. Integration of energy-efficient lighting and shading systems.
Environmental Sustainability	Utilization of time-tested techniques for thermal comfort and energy efficiency. Incorporation of cultural, climatic, and environmental considerations.
Cultural Identity	Blending Iranian and Islamic influences to maintain architectural identity. Incorporation of cultural symbolism and traditional motifs.
Preservation and Challenges	Efforts to honor architectural heritage amidst innovation. Challenges include aesthetic clashes, technical disparities, budget constraints, and more.

Table 1: Summary of the key points from each section (Source: author)

NOTES AND REFERENCES

[1] Maryam Jafarbegloo, 'How Modernization Encounter Tradition: Iranian Housing Development in the Second Pahlavi Period in Tehran (1940-1970)', *YBL Journal of Built Environment,* 6 (2018), 114-29.

[2] Javad Eiraji, and Seyed Ahmad Reza Yekani Fard, 'An Evaluation of Iran Architecture During First Pahlavi Era: A Transition from Tradition to Modernity', *Journal of Design for Resilience in Architecture and Planning,* 2 (2021), 222-33.

[3] Javad Eiraji, and Shabnam Akbari Namdar, 'Sustainable Systems in Iranian Traditional Architecture', *Procedia Engineering,* 21 (2011), 553-59.

[4] S Asadi, and A Shokoohi, 'Acoustic Investigation of Architectural Spaces with an Emphasis on Traditional Architectural Decorations (the Case Study of the Sound Room of Ali-Qapu Palace)', *J His Arch & Anthropol Sci,* 8 (2023), 59-67.

[5] Gholam Hossein Memarian, 'Introduction to Islamic Architecture of Iran', *Tehran: Memarian Publishing* (2018).

[6] S Karimi, 'Study and Comparison Arch at Framework Modern Materials Case Study: Iran', *Journal of Fundamental and Applied Sciences,* 9 (2017), 573-96.

[7] Yan Liu, and JiaTing Chen, 'A Multi-Objective Optimization Study of Modern Architectural Heritage Based on Intelligent Algorithms', (2023).

[8] Ana Tostões, *Modern Heritage: Reuse. Renovation. Restoration* (De Gruyter, 2022).

[9] Agnes Couvelas, 'Modern Architecture and Cultural Heritage', (2018).

[10] Gizem Güler Nakip, Gülnur Ballice, Eda Paykoç Özçelik, and İrem Deniz Akçam, 'Documenting and Conserving Modern Architectural Heritage: Çağlayan Apartment Building İzmir-Karşiyaka', in *Architecture Civil Engineering Environment* (2022).

[11] A. A. Kharytonova, 'Formation and Modern Development of Architectural Cultural Heritage in Ukraine', in *Regìonal'nì problemi arhìtekturi ta mìstobuduvannâ* (2022).

[12] Amirmasood Nakhaee Sharif, Sanaz Keshavarz Saleh, Sadegh Afzal, Niloofar Shoja Razavi, Mozhdeh Fadaei Nasab, and Samireh Kadaei, 'Evaluating and Identifying Climatic Design Features in Traditional Iranian Architecture for Energy Saving (Case Study of Residential Architecture in Northwest of Iran)', *Complexity,* 2022 (2022).

[13] Ali Ebrahimi, Aida Shayegani, and Mahnaz Mahmoudi Zarandi, 'Thermal Performance of Sustainable Element in Moayedi Icehouse in Iran', *International Journal of Architectural Heritage,* 15 (2021), 740-56.

[14] Mehrab Madhoushi, Saeideh Ebrahimi, and Asghar Omidvar, 'Structural Health Assessment of a Historical Building by Using in Situ Stress Wave Ndt: A Case Study in Iran', *Cerne,* 27 (2021).

[15] K. B. Zhetpisbayeva, and B. N. Zhubatova, 'The Symbolic Meaning of Turquoise in Iranian Culture', *Journal of Oriental Studies,* 97 (2021).

[16] Mojtaba Valibeigi, Sakineh Maroofi, and Sara Danay, 'The Material Cultures of the Iranian Home: Cultural Reading', *Estoa. Revista de la Facultad de Arquitectura y Urbanismo de la Universidad de Cuenca,* 11 (2022), 13-32.

