MICROCLIMATE CONTROL IN MUGHAL ARCHITECTURE: A CASE STUDY OF LAHORE FORT

By

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MICROCLIMATE CONTROL IN MUGHAL ARCHITECTURE: A CASE STUDY OF LAHORE FORT

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Supervisor
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My all necessaries and relations are related any surrounded by ISHQ. My God please don't let my dreams go unrealized in the way half done. O hard times let me escape a while I may write. My life pregnant of roses and nightingale

Dedicated to the heart of Pakistan
A city of life; Lahore
A city of inspirational people that always laid close to my heart

Candidate's Declaration

I, Saira Iqbal, Student of M.Phil in Taxila Institute of Asian Civilizations, hereby declare that the material printed in the Dissertation titled ***"Microclimate control in Mughal Architecture: A case study of Lahore Fort"*** is my own work and has not been printed, published and submitted as research work in any form in any University in Pakistan or aboard.

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Saira Iqbal

Candidate

Supervisor's Declaration

I hereby declare that the M.Phil candidate **Ms. Saira Iqbal** has completed her thesis titled **"Microclimate control in Mughal Architecture: A case study of Lahore Fort"** under my supervision. I recommend it for submission in candidacy for the degree of Master of Philosophy in Asian Studies.

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Final Approval

This is to certify that we have read the thesis submitted by **Ms. Saira Iqbal** and it is our judgment that this thesis is of sufficient standard to warrant its acceptance by Quaid-i-Azam University, Islamabad, for the award of degree of Master of Philosophy in Asian Studies.

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Alone we can do so little – together we can do so much. (Keller)

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ABSTRACT

People depended on techniques driven from natural phenomenon that yielded convenient results – before the inventions of mechanical means. This research will deal with the use of such mechanisms like landscaping, vegetation , open spaces and water bodies in the Shah Jahan's quadrangle , Paien bagh quadrangle and Sheesh Mehal - Lahore Fort to understand how the temperature and the environment of the building can be controlled by using the objects of nature. The Mughals infused Islamic ideas with local traditions to improve the relation between man, environment and architecture. Thus studying relation of man and environment - house building was the first attempt towards possibilism to create artificial climate. Water bodies and gardens were used as the architectural elements in early times while constructing the ancient buildings. The Mughals gave new image and a new form to vegetation and landscaping by using trees, green areas, water bodies and open spaces in and around the buildings to enhance physical comfort and visual pleasure. The gardens and lawns perspire, and the evaporation leads to cooling. This study focuses on the use of indoor and outdoor water bodies to utilize the high thermal storage capacity of water for a moderating effect on the internal and external environment. We shall also deal with the deliberate focus of the builders upon psychological, aesthetic, visual and auditory effects of water and green areas and how they exploited transitional spaces to control the climatic conditions without employing mechanical means. Thus we try to establish the significance of the open spaces, water bodies and vegetation as a climate moderator in this study. Hence, the natural objects in architecture – effects the environment scientifically as well as aesthetically.

Chapter # 1
Introduction

1.0. INTRODUCTION:

"Makan dilnasheen hai az nasheman hai nuzhat aafreen" which means "heart pleasing buildings and praiseworthy mansions"- this phrase was used by Saleh Kamboh; to describe the beauty of the buildings.[1] Mughal architects are legendary for their creativity. The magnificent era famous for its art forms and innovations in its aesthetics was founded by Zaheer-ud-Din Babur. No doubt, Mughal era was the amalgamation of aesthetics and logic. The Mughal era that started from Zaheer-ud-Din Babur till its decline to Aurangzeb Alamgir was an era in which art and architecture flourished to its peak and then – came to its decline depending upon the interest of the emperors. This time period (1526-1707) saw many refinements in technologies. These refinements made Mughal era the originator and the initiator of many innovations in the history of civilizations. The architecture of Mughals were based not only on the aesthetics but also on the imaginative designs. These designs were based on a variety of experiences in the field of geometry, hydraulics, and other building sciences. These ideas reached to innovations in Akbar's reign. Not only Akbar – but it was Emperor Shah Jahan too, who created wonders in the field of Architecture. Utility, stability and beauty are three necessary pre-conditions of an architecture. Without beauty, architecture would just be the combination and amalgamation of some material. Hence art is the soul and spirit of architecture. Mughal Architecture is the example of "Feeling of Wonder" that is the source of aesthetic experience. In Aini Akbari, Abul Fazl cited splendid examples of the emphasis of Mughal Rulers on "wonderful" (*nayab*) Architecture.[2] Architecture, according to Ibn Khaldun, is one of the 'necessary' crafts: This is the first and the oldest crafts of sedentary civilizations… Using houses and mansions for cover and shelter…

[1] Abdul Rehman, Munazzaha Akhtar, Pak. J. Engg. & Appl. Sci. Vol. 10, Jan., 2012, Heart Pleasing and Praise worthy buildings : Reviewing Mughal Architecture in the light of Primary resources (p. 103-113)
[2] R. Nath, Some Aspects of Mughal Architecture (New Delhi: Abhinav publication, 1976)

to avert the harm arising from heat and cold' by the construction of walls and roof that intervene between man and 'those things in all sides'.[3] In this manner examining connection of man and environment - house building was his first endeavor towards possibilism[4] to make comfortable atmosphere. Building has significant impacts on the environment and natural resources.[5] The climate of an area speaks to the condition of the environs over a brief period of time. Coordinated climate condition more than quite a while is by and large alluded as atmosphere or all the more particularly, as the 'macro-climate. An investigation of the atmosphere of a specific area can help in evaluating the seasons or periods amid which an individual may encounter agreeable or uncomfortable conditions. It further aides in recognizing the climatic components, and in addition their seriousness, that causes distress. The data helps an originator to construct a house that channels out unfavorable climatic impacts, while at the same time permitting those that are gainful. Uneasiness and the comparing vitality interest for mechanical frameworks can be fundamentally decreased by sensible control of the climatic impacts. A building is not only used for shelter but to change to the microclimate control as well. Ancient men built houses to keep themselves safe from the effects of climate such as rain, snow, heat and wind. The microclimate varies with the buildings and their directions.[6] The microclimate of north wall would be different from that of the south wall. People were dependent on the natural means – before the inventions of mechanical means. Those natural means were comfortable to live in.[7] In buildings built during the Mughal period, extensive use of thick walls, high ceilings, and domed tops, shading of external

[3] Ibn e Khuldun, The Muqaddima (New York : 1958)

[4] Possiblism is one of the theory of Geography that states, environment is dependent on humans – the can shape the surroundings according to their ease and requirement.

[5] Zhiqiang (John) Zhai , Jonathan M. Previtali, Ancient Vernacular Architecture : Characteristics categorization and energy performance evalutation,

[6] Hassan Fathy, Natural Energy and Vernacular Architecture : Environment and Architecture (The University of Chicago Press Chicago and London , 1996)

[7] V K Bajpai , S Kumar , K S Kasana, Energy saving through passive cooling measures using bags with sawdust , Journal of energy in South Africa , 2006

surfaces, water channels, courtyards, verandahs, corridors and gardens can be found.[8] All the mentioned elements helped in controlling the microclimate. The condition of exchange of energy and thermal comfort through the building material that shape the warm reaction of individuals and are neighborhood and site-particular. These conditions are by and large gathered under the term of 'microclimate', which incorporates wind, radiation, temperature, and dampness experienced around a building. Essentially – it is to control and equalize the interior temperature as for the temperature outside the building. The research will concentrate on the period of Shah Jahan with reference to the contribution in Lahore Fort. As per John Brookes, At Lahore Fort he made huge commitments to the post initially made by Akbar. The Shah Jahan Nama of Lahori contains an extensive variety of data including everyday undertakings, military crusades, common works, transcripts of vital state archives, and letters traded with different rulers. The idea of citadel and fortress was to secure the bashful, terrify the insubordinate, and satisfy the loyal. They give superb assurance against cool and downpour, accommodate the solace of the princess of Harem, and are helpful for that nobility which is so essential for the common force. These fortresses were designed on the scientific as well as aesthetic principles. This research will cover the impact of vegetation and landscaping, usage of water, mechanism of open spaces and use of lattice screens. The historical backdrop of landscape architecture clearly depicts that the greenery enclosures by Mughals are the ideal and the finest accomplishment. Trees, green ranges and water body around a building enhance the physical solace alongside the visual delight. The aim of landscaping architecture is to reduce the input of the solar radiation in the building and surrounding spaces by trees, bushes, grass and creeping plants. The water bodies like wellsprings and water channels were included in the

[8] Ahmed Reza, K. Faghih , Mehdi N. Bahadori, Thermal Performance Evaluation of Domed Roofs (World Renewable Energy Congress, 2011) p.8

architecture which goes through the interior structures - was to change the internal environment. Water has a moderating and managing impact reporting in real time temperature of microclimate. It holds high thermal storage capacity, much higher than the building materials like block, cement and stones. It likewise has a cooling impact on the environs. Water pool in the middle of the courtyard with maximum dimensions stores the solar energy and decreases the heat of summer. This pool along with gardens, trees and boundless sky provide the limited but fresh nature. Openings have influence in sunlight based inactive structures. There are two sorts of openings: Main openings and the semi openings. Primary openings are as patios (courtyard) and porches, though semi openings are as verandahs. The uncomfortable climate components can be confronted with the suitable presentation of conventional houses and structures. Mulling over the atmosphere criteria – it can shield the human from the hot and cool climate. Courtyard is a proper spot for association of individual and the nature components including water. To keep the inner space cool is a vital assignment in controlling the microclimate. Grid screen or *jaali* is a critical highlight in keeping up the temperature. *Jaali* is as often as possible utilized as a part of Mughal structural planning. Extensive openings were filled in by the screens that let the air in and some light as well. Now and again, manufactured in covered openings was additionally seen in *jaalis* for perspective. Keeping the hot and humid climate of Lahore, cross ventilation framework was favored in buildings. Cross ventilation framework is an arrangement of ventilation in which the air enters from one side of the building and leaves on the other side. The ventilation air moves from the windward side to the leeward side. Old momentous structures, castles are still a spot to unwind without fan, coolers and aeration and cooling systems. There is a need to study the conventional structures in light of the fact that they are time tested. It is vital to research the adequacy of the

detached environment control arrangement of Indian customary structural engineering and distinguish its potential for contemporary application. Let us go back and audit the science behind the design configuration of legacy structures.

1.1 Problem Statement:

Ancient monumental buildings, palaces are still a place to relax without fan, coolers and air conditioners. There is a need to study the traditional buildings because they are time tested. Passive cooling, vernacularism and energy efficient architecture has had been the topic of research for the architects, archaeologists and artists. Most of the work was done in Northern Indian States having monuments and palaces like Fateh pur Sikri, Taj Mahal. Lahore Fort is famous not only for its aesthetics and art work in architecture but it also has a significance for its innovative style in construction techniques. Because of its highly admired art work, the fame of paintings and beauty in architecture - the innovation in technology and construction is being neglected. In this energy deficient era – there is a dire need to study the effective methods that can help the architects and engineers of today in sustainable development.

1.2 Research Questions:

Certain inquiries have not so far been raised, particularly those identifying with the hierarchical part of building developments? Who were the architects? What was their forte? Was there any foundation? Hundred years back when there was not any progression in innovation – how were the structures built, after the fundamental and propelled necessities of the ruler. A few issues will be examined in this examination with respect to structural engineering and advancement of building design – beginning from the site, its noteworthiness, and utilization of characteristic assets viably to the craftsmanship and style. Following are the research questions designed according to the paradigms, limitations and the hypothesis statement of research:

1. Can we associate ventilation system of Shah Jahan's quadrangle (Lahore Fort) as an example of signature "Mughal Microclimate control system?"

2. Did the Mughal architects use landscaping and plantation to control microclimate in Lahore Fort?

3. Is the utilization of water by Mughals in Lahore Fort still an eminent representation of undaunted Mughal Architectural mastery in retaining and regulating the temperature along with the beautification purpose via fountains, water channels and pools?

1.3 Objectives of the Study

Nothing is useless in this world. Everything has its specific purpose and objectives with respect to its importance. The present day hardware and materials utilized as a part of building swallow noteworthy measure of our national vitality. In perspective of the deficiency of vitality it is all that much fundamental to audit the recorded cause of Architecture and Technology to restore the solace inside the building. Climate responsive architecture is the need of the day. The main objectives of this study are to:

a. Review the science behind the architectural design of heritage buildings.
b. Learn and adopt the passive design techniques to maintain the comfortable environment inside without much use of active systems of cooling or heating.
c. Energy consumption can be reduced in heating & cooling from 50-80% if the buildings are designed and planned considering the microclimate, topography of the place, and other external features.

1.4 Significance of the study:

Lahore Fort is venerated for its beauty and aesthetics in architecture. The Mughals were not only beauty paramour but they were the innovative and inventive among all. Their love for construction paved the way for the coming generation to remember them – if

not in books as warriors, but in their minds as artists and beauty lovers. Observing our daily lives, watching news, and reading newspaper – we come to know that the present era is facing a great challenge for energy. The regular assets of vitality are draining step by step and as indicated by human populace, the present assets appear to be lacking to satisfy the needs of individuals in future- even it is being accepted that the third world war will be the war for water. The building segment, being a real customer of vitality requires needs a discriminating assessment on this viewpoint. The procedures utilized for cooling, warming and ventilation of the structures in the past were more agreeable with nature. Utilization of generally accessible assets for outline of verifiable structures was vitality proficient. The aloof cooling, microclimate control, ventilations frameworks in authentic structures give a wellspring of motivation to supportable advance in current world. The research will be significant if the techniques applied by the Mughal architects for construction would be applied and kept in special consideration while spending a large amount of money in making it energy efficient by using artificial techniques.

According to Neeta Mittal, "Ancient monumental palaces are still a place to relax without fan, coolers and air conditioners". This study will help the readers and the researchers to know the techniques that made the ancient buildings an emblem of architecture not only remarkable in its beauty but also in technology.

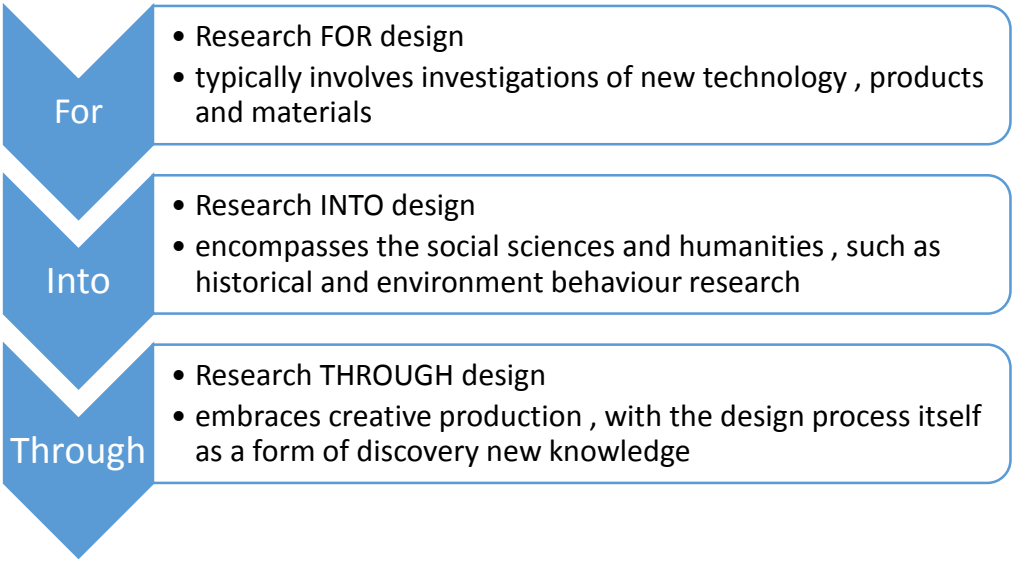
1.5 Hypothesis:

Lahore Fort is a remarkable sample of unusual methodology of the usage of water, ventilators, lattice screens, open spaces and gardens as a part of microclimate control.

1.6 Research Methodology:

Architectural research has characteristics of both scientific and technical research, on the one hand and artistic and humanistic on the other hand. Christopher Frayling, rector

of London's royal College of Art has argued that all research in architecture revolves around one of three or either all of the three prepositions.



This research revolves around the preposition INTO, as it encompasses the historical and environment behavior research. The perspective - historical will cover the significance and development of the historical site *Lahore Fort* under Mughals. The research into environment and behavior will deal with the effect of climate and microclimate surrounding the building and the use of natural vegetation, water and openings in the buildings.

Nature of Research:

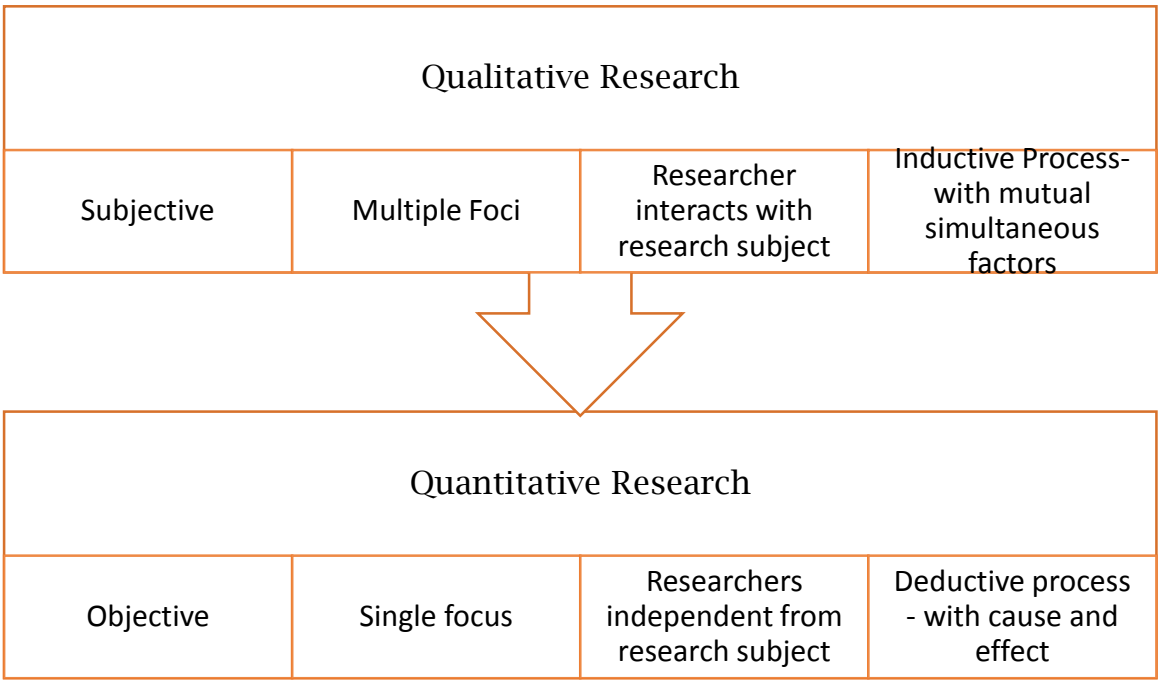
Approaches of Research:

In architecture; there are two kinds to approach a research:

Approach	Description	Detail

Deduction	Specific belief based on general situation.	Starts with generalization and moves towards observations.
Induction	General beliefs from many single cases.	Works from a set of principles towards way of achieving it.
Hypothetically Deductively	Back and forth from general to specific.	Starts with either a general situation or a particular case.

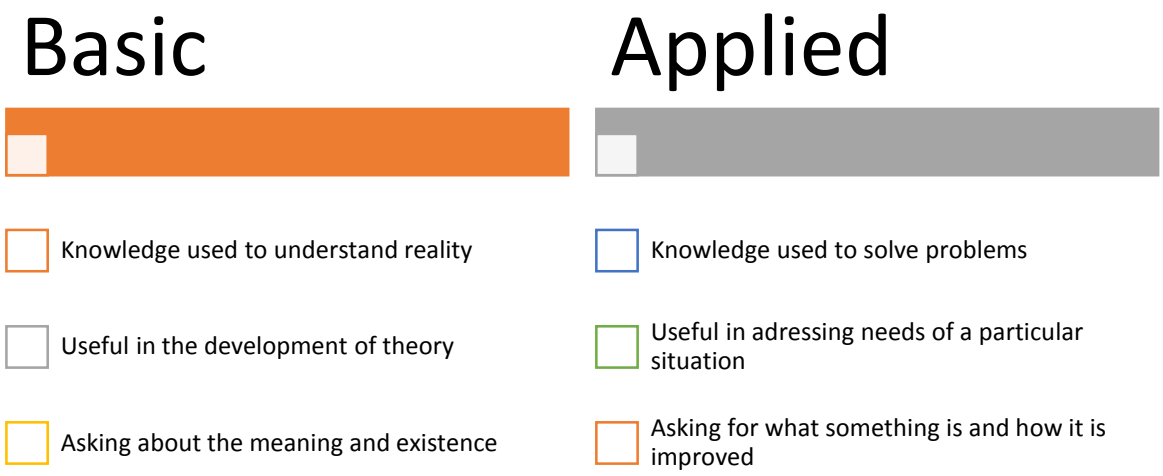
Types of Architectural Research



This research will be Qualitative research – as it will be subjective revolving around multiple foci i.e. ventilation system , passive cooling , use of openings , lattice screens , courtyards and corridors under the umbrella of microclimate control. This research

will follow the inductive process – starting from Mughal Architecture, covering Lahore Fort with special reference to Shah Jahan's quadrangle.

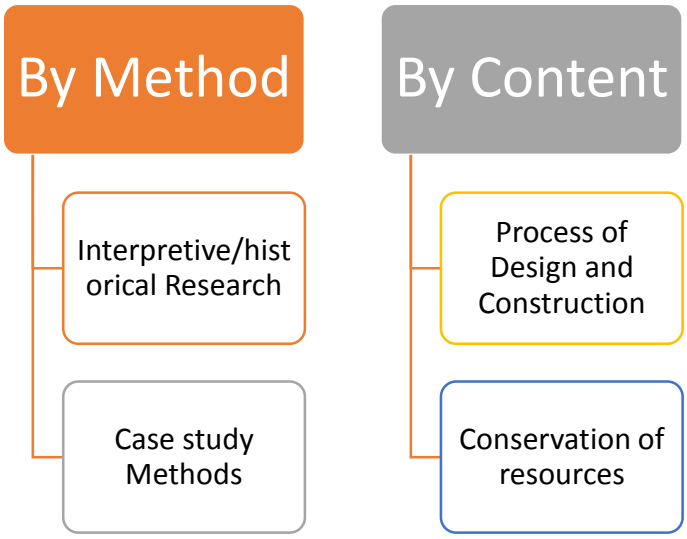
Architectural research while it is almost directed to very practical applications, also ranges from basic to applied research.[9]



The research conducted in this thesis will be a mixture of basic and applied research because this research will stipulate the connotations and importance of microclimate control as a unique and distinctive system in Mughal architecture highlighting the ventilation system, landscaping architecture and open spaces of specific areas of the Lahore fort. This will further provide the solutions and techniques in modern architecture to improve the ventilations and cooling system of buildings of the present century. This will help in reducing the onus from energy department in this energy deficit era.

[9] Van Nostrand Veinhold ,Architectural Research :1984

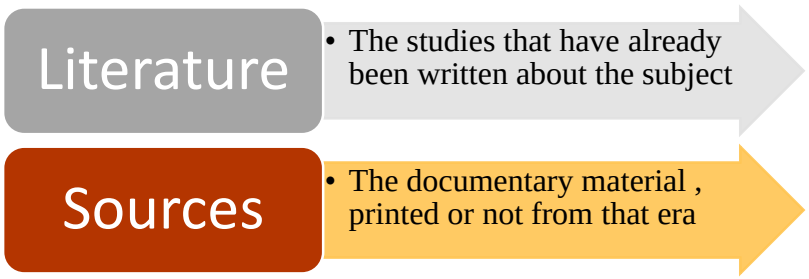
The range of architectural research is quite broad, according to Linda Groat and Wang in *Architectural Research methods*.[10] It is divided into two types:



A. By method :

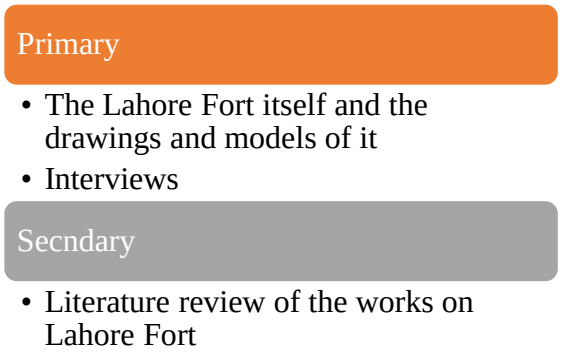
1. Interpretive and Historical Research :

As the examination is on the authentic building, the recorded exploration will assume a critical part in construction modeling. It can incorporate the examination of the historical backdrop of the site, the current fabric of a structure or a specific material or a framework. Chronicled examination depends extraordinarily on the reach and nature of sources.[11] These includes:



[10] Linda Groat and David Wang , Architectural Research Methods : 2002
[11] Otakar Macel , Ways to study and Research Urban, Architectural and Technical Design (DUP Science, 2002)

The sources are further categorized in two ways:



In historical research, the data analysis will be of two types:

a. Morphological Analysis

It involves looking at the specific characteristic of research i.e. Microclimate control of Lahore Fort – its significance and how it was better than the ventilation and cooling system of modern world.

b. Technical analysis

It includes looking at the specific site i.e. Lahore Fort, technique of ventilation system, landscaping, hydraulic system, use of water, hard area, soft area and the material used in construction.

2. Case Study Method :

In case study method, a case study building (Lahore fort in this research) is taken under the consideration of the researcher to study the microclimate control of Lahore Fort.

B. By Content :

1. Process of Design and Construction

It includes the design and construction style of Lahore Fort i.e. the technique of ventilation system. The mechanism of lattice screens, the use of water bodies around the buildings, the significance of courtyards and verandahs.

2. Conservation of Resources (Technique)

It includes a comprehensive understanding of techniques and their utilization in modern architecture to reduce the onus of energy sector in construction.

1.7 Literature Review

a. Heart Pleasing and Praiseworthy Buildings: Reviewing Mughal Architecture in the light of Primary Sources by Abdur Rehman and Munazzaha Akhtar

Mughal leadership defines the magnificent past of Muslims of the subcontinent. They not only expanded their authority over larger areas with the passage of time with multiple conquests, but also excelled in art and architecture. Their designed buildings are now considered a worth seeing asset around the world and people travel from distant lands to view them. Their amazing designs and their phenomenal construction ideas inspire people belonging to different walks of life and they are spell bound by their knowledge and abilities.

Every new architectural structure surpassed the previous one in designing and development as the experts working under Mughal leaders studied each aspect of the idea wonderfully. Without having today's powerful technology they created marvels that explain their proficient knowledge and tremendous capabilities.

Their ideas were not only focused on designing and art, but they ensured that the place is the best one for practical use. They studied the effects of environment and the surroundings of the construction site and then developed a complete construction plan covering all the aspects. With experiments and research new ideas evolved and their experts kept on tutoring the field of architecture by developing matchless monuments and tombstones.

This paper tries to provide the readers an insight of the Mughal's architecture by exploring all the features of these breath-taking sites. The sense and wisdom of our great Mughal leaders is represented by their structuring ideas for construction, their selection of a particular area for developing a beautiful place, their abilities to observe the key features deeply and their expertise to implement it perfectly. So, they can be considered as the true pioneers who laid the basis for modern architecture by leaving numerous beautiful examples as a proof of their talent.

b. The Benefits of Natural Light by Kevin Van Den Wymelenberg

Natural lightening offers numerous benefits to humans that can never be overlooked no matter what technology is introduced because its positive impacts for human health are irreplaceable. Modern architecture focuses on exterior design and shapes of the buildings more instead of benefiting the habitants with natural light resources. This approach is not doing any good for the people living in such buildings because they are being deprived of one of the natural sources that can nourish them in a way no other artificial source can. So, our modern designers should realize the importance of natural light by listing it as their top priority while developing a construction idea.

This paper suggests that our modern buildings should be constructed in a way that utilizes maximum natural light. It simply does not mean to have windows in all the spacious rooms from where day light can peak in. Instead, daylight can be consumed for using electric appliances balancing the energy demand in a cheap and reliable way. Architects should consider different options that can use natural light for illuminating purposes, as it is healthy and beneficial for the inhabitants too. Their work efficiency and productivity can be increased if they make a better interaction with natural light as they will feel comfortable both physically and mentally.

Similarly, energy saving can be done in an easy way by preferring natural light over electric means of producing energy. So, make maximum use of natural light by focusing on the numerous advantages it provides to the residents of the building.

c. Shalimar Gardens (A Report by UNESCO)

History and culture are strongly associated with each other as they both have developed the customs and traditions for each other. Pakistan is enriched with such beautiful cultural sites that portray our magnificent historical era. From north to south, we have such amazing architectural landmarks that speak of the glory of our past governed by remarkable leaders. Shalimar gardens and Lahore fort also comes under this category as they remind us of the amazing leadership of Mughals that focused on art and architecture. But, these worth-seeing places are prone to damage and require our attention so they can be preserved for a lasting time. Shalimar gardens and Lahore Fort are a part of world's heritage sites but due to damages caused to them by environment and lack of proper care, they were declared as the world's heritage sites under danger by UNESCO. This master plan explains all the necessary steps that should be taken to save these places from further damages. Step by step explanation is provided by describing the magnificent structure and its construction in the start. The focus is then shifted towards the importance of preserving a site that is listed as world's heritage by UNESCO. People from all over the world visit these places and admire their amazing architecture. They should remain in the same position as they are reminder of the glorious historical Mughal period. So, it is the legal and moral responsibility of the authorities to keep an eye on these places and follow a proper check routine on their maintenance work. Additionally, this paper then explains the areas that need attention for securing the buildings. For instance, the fountains, the water distribution system and the beautiful pavements of the garden are discussed in detail, so that the authorities can

be presented with a roadmap to follow, needed for the restoration process. Similarly, this research also indicates the need for conservation and maintenance of these remarkable pieces of art so that our future generations can also visualize their past. Expert opinion is provided on these serious damages and a detailed strategy is provided that assists the authorities in taking short and long term measurements. It not only describes the mandatory tools needed for development work but also highlights the need of funds for the maintenance process. So, by reading it you get a clear picture of the old Shalimar Gardens and its current needs to shine again with all its splendor.

d. Heritage Buildings-An Inspiration for Energy Efficient Modern Buildings by Miss Nitta Mittal

Ancient Asian buildings highlight the beautiful architecture and amazing ventilation techniques that the emperors used for efficient cooling processes due to hot and dry climatic conditions of the continent. Those implemented practices can be utilized for designing today's modern buildings that require proper ventilation as those ideas explains some inexpensive and easy ways to find a good solution for dealing with climatic issues.

The world-wide famous buildings that are considered a heritage for Asians left by their Mughal leaders, utilizes some easy and convenient ways for maintaining sufficient amount of air inside the rooms for balancing the temperature difference. This research explains their methodologies for making the living area a comfort zone for its residents.

Plantation of trees and expansion of water bodies inside these famous buildings explains the importance of greenery in balancing the temperature. Similarly, placement of *jalis*, a decorative feature in buildings also eases the ventilation process. Likewise, construction of courtyards and in-house wells were considered a must thing for any

building of that era, because both these things provided a proper ventilation mechanism for the residents by meeting their water needs in extreme temperature.

Therefore, this paper explains the need of merging these old and beautiful concepts with modern architectural designs for getting a permanent fix to the increased energy demands.

e. *Passive Cooling and Vernacularism in Mughal Buildings in North India: A Source of Inspiration for Sustainable Development by Asif Ali*

Today's world's never ending energy needs are on the rise with each passing day and the natural resources of energy are depleting with time. With the increase in technology we have discovered multiple ways of saving energy. But, on the opposite, today's world face major energy depletion challenges caused by different climatic threats like global warming and reduction of fossil fuels. These issues can cause severe problems to major energy consuming sectors and so our building sector needs to ponder on different other methodologies to save more energy by utilizing the available resources.

Current construction ideas need some modifications by exploring the ventilation procedures implemented in old historical buildings. Their cooling and heating process were formatted in accordance with the natural environment so that the inhabitants could utilize the natural energy resources fully. Mughal architecture is a model example of excellent cooling techniques that explains the tactics of saving natural resources for fulfilling the demands of energy. Their designs are harmonious with the climatic conditions of the area so that the dwellers can cope up with the extreme hot season without any issue.

So, for having sustainable development regarding energy consumption in the building sector our present architecture preferences need to be modified. We should focus on energy saving ideas by utilizing the available resources and make use of the natural ventilation techniques so the increased demands of energy can be managed within less expenses. This paper suggests strategies for natural cooling methods for a better future that can cope with the ventilation problems in an easy way.

f. A Literature Review of the Effects of Natural Light on Building Occupants by L.Edward and P. Torcelli

Daylight was the major source of lighting in old times as artificial lightening concept was not that much developed in that era. Architects designed buildings in accordance with the angles and direction of the daylight because they knew it is the chief source of energy. With the passage of time, buildings designs changed and electric lightening concept brought a revolution in old construction ideas. New concepts of developing huge buildings emerged and people welcomed these changes by accepting the newest technology that involved electric lightening. But, the benefits of daylight can never be overpowered by artificial lightening devices as daylight offers legion benefits to the residents apart from providing them light and energy.

Different electric light producing sources offer various wavelengths and each wavelength has a different impact on the residents. From cool-light fluorescent to energy-light fluorescent, all offer different wavelengths but they can never replace daylight's spectral distribution that is necessary for human growth. So, the progress in artificial lightening industry can never overcome the benefits of daylight for it is an essential component for us that can never be compromised.