[17] Golshan Moghassemi, 'The Advent of Modern Construction Techniques in Iran: Trans-Iranian Railway Stations (1933-1938)', ed. by Peyman Akhgar (2022).

[18] Rebecca Lin, and Craig S Kaplan, 'Freeform Islamic Geometric Patterns', *arXiv preprint arXiv:2301.01471* (2023).

[19] M Golabchi, and A Javani Dizaji, 'Architectural Technology of Iran', (Tehran: University of Tehran Press, 2016).

[20] Nader Ardalan, and Laleh Bakhtiar, *The Sufi Tradition in Persian Architecture* (University of Chicago Press, 1979).

[21] Faramarz Hassan Pour, Miles Lewis, and Qinghua Guo, 'Inconsistent Perceptions of Early Modern Iranian Architecture'.

[22] Morteza ELMI Jaafarloo, 'Reviewing Qajar Era Architectural Decoration with an Emphasis on European Designs in the Works of Shiraz', *Cumhuriyet University Faculty of Science (CSJ),* 36 (2015).

[23] Darab Diba, 'Contemporary Architecture of Iran', *Architectural Design,* 82 (2012), 70-79.

[24] Seyyed Nasroddin Eliaszadeh Moghadam, Mahmood Feizabadi, Mohamadreza Bemanian, Mahmood Golabchi, and Mojtaba Ansari, 'Methods of Utilizing Nature in Samples of Iranian Contemporary Architecture', *Armanshahr Architecture & Urban Development,* 6 (2013), 15-29.

25 Paloma Pajares-Ayuela, *Cosmatesque Ornament: Flat Polychrome Geometric Patterns in Architecture* (WW Norton & Company, 2001).

26 Hamed Kamelnia, Pirouz Hanachi, and Mina Moayedi, 'Exploring the Spatial Structure of Toon Historical Town Courtyard Houses: Topological Characteristics of the Courtyard Based on a Configuration Approach', *Journal of Cultural Heritage Management and Sustainable Development* (2022).

27 Tofigh Tabesh, and S Begum, 'An Investigation on Energy Efficient Courtyard Design Criteria', in *International Conference on Chemical, Civil and Environmental Engineering. Istanbul: Turkey* (2015).

28 N Tayari, and M Nikpour, 'Investigation on Daylight Quality of Central Courtyard's Adjacent Rooms in Traditional Houses in Hot Dry Region of Iran: A Case Study Yazdanpanah House', *Iranian (Iranica) Journal of Energy & Environment,* 13 (2022), 320-32.

29 Ali Salehipour, Iraj Etessam, and Seyed Majid Mofidi, 'Recognition of the Quality of Sunlight Hours in Traditional Houses of Tabriz, Iran', *Journal of Solar Energy Research,* 6 (2021), 696-712.

30 Hamed Kamelnia, and Pirouz Hanachi, 'Building New Heritage for the Future: Investigating Community Architecture Paradigms in Contemporary Architecture of Iran (1978–2020)', *Journal of Architecture and Urbanism,* 46 (2022), 171–90-71–90.

31 Kimia BELADİ, 'Evaluating Sustainability Aspects of Housing in Unesco World Heritage City of Yazd Case Study: Lariha House', *AURUM Journal of Engineering Systems and Architecture,* 6 (2022), 291-313.

32 Hessam Ghamari, 'Vernacular Iranian Architecture, Symbiotic of Meaning, Structure and Aesthetics Towards Energy Efficient Design', *Journal of Energy and Power Engineering,* 13 (2019), 283-91.

33 AM Moradi, and MS Taher Tolou Del, 'Modern Technology Necessity in Academic Training to Protect of Iran Architectural Heritage Authenticity', *International Journal of Architectural Engineering & Urban Planning,* 23 (2013), 23-33.

34 Maedeh Arabi, 'How to Reflect Spirit of the Time in the Current Architecture of Iran', *International Journal of Science, Technology and Society. Special Issue: Research and Practice in Architecture and Urban Studies in Developing Countries,* 3 (2015), 64-69.

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