Daylight increases productivity as it provides that energy needed for motivating you to produce results. Similarly, it assists in relaxing fatigued muscles and produces a calm effect on one's mind. Consequently, a sense of positivity is developed in the person having a good interaction with natural light and a more optimistic approach towards work and life is likely to be developed. It also reduces eyestrain and releases the emotional stress by soothing the stretched out muscles of the body. Likewise, it lowers absenteeism and people are willing to work and show better performance because their mind is fresh and clear. Therefore, natural light offers numerous effective benefits to the occupants and buildings should be designed keeping in view these advantages so that the ventilation systems are such developed that daylight can pass the rooms easily.

f. Indigenous Architecture and Natural Cooling by Vinod Gupta

The coolness of an old expanding on a hot summer after- twelve never neglects to inspire the guest and makes one miracle how the indigenous manufacturers could make such agreeable structures without the help of cutting edge logical information. Prodded on by the vitality emergency, we are today aggregating a limitless assortment of specialized writing on "detached cooling frameworks" but our present-day buildings have a tendency to be poor entertainers contrasted with the well- tempered indigenous structures. The motivation behind this paper is to look at how our ancestors handled warm outline issues and what instruments and strategies were accessible to them in the hot dry districts. It is critical to comprehend the contrast between the present-day method and that of the indigenous builders. At the point when draftsmen talk of inactive cooling, it is as though the upkeep of certain predefined temperatures in a building is an end in itself. Then again, the indigenous developer couldn't give a second thought less if the building was cool or warm so long as individuals could be agreeable inside or without the building. What's more, in this, the manufacturer's assignment was

disentangled by the readiness of the building clients to endure minor impairments. The indigenous structures were either unassuming abodes or monumental royal residences and sanctuaries. In either case, committed specialists in satisfactory numbers were accessible to keep up the structures. The errand of the current modeler who outlines habitations as well as plants, workplaces, inns, doctor's facilities, business focuses, instructive foundations and spots of stimulation, is a great deal more confused. Some of these new structures have all the more demanding requirements than those of the more established ones, while the utilization is entirely unoriginal. Notwithstanding, the devices, materials and strategies accessible today are more than what the indigenous developers had entry to. The hypothesis of uninvolved cooled or commonly cooled (as the author likes to call them) structures is well-developed. Different methods recommended for ecological control in advanced structures are: (a) shading of building surfaces from sun (b) damping of temperature varieties by warm mass (c) specific ventilation (d) radiation to night sky, and (e) dissipation of water. The indigenous developers utilized these and some other techniques that are maybe out of our reach today.

g. The Adoption of Central Courtyard as a Traditional Archetype in Contemporary Architecture of Iran by Mohammad javad Mahdavinejad, Abdolbaghi Moradchelleh, Sohaib Dehghani and Seyyed Mojtaba Mirhosseini

Islamic-Iranian character is a standout amongst the most dubious issues in contemporary structural engineering of Iran. The writing audit of the exploration demonstrates that Iranian contemporary engineers give careful consideration to customary paradigms keeping in mind the end goal to meet a commendable structural

planning which has an important association with interminable history of old Iran in which eye-getting gems can be seen effortlessly. "Focal yard" is a standout amongst the most imperative parts of Iranian customary structural planning. It assumes an essential part to bring together design components and log of spaces in customary structural planning of Iran. Consequently it considers as a key component in conventional construction modeling which can motivate contemporary modelers. The fundamental inquiry of the examination is: What is the part of focal patio in customary structural engineering of Iran? Also, what are the effects of focal yard as a conventional paradigm in contemporary structural planning of Iran? With a specific end goal to answer these inquiries contextual analysis technique and compound techniques have received for deduction component. Forty quantities of Iranian remarkable structures have been chosen as contextual analyses and the part of focal patio analyzes in these specimens. The examination results demonstrate that focal yard has a ton to do with building capacity and its constructional innovation.

h. An Overview of Passive Cooling Techniques in Buildings: Design Concepts and Architectural Interventions by Mohammad Arif Kamal

There has been an intense increment in the utilization of cooling framework for cooling the structures all around the globe. The most recent two decade has seen an extreme vitality emergency in creating nations particularly amid summer season fundamentally because of cooling burden prerequisites of structures. Expanding utilization of vitality has prompted natural contamination bringing about a worldwide temperature alteration and ozone layer consumption. Aloof cooling frameworks utilize non-mechanical systems to keep up an agreeable indoor temperature and are a key consider relieving

the effect of structures on nature. Aloof cooling procedures can decrease the crest cooling load in structures, in this manner diminishing the extent of the ventilating hardware and the period for which it is by and large needed. This paper audits and discriminatingly investigates different latent cooling systems and their part in giving warm solace and its essentialness in vitality preservation.

i. Traditional Energy – Free Solutions for Ventilation and Air-Cooling in Arid Tropical Areas of Asia by Nandor Zagyi

These days, more aerating and cooling gadgets are introduced to cool the internal spaces of staying houses and open structures in the crowded creating nations, primarily inside Asia—in India and in China. The requirement for such gadgets contributes not just to the development of metropolitan and open power utilization and discharge of toxins, however it is likewise in charge of a negative self-generating process: the more nursery gasses are discharged as a consequence of air-conditioning—the hotter our surroundings gets to be. Consequently, it merits attracting thoughtfulness regarding those customary routines and building structures by which agreeable aerates and cools could be produced in the hot dry and semi-dry zones of our Planet as for this study in South Asia. We can discover a few illustrations of such arrangements in India and in the Iranian Basin, too. Current age planners have additionally begun to find the significance of these antiquated routines and to apply them in their works. Albeit, across the board utilization of such strategies can't be normal sooner rather than later, the achievement of these creative however serene endeavors attained to up to this point ought to be accounted.

j. Ecological Aspects of the Courtyard House as a Passive Cooling System by Dr. Mahmoud Ahmed Eissa

The present day legislative issues of lodging, poor expert practice in building design and arranging, a non-biological way to deal with the configuration issue, construction laws, land hypothesis and zoning have added to the death of the yard house typology. The yard house frame additionally had a utilitarian capacity: to satisfactory the house to the tropical atmosphere by giving the rooms ventilation and light and, sometimes, to gather the downpour water for family employments. In this way, the yard was both a maintainable environmental reaction to the climate furthermore a social gadget to keep the tenants in touch. Natural outline is a method for incorporating human purposes nature's own streams, cycles, and designs. The present examination paper intends to rediscover the parts of the yard house building structure considered as low-vitality plan system and as a latent cooling.

k. Investigating the Courtyards of Traditional Houses and the Effect of Western Architecture by Javad Samadi

The progression of time enters the determinism which makes the planners a long way from the customary structural engineering and can be monetary, social, social or political. On the other hand, the presence of determinism in all cases above is the aftereffect of entry of time. The workmanship and construction modeling are dependably the subject to the certain and known standards and administers and have the steady, relentless and securely attached connection with the way of life, conduct examples and estimations of society. Accordingly, the building design styles of any period mirror the way of life and craftsmanship. This study, entitled as "Researching

the patios of conventional houses and the impact of Western structural engineering" examines the impact of nearby culture of atmospheres, Western society and the social variables on the morphology of yards in the customary places of Iran.

l. Natural cooling systems in sustainable traditional architecture of Iran by F. Soflaee and M. Shokouhian

This paper focuses on the consequences of supportability created by characteristic cooling frameworks in Iranian conventional structural engineering of hot-bone-dry districts. Manageability in structural planning means preserving developments for the future, as far as physical strength planet ensure rationing on vitality assets. For this situation, it appears that manageability would be in view of the presentation gainful models in which accessible materials and assets are utilized all the more productively, instead of being disregarded. These days, the information of building environment concentrates on its ability to coordinate natural and climatic parameters into configuration and hence upgrades space qualities, for example, solace capacity. Conventional building design of Iran is seen economical for having practical highlights. It has the capacity reaction to natural issues from a long stretch. Its highlights are in light of climatic elements and in addition neighborhood development materials of hot-bone-dry districts and characteristic cooling frameworks are one of these highlight. There are different regular cooling frameworks in conventional building design of Iran Like: Showdan, Khishkhan, Shabestan, Hozkhaneh and Badgir or wind catcher. Wind tower is a compositional component in conventional structural engineering of Iran. That is seen in hot atmospheres, hot & dry and hot sticky. It makes accessible auditable common ventilation which is known as a critical guideline for moderating vitality. Customary building strategies are typically all around adjusted to the atmosphere and we can utilize them with new innovation. This paper reasons that as indicated by a few

elements it is conceivable to address Iranian conventional structural planning. Iranian conventional structural engineering delicate impact of climatic strengths on framing of tenable spaces and it clarifies atmosphere was seen like natural constructional subject. It is obvious significance utilization of supportable and renewable wellspring of vitality, for example, wind structure and type of building. Consequence of this methodology is concordance with nature. The point of this examination is to show the tenet of characteristic cooling frameworks in maintainability of conventional structural engineering in hot-bone-dry atmosphere of Iran.

Chapter # 2
HISTORY OF MUGHALS AND THEIR ARCHITECTURE

2.0.HISTORY OF MUGHALS IN INDIA AND THEIR ARCHITECTURE

India in the early sixteenth century was like a turbid sea between two tides. There was energy, power and enterprise but no unity. There was promise rather than performance, aspiration without achievement. This situation had developed in north India since the collapse of the Delhi Sultanate under the impact of Timur's invasion in 1398 and of the Bahimini kingdom of the Deccan after the murder of Mahmud Gawan in 1481.[12] In the west the term "MUGHAL", usually spelled Mogul, means a man of great power.[13] The Mughals originated in Central Asia, and were descended from the Mongol ruler Genghis Khan and Timur, the great subjugator of Asia. They were greatly proud of their aristocracy, and it was the memory of Timur's raids on India in the fourteenth century that encouraged Babur on to invade. The great Mughals started from the invasion of Babur (1526) and ends at Aurangzeb Alamgir in 1707. After Aurangzeb, the rulers were weak, sluggish and ease lovers and the Mughals were just by name in rule till 1857.

Amid the early years of Mughal principle the nation was so unsettled there was no option deliver any considerable and particular work. But gradually with the passing time – the art of buildings took remarkable importance. There was wealth and power – the country was settled and organized so they left eye catching construction behind them. Not only wealth and power, the principle factor was the pronounced aesthetic nature of Mughal rulers themselves. History can indeed present rare examples of such a succession of sovereignty representing some five generations each member of was imbued with a keen desire to contribute to the visual arts. The art of Mughals was dependent on the majestic support and the power of throne. The ruler inclined towards art and architecture – take the paintings and buildings to its peak. Its rise and fall varies

[12] Percival Spear, Pakistan : Mughal Ascendency, by Ed.I.Hussain(London: Stacey International,1997) p.49-57
[13] Francis Robinson, The Mughal Emperors and the Islamic Dynasties Of India , Iran and Central Asia , 1206- 1925 (London : Thomas and Hudson,2006) p.6

from emperor to emperor. The majestic Mughals were awesome benefactors of workmanship and structural planning. They look unmistakable fascination in the arranging of strongholds, spots, mosques, tombs and even the new townships. They had their own thoughts regarding the development of build ins by the free amalgamation of what was known as the Mughal construction modeling which was indeed, the national Indian building design of that age. In structural engineering, the Mughal period was not by any stretch of the imagination a time of development and renaissance, however a continuation and finish of procedures that had their starting in the later Turko- Afghan Period. Mughal architecture is the modified form of Indian, Timurid and European designs.[14] There were several factors responsible for the architectural development and the standard of production during the Mughals. They were not only wealthy people but also the aesthetic nature of the Mughals was recorded in the history.[15] Hindu impact on architectural style kept going all through the Mughal period and conveyed what needs be in the narrow columns; Pilasters, corbel and other communicated in the thin segments, narrow columns, pilasters, corbel and other fancy highlights of Mughal structures.

The striking highlights of the Mughal building design, writes Sarkar' are the declared vault, thin turrets and the corners, the chimes upheld on columns and the Indo-Savaunic entryway which takes the manifestation of a tremendous semi-arch soaked in the front divider and bearing a commendable extent to the building while the genuine passageway is a little rectangular opening under the arch.[16]

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[14] Asher, Catherine Blanshard; Architecture of Mughal India (London: Cambridge University Press) 1992
[15] Percy Brown, Indian Architecture (Islamic period); The Mughal Period (India: D.B. Taraporevala ,1956)
[16] Pooja Mondal , The Development of Art and Architecture under the Mughals in India (http://www.yourarticlelibrary.com/history/the-development-of-art-and-architecture-under-the-mughals-in-india/4099/)

2.1. Zaheer ud Din Babur

Babur was born in Uzbekistan, the Timurid Babur acquired the throne of a little realm known as Ferghana in 1949.[17] The rule of Mughals began from Zaheer al Din Muhammad Babur who was a victor in Central Asia, after such a large number of endeavors, established the framework of Mughal realm - when he vanquished Ibrahim Lodi at the clash of Pani Pat in A.D. 1526.[18] According to *Ferishta* - *He was the person of greatness and he was so generous that he spend so extravagantly. He often forgave betrayal and thankless attitude of people that shows his goodness. He invalidate hate in his reign which made people love him more. He also wrote his own autobiography in Turkish language which is appreciated world widely.*[19]

Babur Nama is the most remarkable autobiography of medieval Islamic civilization. He himself declared that he has simply written the truth. The memoir was highly appreciated and valued by the Mughals. Babur led a marvelous and a remarkable life. He was famous for his love for innovation whether in the field of war or in art and literature. He is known as the man of actions. He died on 21 December 1530. In the 1540's he finally laid to rest in his favorite garden in Kabul.

"Babur was not only a great warrior, but also an intellectual personality, poet, calligrapher and a connoisseur of knowledge and art"[20]

Babur's reign in Samarqand had been short, the city's impact upon him was profound, shaping his attitude towards architecture and even more significantly towards

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[17] Catherine B. Asher, Architecture of Mughal India, Part 1 Vol. 4 (London: Cambridge University Press,1992)p.19

[18] The last emperor of the Lodi's dynasty (1451 - 1526). He ruled by succeeding Sikander Lodi (1489-1517). His time period was (1517-1526)

[19] Francis Robinson, The Mughal Emperors and the Islamic Dynasties Of India , Iran and Central Asia , 1206- 1925 (London: Thomas and Hudson,2006) p.114

[20] Kaleem Chughtai ,Islamic personalities; Zaheer ud Din Babar , accessed January 2,2015. http://www.bizbrowse.com/yarehman/islam/Mazameen/History/babar.htm

landscape.[21] Babur was a great lover of decorative gardens and orchards and seems to have put a considerable amount of effort in their construction. He was gifted with a real , as opposed to literary , sense of nature and stepped in Persian culture with its exaltation of the ideal landscape and of the 'paradise' with plants and flowers arranged in elegant geometric order around water.[22] As time passed, they were allowed to fall on decay because of their secular nature. Babur's period was so brief and taken up with the warfare that hardly it's any monument can be traced. Apart from the creation of gardens, the brief reign of Babur also saw the construction of mosques in various places: Sambhal, Panipat, Rohtak , Maham ,Sonepat, Palam (Delhi), Pilkhana, Agraand Ayodha. But in his memoirs Babur mentions only one mosque, at Dholpur, so it is possible that the majority of them were built not by him but only during that period.[23]

2.2. Naseer ud Din Muhammad Humayun

Humayun the auspicious, was born in Kabul on March 6, 1508 from third wife of Babur, Maham Begam and the daughter of a Shia noble of Khorasan. Humayun's real name was Nasir Uddin Muhammad.[24] He is popularly known as Naseer Uddin Humayun.

Humayun (1508-1556), Babur's favorite son took the reins of the empire after his father death. Humayun's first campaign was to confront a Sher Khan Suri, an Afghan, who was soundlessly spreading his state in the east. He had to leave this mission in its mid and had to focus on Gujarat where a threat from Ahmed Shah had to be crushed. As rulers are not free of mistakes and faults – same is the case with Humayun, because of

[21] Catherine B. Asher, Architecture of Mughal India, Part 1 Vol. 4 (London: Cambridge University Press,1992)p.20
[22] Bianca Maria Alfieri, Islamic Architecture of the Indian Subcontinent: The Arrival of Mughals (London: Laurence King Publishing ,2000) p.185
[23] Bianca Maria Alfieri, Islamic Architecture of the Indian Subcontinent: The Arrival of Mughals (London: Laurence King Publishing ,2000) p.186
[24] Vijay Rayan, Preserved Articles; Complete Biography of Mughal King Humayun . http://www.preservearticles.com/2011122218931/complete-biography-of-the-mughal-king-humayun.html

his weaknesses he was deceived by his fellows and brothers. Once again he fell into sluggishness and fall back in love with pipe and playmates. All this time he didn't confront Sher Khan Sur, who was collecting land and vassals in the east. As decision maker Sher Khan was far better than Humayun. In 1539, Humayun and Sher Khan met in Chausa's war which was among Varanasi and Patna. Humayun scantily retreated with his own life intact. His brothers refused to help. Finally, the Shah of Iran, Shah Tamasp, who was the lover of diamond (Koh e Noor) – gave him refugee taking diamond as bribe. After Sher Shah's death in gun powder explosive. Sher Shah's son Islam Shah Reign was till 1553. After his death the Sur Empire lost its pull on its people because of controversial rivalry and acute starvation.[25] In July 1555, Humayun retrieve his father's states in Agra and Delhi. In January 1556, he was building a regular civil government and died by falling from the stairs of his library. Once more the Mughal imperial stone had rolled to the bottom of the hill of success.[26] His descendant was a thirteen years old son Akbar. Humayun was the first of the line to build substantially, although most of his work has disappeared.[27] Art and Architecture of Humayun's era was influenced by Persia- because on his return from Persia he had been accompanied by Persian artists. His art work was not only inspired by Persians but after his alliances with Rajput princess he become more inclined towards indigenous Indian fashion and art. The only building in Agra that undoubtedly belongs to Humayun's era and that still has its original form is the mosque of the village of Kachpura, on the left bank of river Jumna.[28] His most ambitious architectural project was "Refuge of the faith" (*Din e Panah*). According to Khwanand Amir it was intended to include grand palaces,

[25] Dr. Neria.H.Hebbar, History of Islam in India , The Fujitive King : Humayun (1508- 1556), accessed December 14,2014

[26] Percival Spear , "Mughal Ascendency: Pakistan, by Ed.I.Hussain"(London: Stacey International,1997) p.50

[27] Stephen F. Dale , Safavid , Persia The Ottoman Empire and Mughal India : The Mughals in India (USA : Cambridge University Press , 2010)

[28] Bianca Maria Alfieri, Islamic Architecture of the Indian Subcontinent: The Arrival of Mughals (London: Laurence King Publishing ,2000) p.188

gardens and orchards. It provided exile for the scholars and refuge to the vigilant people. The great period of Mughal buildings, however followed the accession of Akbar, son of Humayun.

Figure 1 : Humayun Mosque situated in the village of Kachpura in Agra

A Contribution in Architecture by Humayun

2.3. Jalal ud Din Muhammad Akbar

Akbar, a person who ruled for about 49 years and secured Mughal rule throughout India. His full name was Jalal al Din Muhammad Akbar. He was born on 23rd November, 1542 when his father was defeated by Sher Shah Suri and he had lost his empire.[29] Akbar was respected and laurelled king of Kalanaur in the Punjab, on February 14, 1556. The only state he dictated was a small part of the Punjab.[30] He was fourteen years old, but he proved himself a great guider and victorious person. He created governmental system in which all his people had right to property, security and a say in the government interests. He pursue religious approach in his Mughal state. After

[29] Aslam Rahi , Shehanshah e Hindustan-Jalal ud Din Akbar (Lahore: Shama Book Agency , 1994)

[30] Hemu, a Hindu vegetable seller, who by dint of genius rose to become the chief arbitrator of power under Adil Shah Suri.

Humayun's death – Akbar was just thirteen. He declared Bairam Khan as the guardian of Akbar – because he was too young to rule but he proved himself. Till 1562, Akbar was dependent – first on Bairam Khan and then on Maham Anaga. After the death of Adham Khan (Maham Anaga's son) she never recovered from the shock. In this way Akbar took full control of his government. Akbar the great moved his capital southwards from Delhi, the city his father has lost and recovered. Akbar was the virtuous man and he acquired respectable reputation. His amendments in monetary and his great religious management resulted in his applaud. He got riddance from Jizyah, capitation of tax on non-Muslims, and the constitutional tax Hindus pay. He repressed ul'ama power. He himself was illiterate but was very much interested in knowing about different religions. He also built a house for worship where people gather and learn and discuss religious issues.[31] He was interested in religion in an open way – constantly working on expanding the knowledge and understanding. His free patterns of thinking brought strong opposition from Ul'ama but his liberal approach made good sense in a multi-faith empire. Akbar was a remarkable as an individual as he was a ruler. His interest rang widely from books to art, painting, music and literature. He had great interest in crafts and machinery. The Jesuits who visited Akbar's court was impressed by his skills of using prefabricated structures in the development of new textiles, in the cooling of buildings, in the making of hand guns. Abul Fadl tells us that, 'His majesty from his knowledge has invented a wheel, by the motion of which 16 barrels (of handguns) may be cleaned in a very short time. The wheel is turned by a cow. According to Jesuit Du Jarric, 'There is no doubt he was a great king – for he knew that the good ruler is he who can command, simultaneously the obedience, the respect the love and the fear of his subjects.' He worked hard and slept little – with each passing day, his

[31] Muslim Rulers and Sufi Saints- Jalal ud Din Muhammad Akbar, 1962.
http://www.thesikhencyclopedia.com/biographies/muslims-rulers-and-sufi-saints/akbar-jalal-ud-din-muhammad

health suddenly gave away. On 21 October, Akbar unable to speak, invested Salim as his successor. On 25 October, aged 63, he died.

Mughal style of architecture did not take concrete and tangible form until the time of Akbar. This was the early phase of construction – in which the principle construction material was red sand stone. Akbar was more inclined towards beauty and aesthetics. After his alliances with Rajput princess – he was more inclined towards Indian art and architecture. In the Mughal architecture of Akbar's later years the Indian, Gujrati, Malwa and also Persian features were dominant- in the form of gate ways , arches , and vaults of sub-structures , arcades ,the mosques , facades and *mihrabs*. The trend was changed as the amelioration in the architecture by using caravan *Sarai* and palace enclosures. In the domestic architecture, Rajput architectural features were dominant. This trend kept on changing until Jahangir's time - all the Persian elements had disappeared. The archives of Akbar i.e. *Ain-i-Akbari* and the official history, *Akbarnama*, provide ample information on the various stages in the design and implementation of his architectural projects. Site selection in his era was very important in the process. Before site selection the *hakims* from the court examined the qualities of soil. Hakim Misri and Hakim Ali were the highest *hakims* at Akbar's court. They were assigned the task to test the soil. After their formal approval the site was then acquired for the construction of the town, fort or garden.[32]

One of the earliest buildings built is the Tomb of Humayun, in Delhi. It was built after Humayun's death by his first wife Hamida Banu Begam. This splendid tomb, designed by the distinguished architect and poet Sayyid Muhammad Mirak and his father Mirak-i-Sayyid Ghiyas who worked for Sultan Hussain Bayqra and executed by Indian

[32] Abdur Rehman , Earthly Paradise : Mughal Gardens : History and Architecture (Lahore : Habib ur Rehman Publications , 2001)p.86

craftsmen and masons, is a fine example of the synthesis of Indian-Persian traditions. He built a large number of forts and towns through Mughal Empire. Only a few buildings of Akbar's period survive today. Important buildings in Akbar's era were Red Fort at Agra, City (1564-80) on the banks of Jumna. It was executed under the supervision of Qasim Khan, a renowned architect of the time, at a cost of rupees thirty-five lacs.[33] It's enclosing wall of red sand stone, 20m high on the river side. Two sophisticated multiple gates provides access and although palatial internally it remains a fortress. The main building of the place are set on the eastern flank overlooking the river Jumna. Polygonal towers are decorated with inlaid panels, string courses and domed pavilions, and are topped with massive and carefully aligned crenellations.[34] Akbar's fort at Lahore carries panels of ceramic mosaic on its outer walls. At Delhi the sandstone walls of red stone are inlaid with white marble. Within the red fort at Agra, the Jahangir Mahal, built by the emperor for his son, survive in good condition. The peak of Akbar's building activity was the creation of new town, Fatehpur Sikri (1569-80) was a new city. It was the first large scale town planning project undertaken by the Emperor. It was planned as an elaborate royal residence.

It survives as a remarkable monument to Moghul architecture in a virtually intact state, and displays techniques of construction – which may be described as 'stone joinery'. During Akbar's time, it is said that about 500 beautiful buildings were constructed in the Red Fort at Agra but only a few of them now survive.

The Panch Mahal rises through five airy storeys, each diminishing in size while the isolated Diwan-e-Khas is a unique, cubic throne room in which the first floor consists of an isolated central platform carried on a stone pier. Bridges on the diagonal axis and

[33] Abdur Rehman , Earthly Paradise : Mughal Gardens : History and Architecture (Lahore : Habib ur Rehman Publications , 2001)p.88

[34] Stephen F. Dale , Safavid Persia , The Ottoman Empire and Moghul India (Cambridge University Press, 2009)

the access through spiral staircase for connections was the unique architectural invention. Ornamental pools and courtyards were linked to stables, treasures, houses, baths, public and private rooms and the mosque.

The Great Mosque, Fatehpur Sikri (1571-96) follows the regular Mughal plan with a central pavilion boasting triple domes. The Buland Darwaza rebuilt by Akbar as a triumphal monument. The Tomb of Akbar the Great, Sikandara, Agra, (1604-12) stands in a garden intersected by watercourses.

Figure 2: Panch Mahal - Fateh pur Sikri

One of the contributions of Akbar in Mughal Architecture in Fatehpur Sikri

Figure 3: Buland Darwaz (Victory Gate)

Built by Akbar to commemorate his victory over Gujrat

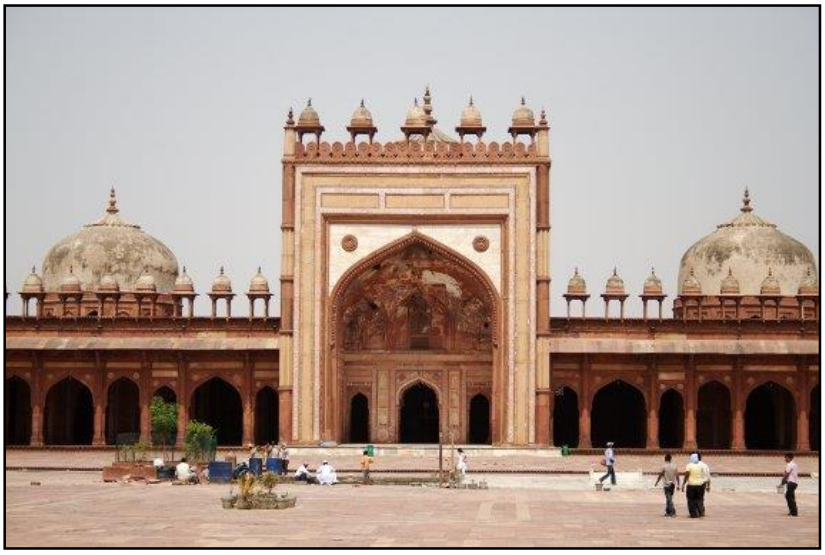

Figure 4 : Great Mosque (Jamia Masjid) Fateh pur Sikri

2.4. Nur ud Din Salim Jahangir

Jahangir, a man of intellect, scholarly abilities and great connoisseurship, was amongst the most interesting of the Great Mughals. His original name was Nur ud Din

Muhammad Salim – famously known as Jahangir – who came to the throne at the age of 36. His reign was the time of growing power and magnificence for Mughal Empire because he maintained the continuity of his father's policies. He admired art and paintings a lot. His highly knowledgeable and involved patronage took Mughal painting to its peak.[35] He lacked his father's genius, but he was shrewd, capable, determined if sometimes ferocious man. It would have been certainly lesser without the succor of famous Noor Jehan. As it was, he kept the empire together and, with his capture of Kangra and aggression in the Deccan, left it a little larger than he found it.[36] It was however – because of investing arts, he achieved real distinction. After a few days of his father's death, Salim writes in his memoirs - the experience of wearing crown and his feelings when an onus of responsibility was on his head. He wrote that when a crown that has been worn by great emperors and the kings brought before him, in the presence of whole assembled and *Amiers* ; that crown was placed on his brows as an omen auspicious to the stability and happiness of his rein. He noticed that his name is the same as the ottoman sultan – he changed it as "the ruler of the world "– calling himself Jahangir.

According to Sir Thomas Roe, "He is very affable and of a cheerful countenance…. And not proud in nature, full of gentle conversation… the wisdom and goodness of the king appears above the malice of others ….."[37] The Itimad ud Daula, Agra was erected by Akbar's son Jahangir. He built little but, having completed his father's tomb, commissioned this mausoleum to the father of his consort in a garden on the banks of

[35] Francis Robinson, The Mughal Emperors and the Islamic Dynasties Of India , Iran and Central Asia , 1206- 1925 (London: Thomas and Hudson,2006) p.142
[36] Percival Spear, "Mughal Ascendency: Pakistan, by Ed.I.Hussain"(London: Stacey International,1997) p.53
[37] Francis Robinson, The Mughal Emperors and the Islamic Dynasties Of India , Iran and Central Asia , 1206- 1925 (London: Thomas and Hudson,2006) p.138

the river Jumna.[38] In the early seventeenth century the transition from red sand stone to white marble facings for monumental and court buildings was seen.

2.5. Shahab Uddin Muhammad Shah Jahan

When Jahangir sat on the throne of empire,

The world attained the splendor of the divine shadow,

Illuminator of crown and throne he was,

Generous, mercy full and lucky.[39]

Muhammad Hadi

Shah Jahan, impatient to succeed even at the price of rebellion, proved to be the most magnificent of Akbar's successors.[40] He got crowned in 1627 after the death of his father. He was crowned in Agra. Shah Jahan was considered as one of the matchless Mughals of all time. His reign is considered as Golden Age and Indian civilization thrived in his reign. Like Akbar, he was also anxious to increase his extensive empire. His administration became a legend of just and stable rule. It was the fate of Shah Jahan that he was overthrown by the same means as he had employed against his own father. He was the man in whose rein – the Mughal power and magnificence reached its zenith.

Francois Bernier French physician and traveler stated about the wealth of Shah Jahan,

[38] Stephen F. Dale, Safavid Persia, The Ottoman Empire and Moghul India : The Moghuls in India (Cambridge University Press , 2010)
[39] Fergus Nicoll, Shah Jahan (India : Penguin Books , 2009)p.1
[40] Percival Spear, "Mughal Ascendency: Pakistan, by Ed.I.Hussain"(London: Stacey International,1997) p.53

"Piles of gold were stored in one and silver in other and to render more difficult any attempt to carry away his treasure, it consisted of both metals, pieces to be made of so prodigious size as to render them useless for the purpose of commerce".[41]

He put considerable effort in fulfilling his forefather's dreams to expand its empire and Mughal authority over Samarqand. He failed, doing no more than to extend the Mughal Empire a few miles north of Kabul. Shah Jahan had a keen interest in music and dance-but his main artistic interest was architecture, which found expressions in a number of magnificent buildings he erected. Mughal construction modeling came to its apex amid the rule of ruler Shah Jahan (1628–58), its most noteworthy accomplishment being the brilliant Taj Mahal. This period is checked by a new development in India of Persian highlights that had been seen before in the tomb of Humayun. The utilization of the twofold vault, a recessed opening inside a rectangular fronton, and park like surroundings are all ordinary of Shah Jahan period structures. Symmetry and harmony between the parts of a building were constantly focused on, while the delicacy of subtle element in Shah Jahan brightening work has rarely been surpassed. White marble was a favored building material. He took enormous pride in them, as reflected in the couplet he got inscribed in the hall of public audience in his Delhi palace.

If there be a paradise on earth;

It's this, it's this, and it's this!![42]

Persian influence in the sphere of architecture, received a great set- back under the policies of Akbar – but it made a great come back in Shah Jahan's era. His over fondness for buildings led to the creation of numerous monuments. Right from the beginning of

[41] Percival Spear, "Mughal Ascendency: Pakistan, by Ed.I.Hussain"(London: Stacey International,1997)
[42] Abraham Eraly , The Mughal India (India: Penguin Books , 2007)

his reign, Shah Jahan used the supreme assets of his empire to express in buildings and works of art the enormity and prominence of his state. At his coronation he ordered the construction of the Peacock Throne. Priceless and magical gems were embedded into it. One of the throne's in the peacock eye was Koh I Noor.[43] The Fort at Lahore (sixteenth and seventeenth century) is a Moghal fortified enclosure built over the existing structures. White, yellow, orange, green, deep blue and purple-black were the principle colors employed. The Wazir Khan Mosque, Lahore is splendidly coated in tile mosaic with geometric patterns, floral arabesques and calligraphy.

The Red Fort and Palace, Delhi display the dazzling techniques and immense building energies of the empire under Shah Jahan. The throne hall, Diwan-e-Am, for public reception is centered on main axis, and under its multiple arcade there is an ornate balcony on which the emperor would appear. Higher formal terraces were built. The refined grace and delicacy of these achievements reached at its peak in the Rang Mahal. The Great Mosque (Jami Masjid), Delhi also was built by the Emperor Shah Jahan, on the edge of bazaar quarter, to serve populace at large. The Moti Masjid, Agra (1646-54) was built in marble within the palace of Red Fort.

Shah Jahan also added a masjid in harem and a private audience hall known as the Diwan-e-Khas (1637). The mausoleum Taj Mahal, Agra (1630-53) is situated in a more formally walled garden entered through a pavilion on the main axis is also the incredible monument by Shah Jahan. Shah Jahan died in 1666, the most glittering of the great Mughals and the one who brought the great tide of Mughal building to its climax, achieving a perfect fusion with the surrounding landscape. He was buried beside his wife in the Taj Mehal.[44]

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[43] Mark Amaru Pinkham, Guardians of The Holy Grails (USA : Adventures Unlimited Press , 2004)
[44] John Brooke , Gardens of Paradise : Mughal India (London : Weidenfeld and Nicolson , 1987) p.159

Figure 5 : Wazir Khan Mosque in Lahore

Figure 6: Red Fort Delhi

2.6. Aurangzeb Alamgir

Aurangzeb, the last of the Great Mughals, who gave himself heart and soul to the business of ruling the empire. A devout man, he is shown here on his knees. Ascetic he strove to live on selling caps he made for his nobles, Qurans he calligraphed for sale and the proceeds of a small farm he brought near Delhi.[45]

[45] Francis Robinson, The Mughal Emperors and the Islamic Dynasties Of India , Iran and Central Asia , 1206- 1925 (London: Thomas and Hudson,2006)

When Emperor Shah Jahan was lying sick, his four sons were battling against each other. Although the emperor recovered, his victorious third son killed his other brothers and held Shah Jahan grounded for the rest eight years of his life.[46] Aurangzeb Alamgir – the third son of Shah Jahan defeated his brother Dara in the famous war of succession, sat in his place. He was the complete contrast of his father – puritanical, keenly orthodox instead of pleasure-lover and easy going in religion.[47] Aurangzeb was less interested in Architecture than that of his predecessors. He did sponsor religious monuments. Most notable amongst them are Pearl Mosque (Moti Masjid) in Red Fort, Delhi. He ordered the world's largest mosque (for 313 years) named as Badshahi Mosque Lahore (finished in 1674) that is simple in concept and severe in detail, Great Mosque of Aurangzeb, Imperial Delhi's Golden Mosque and Tomb of Sufi saint Syed Abdur Rahim Shah was constructed under his orders. Aurangzeb fell ill and died at the age of eighty-nine. "*Az ma-st hamah fasad-i-baqi*," Aurangzeb had once said: After me, chaos!![48]

Mughal Empire flourished through six extraordinary rulers, the Great Mughals. Father to son, they ruled from 1526 until 1707, almost two centuries. With a mixture of military skill and enlightened patronage of the arts, they consolidated and expanded the Empire and brought it to unimaginable heights of power and splendor. At the death of the last great Mughal, Aurangzeb, its vast territories stretched from Gujarat across to Bengal, from Kashmir right down almost to the tip of India. After them Empire began to wane. Weak Emperors followed one another to the throne only to be assassinated,

[46] Kallie Szczepanski, Asian History, last updated on December 03, 2011 accessed on December 14, 2014. http://asianhistory.about.com/od/india/p/Aurangzeb-Emperor-Of-Mughal-India.htm
[47] Percival Spear, "Mughal Ascendency: Pakistan, by Ed.I.Hussain"(London: Stacey International,1997)
[48] Abraham Eraly , The Mughal India (India: Penguin Books , 2007)

deposed and blinded until the sunset of the once great power, when Bahadur Shah II was deposed by British in 1858.[49]

[49] Louise Nicholson, The Red Fort, Delhi (London: Tauris Parke Books) 1989

Chapter # 3
THE LAHORE FORT – SIGNIFICANCE AND ITS HISTORICAL DEVELOPMENTS

3.0. THE LAHORE FORT – SIGNIFICANCE AND ITS HISTORICAL DEVELOPMENTS

3.1. Lahore, its origin and history

a. Location:

It generally lies between north scopes 30 degrees – 38' and 31 degrees – 44' and East longitudes 73 degrees – 38' and 74 degrees – 58'. It involves the entire plain nation lying between the Ravi River on the north and the Sutlej on the south and has the state of a general quadrilateral titled in the general north east and south-west bearings of the river.

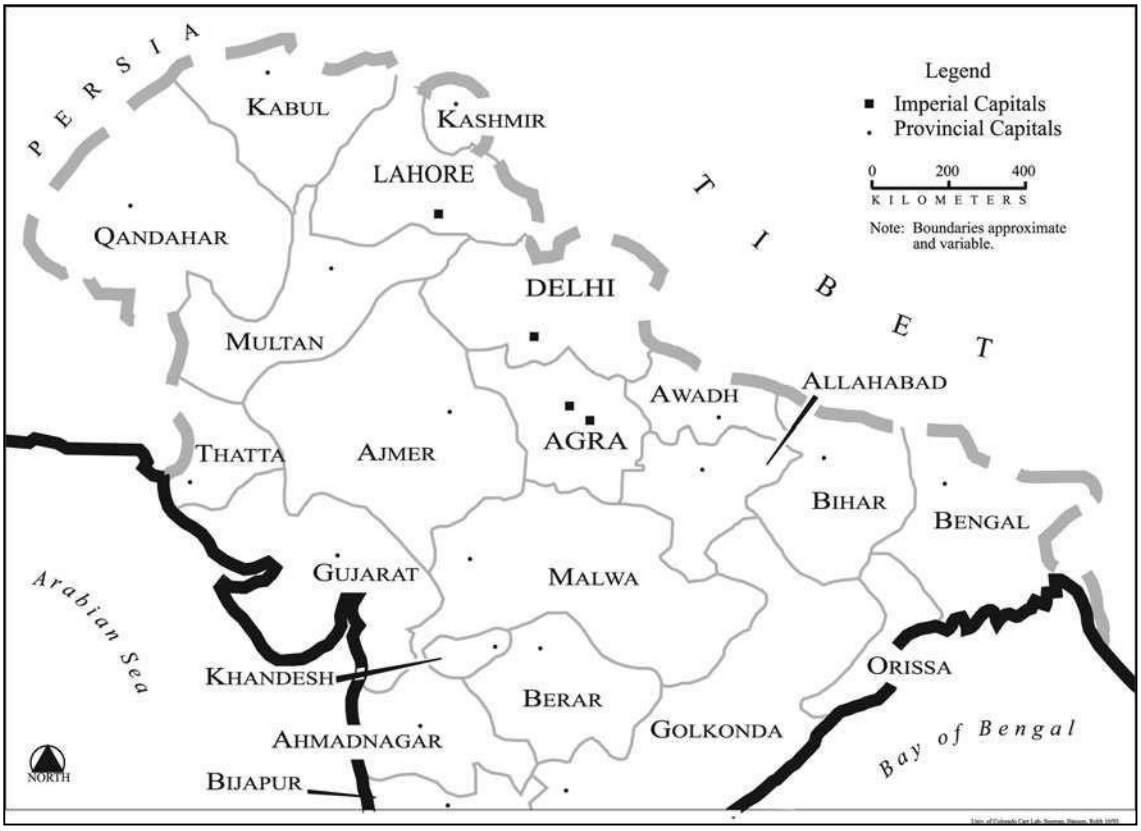

Figure 7: Map of Lahore (Mughal Era)

b. Origin:

The origin of Lahore is shaded, spurious, due to myths and nothing is known about it's before 1024 A.D. According to some people who mastered history, Lahore city was developed in 1st century A.D.[50] According to Al-Beruni in his book (Tarikh-ul-Hind), he says that its foundation is linked to mythic Lau, Lav, or Loh a son of Rama Chandra, the hero of epic Ramayana of the pre-historic age. A small shrine known as *Mandir* is still present near its Alamgiri gate. In 1959, Archaeology stressed on digging of Lahore Fort found terracotta brass plaques, statues and 50 ceramic pieces of non-Muslim origin. The traces of Hindu tradition found in Lahore can be related to the fact that people lived there even before the advent of Islam. However, the exact date of the foundation of Lahore is still unknown and it was not until the Muslim period that Lahore's history is known.[51] Muslim period of Lahore started in 1021 A.D after the defeat of Trilochan Pal by Mahmood Ghaznavi. Lahore remained the provincial capital of the Ghaznavid Empire for around 165 years. In 1186 A.D. it fell into the hands of Shahab-ud-din Ghouri. From then, onwards, Lahore had been ruled by different dynasties like Turks, Khalijis, Tughlaks, Sayeds, Lodhis and Pathans for about more than 300 years. Then the Mughals took over Lahore. During the Mughal rule, Lahore enjoyed the status of state capital and that was the glorious period of Lahore history.

[50] S. Mubin, I.A.Gilani and W. Hasan ,Mughal Gardens in the city of Lahore- A case study of Shalimar Garden(Pakistan Journal of Science (Vol. 65 No. 4 December, 2013) p.511

[51] S. Mubin, I.A.Gilani and W. Hasan ,Mughal Gardens in the city of Lahore- A case study of Shalimar Garden(Pakistan Journal of Science (Vol. 65 No. 4 December, 2013) p.511

c. History- Lahore in Mughal Period:

Lahore, the cultural metropolis of Pakistan and the Dar-u's Sultanate of the Mughal Empire, proudly possesses some of the gems of the Islamic Architecture of Pakistan. Crisp from an exquisite and pleasant nation, possessing large amounts of lovely streams and rivulets, and rich in lush vegetation and waving foliage of trees, the devotees of Babar, that knight errant of Asia, pondered with disappointment the possibility of a delayed stay in the unfriendly districts of India.[52] After the brilliants victories Babar decided to found a new empire in India. Lahore was the first town to be benefited by the Mughal monarchy in Punjab. Amid the rules of ahead of schedule Mughal Emperors, evenhandedly viewed as the brilliant time of the historical backdrop of Lahore, it got to be afresh a regal living arrangement. Lahore saw turmoil, peace and serenity, social party, overcomes pulverizations and obliterations in diverse time of history. However it generally stayed critical after its introduction to the world as a city in the eleventh century. Its key significance had never even been disregarded and it remained a common capital till date. Lahore, then again, achieved greatness and wonderfulness amid the Mughal guideline from 1524 to 1712 A.D. when its decay impelled. The Mughal rule dawdled up to 1524 to 1712 A.D i.e. to the time of Ahmad Shah, the 13th Mughal Emperor, when ultimately Lahore ceased to be a part of Mughal Empire and went under Durrani government of Kabul. Under the early Mughals, Lahore soon became the hub of learning. Fine gardens were laid out, channels burrowed to enhance the method for watering system, roomy mosques assembled, band saraes built , royal residences arches minarets and a driving force was given to the construction modeling of the nation very unbeatable in any age. Almost all the existing monuments

[52] Khan Bahadur and Syed Muhammad Latif , Lahore - Its History , Architectural Remains and Antiquities : The Moghal period (Lahore : New Imperial Press , 1892), p. 21

of Lahore belong to this period. Babar's son Kamran (1530-1540 A.D) was the first to add to its architectural beauty by constructing a summer house in the center of a tank laid amidst a spacious garden, which is now known as Kamran's Bara Dari. Akbar (1556-1605 A.D) who held here his court for 14 years (1584-98 A.D), built the present brick masonry Fort on its earlier foundations, enlarged it and also enclosed the city with a brick wall with some 12 gates sometimes about 1566 A.D. He made Lahore his head-quarters, and from it led military operations against Kashmir, North-east Afghans, Sindh and Qandahar. Lahore was a position of extraordinary significance in Akbar's opportunity. Abul Fazl, talking about Lahore in the second years of Akbar's rule thinks of: 'It is an exceptionally crowded city, the resort of individuals of all countries and the middle of broad trade. In the briefest time extraordinary armed forces could be gathered there, and ammo of war in any amount of time could be obtained for the utilization of troops.[53] Jahangir (1605-1627 A.D) was partial to Lahore, and on his approach to Kabul and Kashmir, held his court there. Officially shady trees on both sides of streets had been planted from Agra to Lahore, under the orders of Jahangir. Jahangir and Shah Jahan (1628-1658 A.D) manufactured royal residences, tombs and laid patio nurseries. Aurangzeb (1658-1707 A.D) gave Lahore the immense and excellent mosque.[54] With the passing of Aurangzeb, the splendid time of the historical backdrop of Lahore may be said to have ended.

[53] Khan Bahadur and Syed Muhammad Latif , Lahore - Its History , Architectural Remains and Antiquities : The Moghal period (Lahore : New Imperial Press , 1892), p. 32

[54] Muhammad Wali Ullah Khan , Lahore and its important Monuments : History (Karachi: Anjum Press,1973)

3.2. The Lahore Fort

"The Lahore Fort is one of the noblest structures of its kind on the planet. Ascending out of the northwest corner of the walled city, it has been an image of its most punctual days. On the off chance that it could talk, it would tell such things that would spellbind the audience. It could recount love, sentiment and enterprise, of dim looked at wonders and furious browed warriors, of rulers in streaming silks and lords in sparkling protective layer, of writers, performers, slaves and mistresses, of fighters and dissidents, of transformations and court interests, of crowning ceremonies and deaths, of foul play and dark requital." [55]

a. Location:

The Lahore Fort is situated on the left bank of river Ravi and in the north western part of walled city. The site is ideally located at the intersection of ancient north-south riverine route which used to run parallel to the river Ravi and east-west hinterland route connecting Kabul with Delhi.[56]

[55] Samina Qureshi , The Citadel : Lahore – The City Within (Concept Media , 1988)
[56] Ed. Muhammad Naeem Mir , Mahmood Hussain, James L. Wescoat Jr. , Mughal gardens in Lahore – History and documentation (Lahore : University of engineering and technology ,1996)p.45

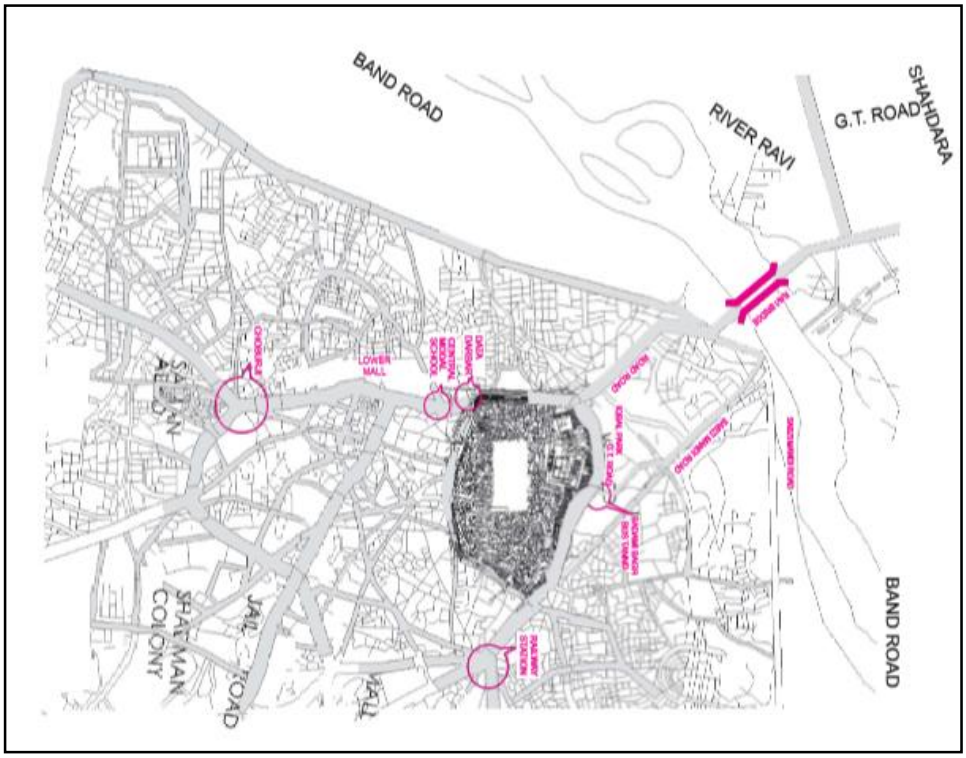

Figure 8: Map showing the location of Lahore Fort, Lahore

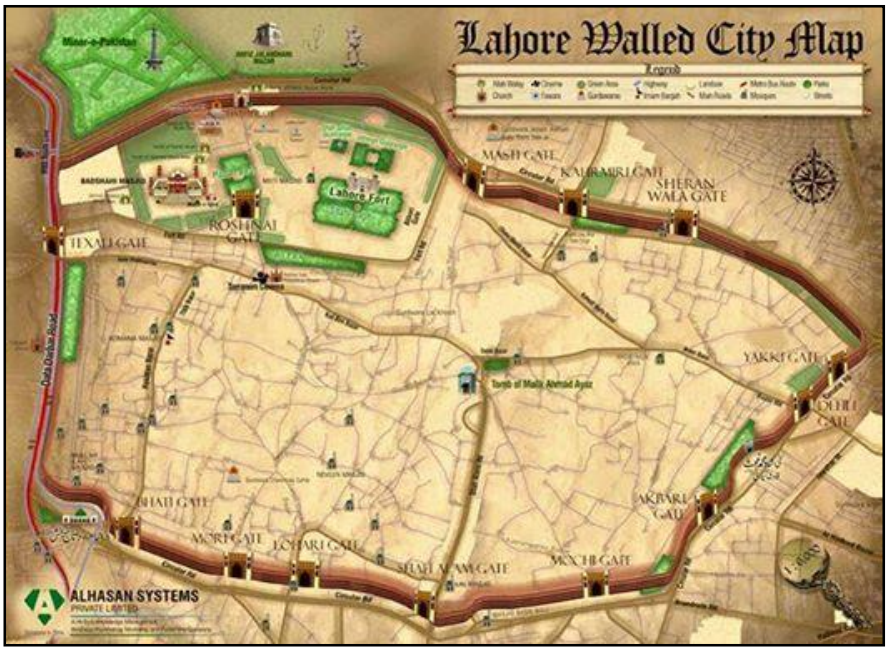

Figure 9: Map of Lahore Fort by Lahore Walled City

3.3. Significance:

Lahore Fort is basically the key site to study Mughal Architecture as it contains buildings starting from Akbar's era till Shah Jahan's reign. It depicts the life styles of Mughal Emperors, their interests, priorities and innovative styles. It speaks about distinctive stages in the advancement of Mughal building design as there is a monument by each ruler in the compound. It covers the complete history of architecture from 10th century onwards to the extinction of the Sikhs and occupation of Punjab by the British. To be more elaborate the fort of Lahore due to its location on highway towards central India, Most of the invaders and rulers would use the place as their temporary abode and thus made new additions and alteration in the buildings and sometimes ordered for new construction to their requirements. The lighting, ventilation in buildings, the hydraulic system, stone framework, paintings and pietra dura have been successfully used here.

3.4. Historical Developments:

Lahore Fort under Mughals:

The exact date of founding of Lahore fort is precisely known. India was invaded several times by the founder of Mughal dynasty – Zaheer ud Din Babur. It is said that on the day when Babur visited India, he visited Lahore Fort too, distributed money among poor and renovated the buildings built by Sikandar Lodi. The reign of Babur was followed by Humayun – later on, Suri dynasty ruled for a short span of time. During that period the importance of Fort remained unquestioned, and the buildings of Fort were continuously looked after.

Following is the plan of quadrangles of the Lahore Fort.

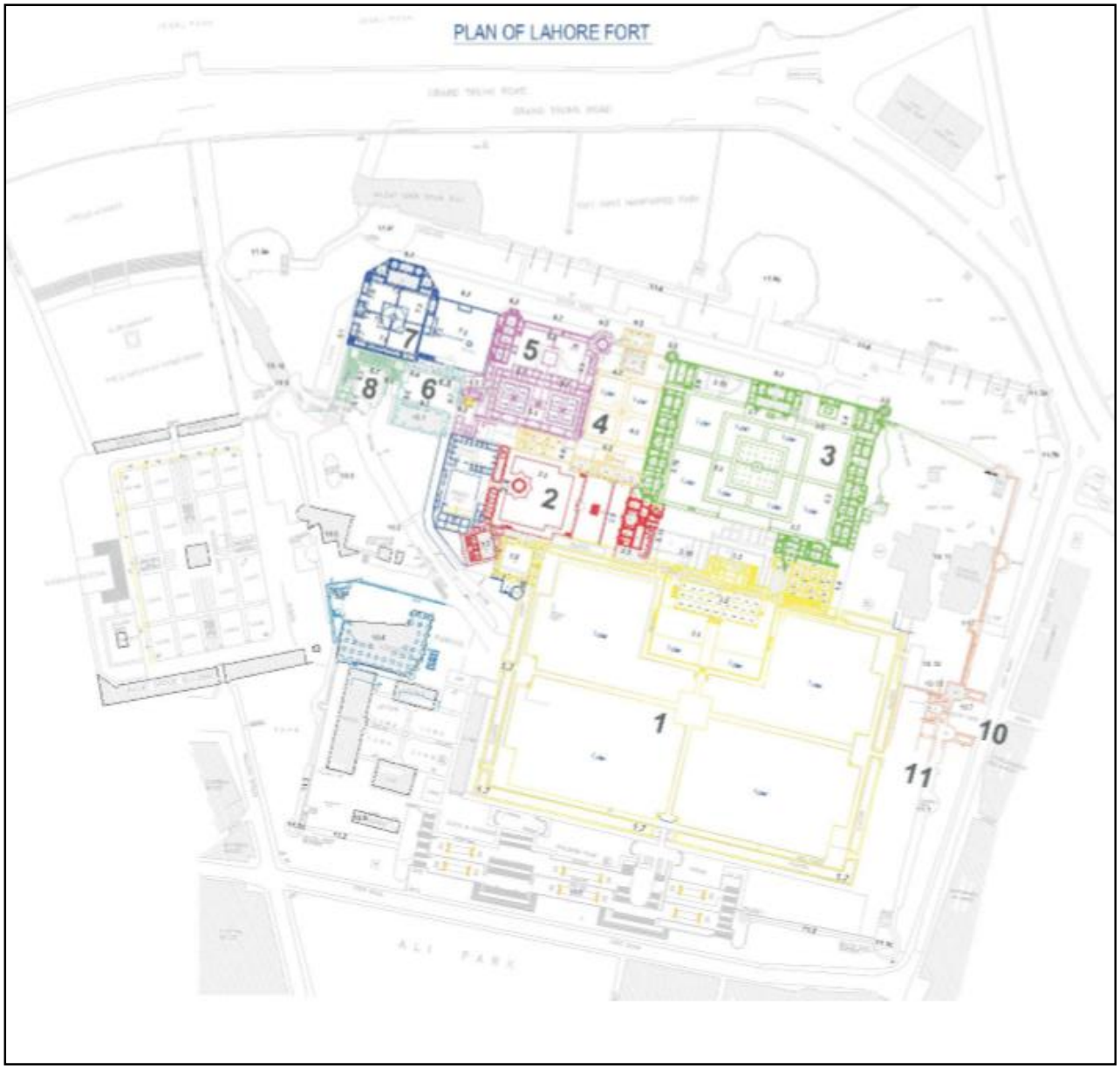

Figure 10: Quadrangles of Lahore Fort[57]

[57] All the plans of Lahore Fort and quadrangles are provided by the architect of Lahore Fort.

1. Diwan-e-Aam Quadrangle
2. Moti Masjid Quadrangle
3. Jahangir's Quadrangle
4. Shah Jahan's quadrangle
5. Paien Bagh Quadrangle
6. Shah Burj
7. Shah Burj Darwaza[58]

   (The focus of the research will be a few areas of Shah Jahan's Quadrangle, Paien Bagh Quadrangle, Shah Burj – Sheesh Mehal and Naulakha pavilion)

a. Lahore Fort during the reign of Akbar:

The Fort gained prominence during the reign of Emperor Akbar the Great, who according to available reports demolished the old Fort and constructed a new one with solid brick masonry in about 1566 A.D.[59] The Ain-i-Akbari mentions that Lahore Fort was built with burnt bricks.[60] There is also a glimpse of the style of architecture which Emperor Akbar made popular in his various palaces and forts at other places in India. Akbar also established a network of forts throughout his empire. While on one hand he found, captured, repaired restored and garrisoned the old forts. On the other hand he found and built new series of them. The palatial mansions in the Fort of Lahore not only reflect upon the aesthetic sense of the emperor but also his precision to keep in line with

[58] Lahore Fort Master Plan , UNESCO 2006-11
[59] Nazir Ahmad Chadhry , Lahore Fort – A Witness to History :Architectural Features of The Fort (Lahore: Sang-e-Meel Publications)
[60] Abul Fazl , Ain-a-Akbari, Vol II, translated by H.Blochmann, M.A. and Colonel H.S. Jarett (Calcutta : Asiatic Society of Bengal, 1989) p.317

the location of Ravi River.[61] Badaoni writes about the fort that it had 140 rooms. Curtains were used to cover the fine openings. He built the fortification wall around the city. The fort built by Akbar measured about 1400 feet east-west direction and 1115 feet north-south direction and is girdled with a high baked brick fortification which is strengthened with semi-circular bastions and crowned with loopholes and battlements for musketry.[62] Its building was divided into two parts – the private quarters on the north and public area on the south. He extended the area of the fort northward to build his palaces and he built basements on the low lying palaces to fill the space on the northern side. The north-east corner of the fort was occupied by the buildings by Akbar – most of these have now disappeared and others in a very bad state of preservation. Some of them were demolished by Emperor Jahangir to build his Daulat Khana Khas-o-Aam and partly by Shah Jahan to erect the huge pillared hall of the Diwan-e- Aam.[63] Near the modern water tank and northern portion of Diwan-i-Aam included a small subterranean octagonal Hammam with elaborate arrangement of hot and cold bathing. On the first floor of the building there was a court – where courtiers, petitioners, visitors assembled to see the emperor. The throne room is covered by a marble pavilion and is carried forward on a balcony on sandstone brackets. Most of the construction in Akbar's period has been carried out in cutwork and dressed brick work. This included a 112 feet long arcade of beautiful ornamental flat arches in Masti or Masijidi Gate of Lahore owing to the fact that it faced the historic Begum Shahi Mosque across the road. It is the only perfectly surviving building in this quadrangle in the Akbar's period. The gate

[61] Nazir Ahmad Chadhry , Lahore Fort – A Witness to History :Architectural Features of The Fort (Lahore: Sang-e-Meel Publications)p.260
[62] Dr. Ahmad Nabi Khan , Lahore Fort (Department of Archaeology and Museum – Government of Pakistan)
[63] Ihsan H. Nadiem , Lahore- A Glorious Heritage : Mughal Era (Lahore : Sang-e-Meel Publications) p.61

is a huge building, very bold in character, linked by two heavy bastions with battlements and machicolations to add to its military character.

The complex on the east of the Diwan-i-Aam consists of a central spacious hall crowned with brick vaulting and supported by a series of brick pillars. The hall is augmented with a spacious gallery on all the four sides. Big halls and corridors were present at the backside leaving the traces of their foundation only. The walls and towers on the east side, the eastern part of the north side and the southern end of the west side belong to the Akbar's period.

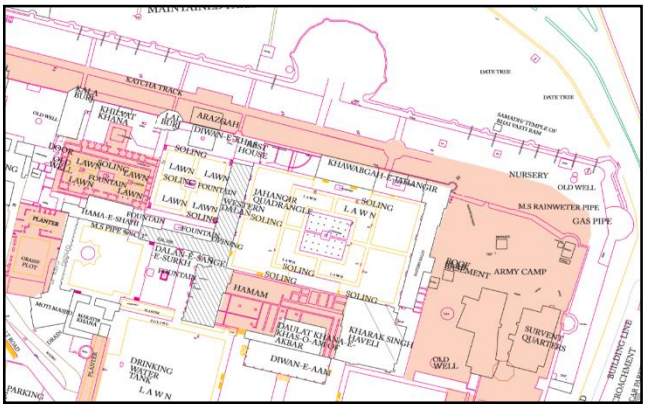

Figure 11: Plan showing the contribution of Akbar – (Diwaan e Aam, daulat Khana e khas o aam)

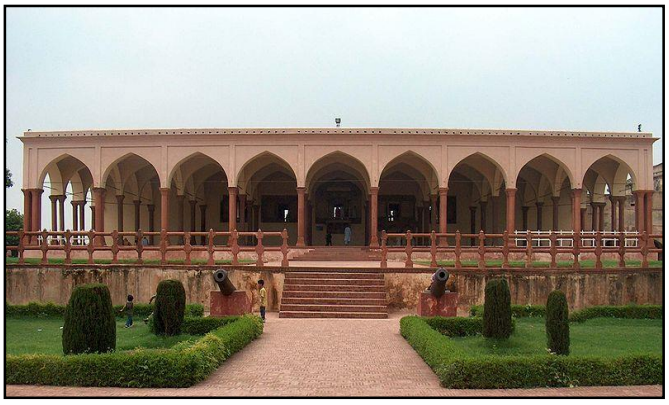

Figure 12: Diwaan e Aam

b. Jahangir's Contribution to Lahore Fort:

One of the best surviving structures in Lahore Fort belongs to Jahangir's period. He began to construct the buildings of Jahangir's quadrangle, Makatib Khana and Kala Burj not long after his increase. The structures were outlined by Khawaja Jahan Muhammad Dost, the engineer in the castle of Agra Fort.[64] The final touches to these buildings were given between 1617 and 1620 under the architect Abd-al-Karim Mamur Khan.[65] Jahangir, in 1620 while visiting the fort, praised the "charming residences and soul-exciting sitting places".[66]

A. Jahangir's Quadrangle :

The group of buildings in Jahangir's quadrangle was completed by Jahangir in 1617-18 AD at a cost of seven lakh of rupees.[67] On the north of the Daulat Khana-e-Khas-o-Aam lies the expensive quadrangle. Its construction was started by Emperor Akbar but was completed by his son and successor. The buildings in Jahangir's quadrangle combine the local brick architecture in the style of Agra and Fatehpur Sikri in the form of sandstones and verandahs.[68] It was meant for seating while the back was used as sleeping chambers. The Chhajjas (eaves) of the Dalans were supported by stone brackets in the shape of elephants, felines, lions, peacocks etc. The southern side of the quadrangle also had a row of Dalans like the eastern or western side. It must be noted that stone carving work in residential quarters here was reserved for the exterior or façade

[64] Ed. Muhammad Naeem Mir , Mahmood Hussain, James L. Wescoat Jr. , Mughal gardens in Lahore – History and documentation (Lahore : University of engineering and technology ,1996)p.46
[65] Ed. Muhammad Naeem Mir , Mahmood Hussain, James L. Wescoat Jr. , Mughal gardens in Lahore – History and documentation (Lahore : University of engineering and technology ,1996)p.46
[66] Noor ud Din Mohammad Jahangir , Tuzuk-i-Jahangiri, translated by Alexander Rogers ed.by Henry Beveridge , (Lahore : 1974)p.183
[67] Muhammad Abdullah Chughtai , Qila Lahore ki Mukhtasir Tareekh (Lahore :1973) p.18
[68] Ihsan H. Nadiem , Lahore – A Glorious Heritage : Jahangir's Quadrangle (Lahore : sang-e-Meel Publications)p.67

of dalans, and all internal surfaces were white plastered to be amenable to the tropical climate.[69]

The center of the garden is occupied by a garden in the *Charbagh* style with spacious water tank having a square *Mahtabi* platform in the middle. The main building of the court which stands in the middle of the north side is *Khawabgah-e-Jahangiri* which is now used as armory museum. The façade of the building is constructed during the British period while the rest of it is in original layout. The building as a whole at present, does not portray any architectural feature of mentionable significance.

Figure 13: A view of Jahangir's quadrangle

B) Makatib Khana

A small courtyard building today is known as Makatib Khana identified as Daulat khana-i-Jahangiri. These are the buildings with high gates situated on the southern side of the quadrangle and west side of the public audience hall. It faces an open courtyard, square on plan and having oblong vaulted chambers

[69] Nazeer Ahmad Chaudhry, Lahore Fort- A Witness to History : Architectural Features (Lahore : Sang-e-Meel Publications)p.269

on the east, west and north. There is an inscription on the gate – carved in an exquisite *Nastaliq* characters on a marble slab and reads.[70]

"In the twelfth year of the favored increase of His supreme Majesty, the shadow of God, a Solomon in poise, Kayumars in express, an Alexander in arms, the shelter of the Khilafat Emperor Nur ud Din, child of Emperor Jalal ud Din, Champion of the confidence, comparing with 1027/1617, the structures of the propitious was finished under the superintendence of the most humable teacher and slaves, the gave worker, Ma'mur Khan"

The massive vestibule having a central arched opening flanked by the shallow pavilion, is the main entrance on the Jahangiri palace recorded as *Dalan-i-Sang-i-Surkh*. It has three arched openings blended with red sandstone screens. The main entrance at present is from the north through a comparatively small door-opening. The entire surface is treated with deeply recessed panels of various shapes and sizes. Internally the space is divided into a central big hall flanked by smaller rooms.[71]

C) Kala Burj

One of the most important Jahangir period structure in the Lahore Fort is the Kala Burj. It literally means Black Tower.[72] The exact date of Black Tower is not mentioned by historians but its architectural features place it in sometimes around 1610 A.D. The decoration on the vault is in fresco paintings.

[70] Dr. Ahmad Nabi Khan , Lahore Fort : The Jahangir's palaces (Lahore : Department of Archaeology and Museum)p.11
[71] Ihsan H. Nadiem , Lahore – A Glorious Heritage : Jahangir's Quadrangle (Lahore : sang-e-Meel Publications)p.71
[72] Ihsan H. Nadiem , Lahore – A Glorious Heritage : Jahangir's Quadrangle (Lahore : sang-e-Meel Publications)p.82

Figure 14 : Kala Burj- Lahore Fort

c. Shah Jahan and Lahore Fort

Shah Jahan in his reign stayed in Lahore for a number of times and a large number of buildings were constructed in the Lahore Fort. The buildings in his periods are designed in vaulted roofs, multi-cusped arches and carved marble screens. They are mostly in white marble enriched with colorful *pietra dura,* inlays and tessellation. His significant contributions to Lahore Fort are discussed as under:

A) Diwan-e-Khas-o-Aam (Hall of Public and special audience) :

He first ordered a forty pillared public audience hall. It is a rectangular platform measuring 241 feet 9 inches by 168 feet. The hall itself measures 187 feet 4 inches by 60 feet 5 inches. The roof is 34 feet high. There is a large open court on its south. The hall collapsed because of the bombardment of Sher Singh. It was reconstructed by the Britishers in February 1846. The pointed arches with

tie rods and roof are all British period additions, but pavements appear to be of the Sikh period.[73]

B) Shah Jahan's quadrangle :

Immediately west of the Jahangir's quadrangle is located an open court enclosed with buildings of the period of Shah Jahan on all the four sides. It is thus known as Shah Jahan's quadrangle wherein are located some of the most beautiful palaces manifest of the pinnacle of the Mughal art of architecture. Shah Jahan is known as the royal builder and he can really crown the architectural domain of Mughal history by virtue of his contribution towards palaces, forts, tombs etc. Under his reign Mughal architecture took on a new aesthetic and entered its classical phase.[74]

The buildings in this quadrangle include the *Diwan-e-Khas* on the north and Shah Jahan's sleeping chambers on the south. The open courtyard in these buildings has been designed on the formal *Charbagh* style by dividing into four by means of walkways, with a square-shaped platform serving as a *Mahtabi* in the centre. The *Charbagh* has been converted into grassy lawns now.[75] The raised platform has a shallow cistern in the centre while a fountain occupies a central place in it.[76]

1) Diwan-i-Khas (Hall of special audience):

It is situated in the northern part of the Shah Jahan's quadrangle. This hall was built in 1645 A.D. It is an arcade pavilion built in chaste marble.

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[73] Ed. Muhammad Naeem Mir , Mahmood Hussain, James L. Wescoat Jr. , Mughal gardens in Lahore – History and documentation (Lahore : University of engineering and technology ,1996)p.47

[74] Nazeer Ahmad Chaudhry, Lahore Fort- A Witness to History : Architectural Features (Lahore : Sang-e-Meel Publications)p.280

[75] Dr. Ahmad Nabi Khan , Lahore Fort : The Shah Jaha Quadrangle (Lahore : Department of Archaeology and Museum)p.13

[76] Ihsan H. Nadiem , Lahore – A Glorious Heritage : Shah Jahan's Quadrangle (Lahore : sang-e-Meel Publications)p.74

This graceful pavilion is 53 feet by 51 feet and 20 feet 4 inches high was a fine example of the refined architecture of Shah Jahan. It was placed on a raised platform. It has qualities of lightness and freshness because of its grills facing the river side and openings all around. The marble floor has different geometrical patterns on it. It is supported on five rows of five pillars carrying scalloped arches. The interior is variegated marble. Saleh Kamboh describes the construction of Diwan-e-Khas in its present site in the following words:

"*After settling the affairs of the government the Emperor diverted his attention towards the conservation and repair of the buildings which required his Majesty's attention for a long time. Since the buildings of Diwan-i-Khas and Khwabgah were aesthetically unpleasant and were not liked by the Emperor due to their appearance and quality of construction. Therefore, on the orders of the Emperor the engineers and the architects prepared some excellent designs and presented them to the emperor who approved one of the designs and presented them to the emperor who approved one of the designs. Wazir Khan and other officials were ordered that construction of these buildings must be completed before his Majesty's return from Kashmir"*

While staying at the fort the emperor used to sit near the northern screens of Diwan-e-Khas showing his face through the opening each morning to the people gathered below near the *Arzgah, as* the *Arz* received petitions from the needy applicants. The building is connected with the Shah Jahan's quadrangle by means of two winding stair cases in the thickness of the wall, each opening into the towers flanking the Diwan-e-Khas on its east and west.[77]

2) Khawabgah-e-Shah Jahani :

[77] Ihsan H. Nadiem , Lahore – A Glorious Heritage : Shah Jahan's Quadrangle (Lahore : sang-e-Meel Publications)p.78

The Khawabgah is situated south of the Shah Jahan's quadrangle. It is lavish building known as Khawabgah-e-Shah Jahani or the sleeping chambers of Shah Jahan. It is also known as Choti khawabgah or smaller sleeping chambers to distinguish it from the sleeping chambers of Jahangir's or Bari Khawabgah located in Jahangir's quadrangle.

The Khawabgah has five spacious rooms laid along east-west direction opposite to Diwan-e-Khas, the front of which had grand multi-cusped arched openings. While proceeding from Lahore to Kashmir in 1633 A.D, Shah Jahan ordered its construction and the work was entrusted to Hakim Alim ud Din Ansari viceroy of the Punjab.[78] The projecting portico on the northern side has been cut off now leaving only the foundations of the walls through the fountain in the cistern still remains at the central place. The buildings is entirely constructed in bricks. The back openings of the chambers were provided with lattice screens of marble, while the interior was finished with glazed lime plaster with recessed and deep panels of various sizes. The floors and walls up to the dado level were provided with marble facing. The vaulted roof were embellished with stucco tracery. The central chamber had a small cistern with a fountain. In front of the chamber was a pavilion in imitation of the Diwan-e-Khas. It has completely disappeared, only leaving traces in the shape of stray foundation.

3) Lal Burj (Red Pavilion)

It is situated in the North-western corner of Shah Jahan's quadrangle. This summer pavilion is octagonal in plan. It comprises three storeys, the first built during the Jahangir's, the second in Shah Jahan's and the uppermost

[78] Mohammad Saleh Kamboh , Shah Jahan Nama ; Vol II.translated by Muhammad Hassan Zaidi (Lahore : 1994) p.6

during the Sikh period. It is decorated with tile mosaic and filigree work. It was built between 1617 and 1631.

4) Hammam-e-Shahi:

At the west of the Choti Khawabgah lies the Hammam-e-Shahi or the royal bath. It occupies the southeastern corner of the Pa'een Bagh quadrangle adjoining the Moti Masjid quadrangle on its southern side. It is a single storey structure symmetrically designed on the longitudinal axis. It continued to serve as such during the Sikh period when it was embellished with color paintings and beautiful frescos.

5) Khilwat Khana (Room of Solitude) :

A general tradition was Mughal emperor did not generally reside in the harem proper, but in a separate court adjacent to it. The Khilwat Khana was constructed by Shah Jahan in about 1633 A.D. The court of Khilwat khana was divided into two parts:

i) The Front or the southern portion is the paien bagh i.e. the ladies garden.

ii) The northern portion was used for the emperor's private and personal residence.

A small door opening from the garden area leads to the adjoining second court which has small but elegant curvilinear pavilion on the north. A deep tank with a fountain is set in the centre .The large chambers in the basement of the Fort can be approached from the east and west of this court.

C) Paien Bagh Quadrangle :

Further on, towards the west – there was an area designed for the ladies of Harem. The court is an enclosed courtyard having a corridor running on its four side. The opening had red sandstone pillars surmounted by capitals and entablatures. They must be having brick vaulted roof. However, all these elements have collapsed leaving only traces of foundations and walling. The chief characteristic of this garden was the provision of a number of paved paths and walks. A spacious platform in the middle of the garden, in cut and dressed brick work, with a water basin in the centre enhances the beauty of the Paien bagh. It is an excellent example of hard and soft landscape design in combination with water.

Figure 15: Paien bagh quadrangle

D) Shah Burj Gate : (King's Pavilion Gate)

In the north-west corner of the fort, stands the magnificent Shah Burj gate used by Mughal royalty and leads to the Shah Burj, the harem portion of the fort. It was completed under the supervision of Abdul Karim in 1631-32 (the fourth magnificent year of Shah Jahan). The external decoration is with glazed tile mosaic in delicate floral design. The archway of the gate was built in red

sandstone while the rest of construction was carried out with traditional bricks using lime mortar.[79]

E) Shah Burj (King's Pavilion) or Sheesh Mehal Complex :

The northwest part of the Fort consists of buildings basically having their origin in the days of Emperor Shah Jahan (though later additions of the Sikhs are also found).

1) Forecourt of Sheesh Mehal:

The main access to the Forecourt of the complex is through a large arched gateway, in the shape of ornate vestibule. The interior of this is decorated with panels of frescos. Although the courtyard is now provided with terraced flooring. A pavilion was there in the middle of the northern fortification, and a marble screen railing possibly running over the whole length.

2) Sheesh Mehal :

This is the most tremendous, fabulous and ornate part of the fort. Some of the real jewels were also found in architecture and in building decorations. It was created by the Emperor Shah Jahan for his beloved Empress Mumtaz Mahal. She is also known as 'the lady of The Taj'. She is buried in the Taj Mahal – which now for long stands as one of the Seven Wonders of the World, also built by the same Emperor. Unfortunately she could not live in Sheesh Mehal as she died before its completion in Aurangabad in 1631. Sheesh Mehal derived it name from the mirrors which are inlaid into the walls and on the ceilings, thus creating a shimmering and a gleaming effect.

[79] Ed. Muhammad Naeem Mir , Mahmood Hussain, James L. Wescoat Jr. , Mughal gardens in Lahore – History and documentation (Lahore : University of engineering and technology ,1996)p.48

On plan, it is a square having a series of Dalans, porticos and pavilions arranged on all the sides of a square shaped open courtyard which has been divided into four parts by means of shallow water channels which are connected with the central big cistern.[80] The whole courtyard including the *Mahtabi* and the tank has been paved with variegated marble. The spacious central *Dalan* has two parts:

i) The front part which could have been used for seating, has an arcade five openings with marble multifold arches, the bases, the soffits of which have been treated with exquisite inlay and pietra dura of colored semi-precious stones.

ii) The interior has several openings for entrance to the adjoining rooms and pavilions of different sizes and shapes for rest and sleep.

According to Ihsan H. Nadiem the decoration of the hall clearly seems to belong to two periods. The ceiling with its prevailing aspect of subdued gilt and balanced style undoubtedly make it a part of the work done in the Mughal era and the other blue-and-white decoration must take its origin to the Sikhs.

Figure 16: Sheesh Mehal- Lahore Fort

[80] Dr. Ahmad Nabi Khan , Lahore Fort : The Shah Jaha Quadrangle (Lahore : Department of Archaeology and Museum)p.17

3) Naulakha Pavilion :

In the centre on the west is located the famous Naulakha. The name refers to its having cost nine lakhs (900,000) of rupees. It was built in the early years of Emperor Shah Jahan. It was tiny but graceful pavilion is a simple oblong structure having a single arched opening in front and a relatively small opening on each side. The pavilion has a curvilinear roof, also known as Bangla style placed over marble brackets. The interior has been lime-plastered treated with frescos. The pilasters, pillars, bases and other points have delicate and very fine pietra dura work.

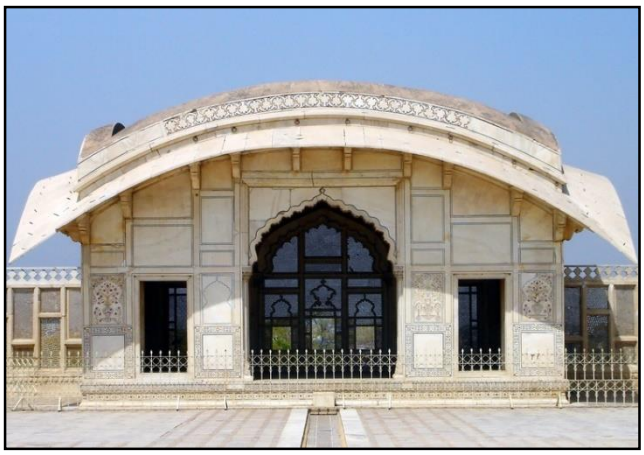

Figure 17: Naulakha pavilion- Lahore Fort

4) Hathi Paer (Elephant Path) :

It starts from Hathi pul gateway and ends at sheesh Mehal entrance. It was built by Shah Jahan in 1631-32. The entire staircase was built with additional bricks and then lime plastered. It was meant for elephant carrying the Royalty from and to the palace. This opening leads to the grand main entrance created in the shape of a double storeyed vestibule embellished with panels of exquisite tile mosaic decoration. The wall on the upper

gallery is designed as *Ghulam Gardish* (Servants Gallery) meant for servants and attendants, connected through an intercommunicating door with Sheesh Mehal.

Figure 18: Elephant path Lahore Fort

F) Moti Masjid (Pearl Mosque):

The mosque is the earliest of the three pearl mosques entirely built in chaste marble and attached to Makatib Khana during the Mughal rule. Its shiny white dome looks like a pearl – such is the reason for its name. There is a conflict in its date of construction. Some linked it with Jahangir's period as the inscription is found missing while its architectural style and decoration of motifs linked it with Shah Jahan's era. The mosque has two aisles of five bays and a slightly raised central pishtaq. The prayer chamber is fronted by five multi-cusped arches. The two other pearl mosques were constructed by Shah Jahan at Agra in 1654 and by Aurangzeb in 1662 in Delhi.

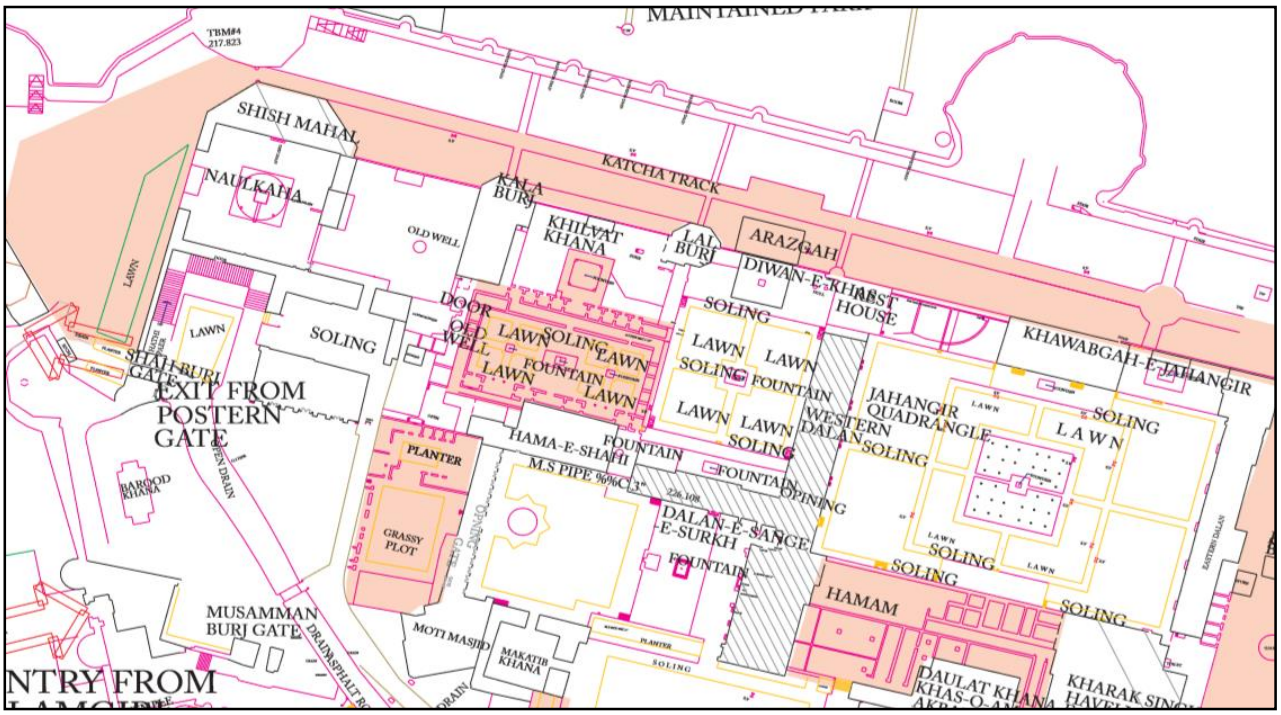

Figure 19: Labelled plan of Lahore Fort

d. Aurangzeb's Period and Lahore Fort:

Alamgiri Gate:

The only building in the fort, built by Aurangzeb in 1674 A.D. is probably the wall an Alamgiri gate facing the Badshahi mosque. It is flanked by two semi-round bastions, strikingly fluted and enhanced with lotus petal outlined at the base.[81] The monumental Alamgiri gate with arches side rooms, cupolas a reception like lobby and rooms for guards, is said to be the simple and massive architecture in the fort. The work as a whole forms a fitting climax to a century of creative construction.

[81] Ed. Muhammad Naeem Mir , Mahmood Hussain, James L. Wescoat Jr. , Mughal gardens in Lahore – History and documentation (Lahore : University of engineering and technology ,1996)p.49

The later Mughals and their governors never contributed anything in terms of adding buildings in the fort. Instead the place was used as the residence for governors and rulers.

Chapter # 4
MICROCLIMATE CONTROL IN MUGHAL ARCHITECTURE

4.0. MICROCLIMATE CONTROL IN MUGHAL ARCHITECTURE

Planning is a key concept in every field of life. Art and architecture depends upon planning and planning further depends upon the logical and practical needs of the people. Architecture, of any time depends on two main concepts:

1) The needs of the people
2) The idea of beauty prevalent at that period.

Kant suggested beauty as a distinct and autonomous employment of human mind comparable to moral and scientific understanding.[82] The virtuoso and the breathtaking era – commonly known as Mughal era (1526-1849) is no doubt the era of aesthetics, art, design and innovation. Mughal era was without any doubt the era where many art forms flourished. This era started with the empire formed by Babur and continued on with his successors, was a remarkable era of technological innovations. Among many other assets and chattels of Mughal Empire, the architecture of the Mughal Empire is brilliant, unique and is admired worldwide because it was the product of experiences based in the field of geometry, hydraulics and other building sciences. New ideas in the construction of buildings was at its peak in the era of Akbar (1556-1605) throughout its empire. The refinement in art and architecture by Shah Jahan created wonders of the world. The research will focus on the era of Shah Jahan with reference to the contribution in Lahore Fort. According to John Brookes, At Lahore Fort he made significant contributions to the fort originally made by Akbar. The *Shah Jahan Nama* of Lahori contains a wide range of information including important public activity of the emperor, day-to-day affairs, military campaigns, civil works, transcripts of

[82] Roger Scruton , The Aesthetics of Architecture: The Problem of Architecture(Great Britain : W & J Mackay Limited ,1979)

important state documents, and letters exchanged with other rulers. He also wrote about the involvement of the emperor in architectural activities in the following words:

"*Apart of the time spent in seeing the works of exalted magical artists such as lapidaries, enamellers, etc. The superintendent of the work of royal buildings in consultation with the wonder working rare masters, lay before the critical (royal) eye design of edifices. The royal mind, which is illustrious like the sun, pays meticulous attention to the planning and construction of these lofty and imposing buildings, which, in accordance with the saying "verily our relics tell of us "speak with mute eloquence of His Majesty's God-given high aspiration and sublime fortune….and for ages to come will serve as memorials to his abiding love of constructiveness, ornamentation and purity*".[83]

Today the attractive and eye-catching cultural and historical buildings not only served the needs of man but also gratifies the eye and invigorates and refreshes the soul.[84] The concept of fort and fortification was to protect the timid, frighten the rebellious, and please the obedient. They provide excellent protection against cold and rain, provide for the comfort of the princess of Harem, and are conducive to that dignity which is so necessary for the worldly power.[85] This is not to deny that the essential character of Mughal architecture is Islamic and foreign. Many ideas, artists and architects were imported by the Emperors from neighboring parts of the Muslim world such as Persia. Mughal Architecture was not a novel import but it was the continuation of an established Indo-Islamic traditions.

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[83] Abdul Rehman , The Mughal Garden : The Mughal Concepts of Gardens: An Enquiry into Shah Jahani Sources (Lahore : Ferozsons (Pvt) LTD , 1996) p.116

[84] Abdul Rehman , Munazzaha Akhtar ; Heart Pleasing and Praiseworthy Buildings: Reviewing Mughal Architecture in the light of Primary Sources (Pak. J. Engg. & Appl. Sci. Vol. 10, Jan, 2012) p.13

[85] G.H.R.Tilloston , Mughal India (SanFrancisco: Chronicle Books, 1990)p.21

Some architectural styles have a special sense of place and atmosphere. Mughal architecture is one of them. During the reign of Akbar Mughal Architecture attained its distinctive character. The syncretistic intelligence of Akbar not only affected the political affairs but also had a strong impact on the developments of the arts.[86] The syncretism of later Mughal Architecture reflects India's great capacity for absorbing and reconciling the pluralism that defines shape and nourishes its culture.[87] The arrival of Muslims in India – fused and unified the local and immigrant architectural techniques that resulted into an astonishing style.[88] Different techniques were merged together to cope with the extremes of climate. The absence of mechanical equipment and advancement in technologies forced our ancestors to design comfortable places. At that time the intention was to provide people a thermal comfort with or without buildings. In present days, our buildings are demanding more effort, investment and technology but providing less comfort than the buildings before.

According to Gupta in his article, 'Indigenous architecture and passive cooling' – "The buildings consume natural energy in three ways:

a) Maintaining the internal environment of spaces to make them comfortable
b) Controlling the microclimate
c) Procuring and manufacturing of material for construction."

The theory of passively cooled or naturally cooled buildings is well-developed. Various techniques suggested for environmental control in modern buildings are:

- Shading of building surfaces from sun

[86] Ebba Koch , Akbar : Mughal Architecture (Prestel-Verlag , Munich 1991)
[87] Richard Yeoman , The story of Islamic Architecture (Lebanon: Garnet Publising 1999)
[88] Asif Ali , Passive Cooling and Vernacularism In Mughal Buildings in North India: A source of inspiration of sustainable development (India : International Transaction Journal of engineering , Management and Applied Sciences and Technologies , 2013)

- Damping and restricting temperature variations by thermal mass
- Selective ventilation
- Radiation to night sky, and
- Evaporation of water[89]

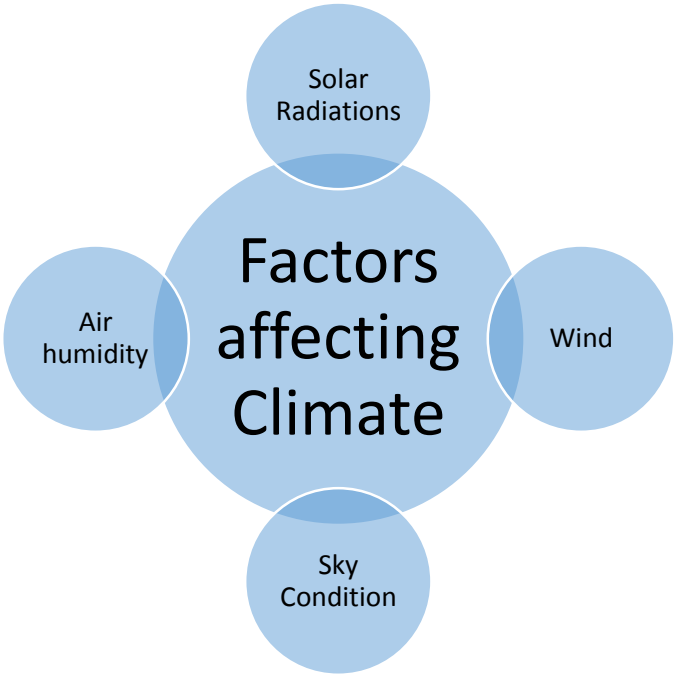
Now the question arises, what is Microclimate control? There are two terminologies - used to refer climate as a factor.

[89]Vinod Gupta , Energy and Habitat : Indigenous Architecture and Natural Cooling

a. Macroclimate

The representation of weather and the atmospheric environment over a brief period of time. Assimilated and cohesive weather condition over several years is generally referred to as climate or more specifically, as the 'macro-climate'[90] .

Macroclimate of a site is affected by following factors:



1) Solar Radiations

It is the solar radiations or the sun rays received from the sun. It is the most important weather variable that determines whether a place experiences high temperature or is predominantly cold. The direction of sun rays effects a lot on the environment.

[90] Govt. of India, Ministry of New and Renewable Energy. (n.d.). CHAPTER – 2, CLIMATE AND BUILDINGS. <http://mnre.gov.in/solar-energy/ch2.pdf>

For Example,

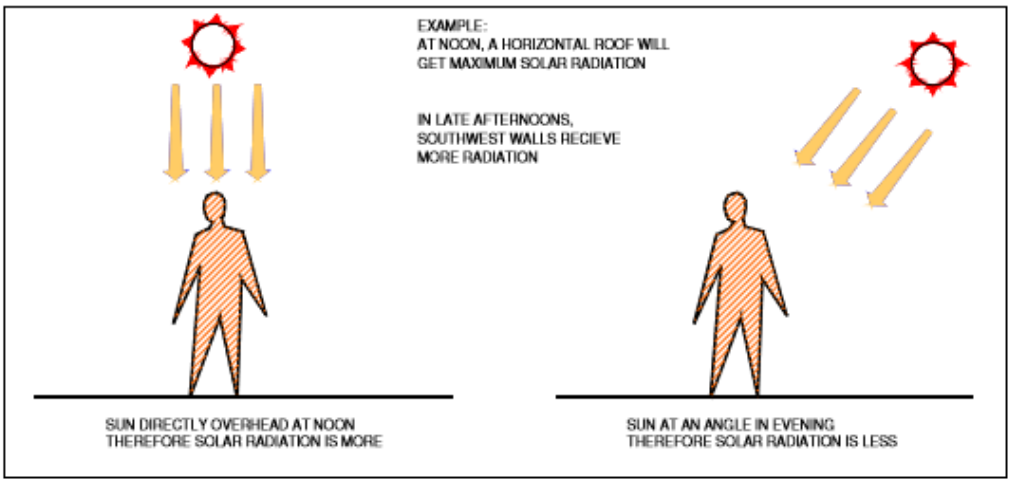


Figure 20: Sun directly overheads at noon receives maximum solar radiation as compared to the sun rays at an elevation

Source: Internet - Google images

2) Air humidity

Air humidity, which represents the measure of dampness present noticeable all around, is normally communicated regarding 'relative humidity'. Relative humidity is characterized as the proportion of the mass of water vapor in a certain volume of clammy air at an offered temperature, to the mass of water vapor in the same volume of immersed air at the same temperature; it is regularly communicated as a rate.

3) Wind

Wind is the movement of air due to a difference in atmospheric pressure, caused by differential heating of land and water mass on the earth's surface by solar radiation and rotation of earth. It is a major design consideration for architects because it affects indoor comfort conditions by influencing the convective heat exchanges of a building envelope, as well as causing air infiltration into the building.

4) Sky condition

Sky condition for the most part alludes to the degree of shadiness in the sky or the term of daylight. Under clear sky conditions, the force of sun oriented radiation increments; though it lessens in rainstorm because of shadiness.

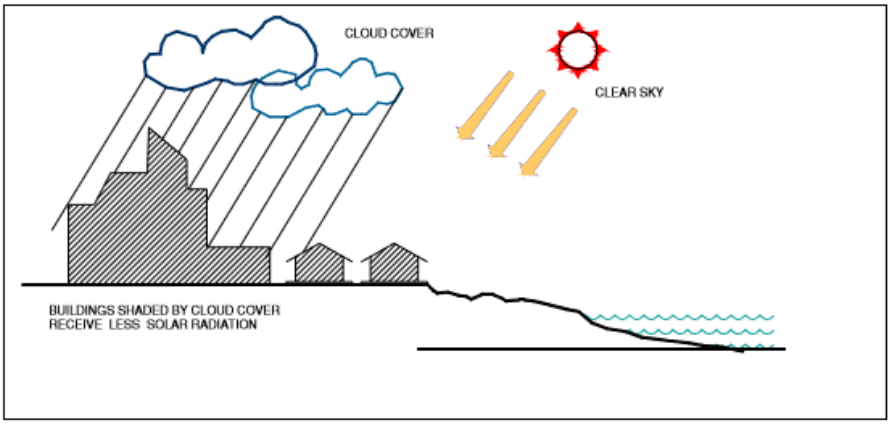


Figure 21: Buildings shaded by clouds cover receive less solar radiations

Source: Internet - Google images

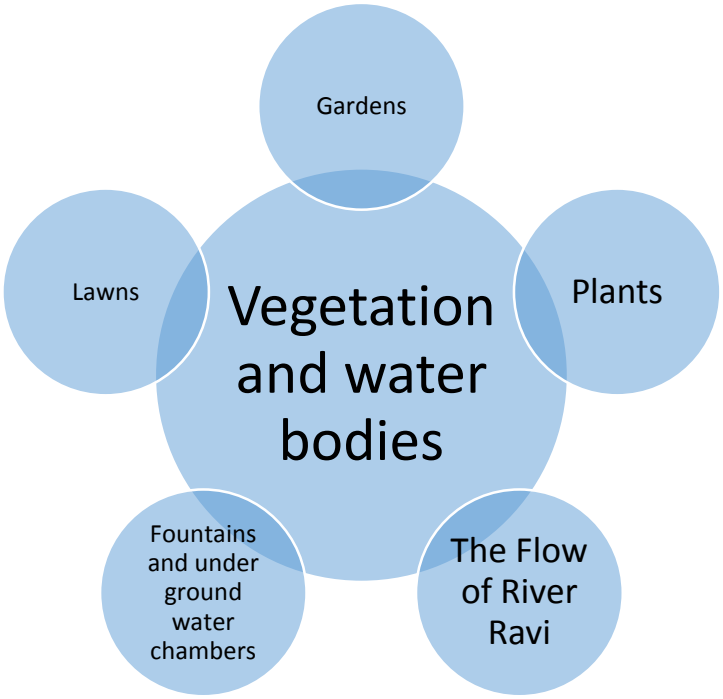
b. Microclimate

"The state of transfer of energy through the building material that shape the thermal response of people and are local and site-specific. These conditions are generally grouped under the term of 'microclimate', which includes wind, radiation, temperature, and humidity experienced around a building. Basically – it is to control and balance the internal temperature with respect to the temperature outside the building."[91]

Microclimate of a site is affected by following factors:

1) Vegetation and Water bodies
    i. Gardens
    ii. Lawns
    iii. Plants
    iv. Fountain and underground water chambers
    v. The flow of River Ravi (In Mughal Period)

[91] Govt. of India, Ministry of New and Renewable Energy. (n.d.). CHAPTER – 2, CLIMATE AND BUILDINGS. <http://mnre.gov.in/solar-energy/ch2.pdf>



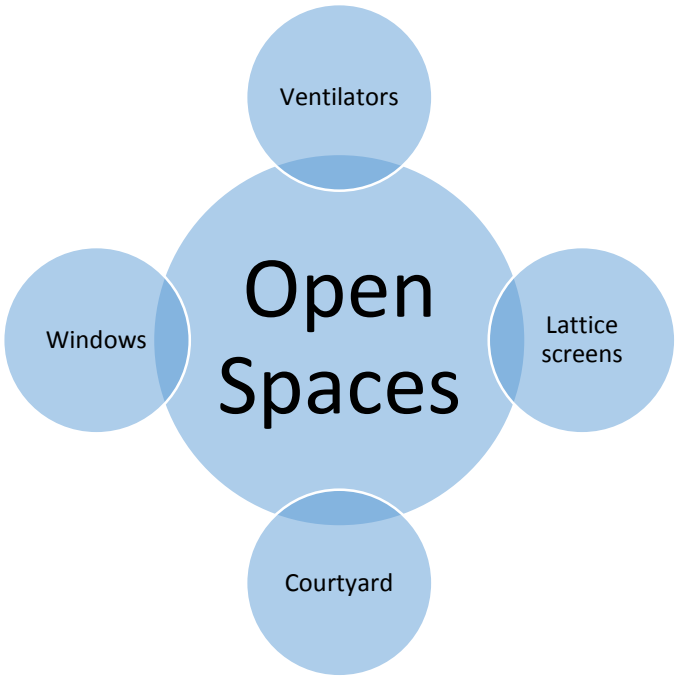
2) Open Spaces

   i. Ventilators

   ii. Windows

   iii. Lattice Screens

   iv. Courtyard



4.1. Climatic Characteristics of Hindustan (Mughal Era):

According to Asif Ali in his article "Passive Cooling and Vernacularism in Mughal buildings in North India: A source of Inspiration for Sustainable development": "Composite atmosphere happens in a large portion of the zones led by Mughals in North India which is portrayed by commanded hot and dry conditions two third of the year and, a degree cool and a warm sticky season happen in the staying 33% of the year. Being sufficiently a long way from the equator, this locale encounters clear regular changes in sun oriented radiations and wind bearings. The striking mean diurnal changes may be seen from 11-12° C in hot dry and cool dry seasons while this extent contracts up to 3-6° C in warm sticky season. Relative dampness reaches up to 95% amid the wet period. There is almost no downpour amid dry season. Hot and dusty winds blow amid dry season. However storm winds are solid and enduring. Ruled hot and dry

season remained a tricky circumstance in this locale as the century's progress".[92]

Elaborating on the 'warm climate', Bernier continues:

"'The heat is so intense in Hindustan that nobody, not even the lord, wear stockings; the main spread for the feet being babouches , or shoes , while the head is secured by a little turban, of the finest and the most sensitive materials. Alternate articles of clothing are relatively light. Amid the mid-year season, it is hardly conceivable to keep the hand on the mass of a flat, or the head on a pad. For more than six progressive months, everyone lies in the outdoors without covering – the regular individuals in the boulevards, the vendors and persons of condition infrequently in their courts or cultivates, and once in a while on their patios, which are first precisely water".[93]

According to Dr. Abdul Rehman in his article "Garden Types in Mughal Lahore According to Early Seventeenth Century Written and Visual sources": "Like the rest of the Indian subcontinent, the climate in this region is generally harsh, especially its long hot summers." Further, in the same article, he writes that "However, the climate of Lahore is somehow milder than that of Delhi and Agra, and it is closer to Kashmir and Kabul and therefore more accessible for local and Central Asian people travelling between them. It was also ideally situated at a crossroad of the land route and therefore many of the Mughal elite maintained a house there."

[92] Asif Ali , Passive Cooling and Vernacularism In Mughal Buildings in North India: A source of inspiration of sustainable development (India : International Transaction Journal of engineering , Management and Applied Sciences and Technologies , 2013)

[93] Ahsan Jan Qaisar , Building Construction in Mughal India (Delhi : Oxford University Press , 1988)p. 2

> The climate of Hindustan is always of noteworthy importance. Babur in his memoirs mentions three things about the climate of Hindustan. "Three things", he wrote in his memoirs 'oppressed us in Hindustan: its heat, its strong winds and its dust'.[94]

4.2. Building Description:

Architecture is not only the art of constructing individual buildings but it is also the creation of environment. Buildings do not exist in isolation. Their character has not only an effect on their surroundings but also have an incalculable effect on the lives of human beings who obstruct them.[95] Building provides shelter and places for retreat for human beings, while also defining our wellbeing and helping to define our quality of life. As Winston Churchill said, 'we shape dwellings and afterwards dwellings shape our lives'. The ideas are bound together by a common desire or purpose – the desire to create a useful and beautiful building- and are mutually interdependent.[96] ***Makan dilnasheen hai az nasheman hai nuzhat aafreen*"** which means "heart pleasing buildings and praiseworthy mansions"- this phrase was used by Saleh Kamboh to describe the beauty of the buildings. Mughal architects are legendary for their creativity.[97] Shah Jahan brought the great tide of Mughal building to its climax, achieving a perfect fusion with the surrounding landscape. The contribution of Shah Jahan in Lahore Fort is its tremendous example. The focus of this research will be the areas under Shah Jahan's reign i.e. Shah Jahan's quadrangle (Diwan-e-khas, Khwabgah-e-Shah Jahani, and the courtyard in between the two buildings), Paien Bagh

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[94] Bianca Maria Alfieri, Islamic Architecture of the Indian Subcontinent: The Arrival of Mughals (London: Laurence King Publishing ,2000) p.185

[95] Flavio Conti, Architecture as Environment (London : HBJ Press) 1977

[96] Talbot Hamlin , Architecture – An art for all men : The Meaning of Style (Columbia , University Press :1961)

[97] Abdul Rehman, Munazzaha Akhtar, Pak. J. Engg. & Appl. Sci. Vol. 10, Jan., 2012, Heart Pleasing and Praise worthy buildings : Reviewing Mughal Architecture in the light of Primary resources (p. 103-113)

quadrangle (Khilwat khana and garden area), Shah Burj complex including Sheesh Mehal, Naulakaha pavilion.

Following is the plan of the site specified to study Microclimate control:

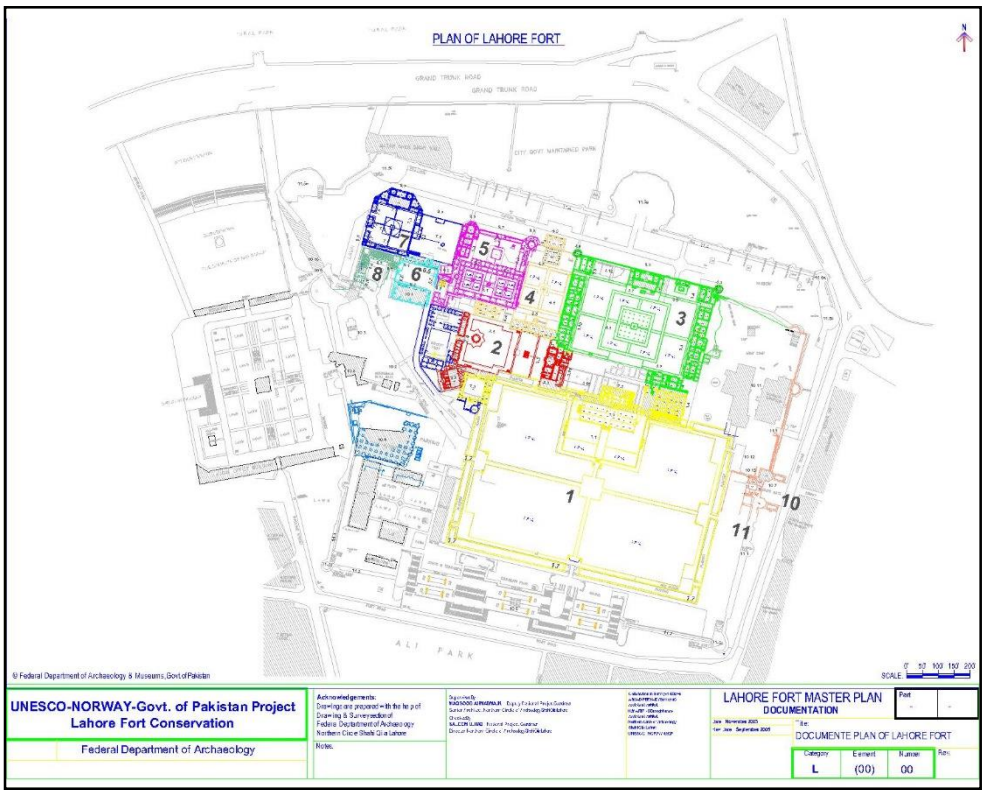

Figure 22: Master plan of Lahore fort[98]

4.3. Climate of the site:

Mughals made Lahore, their winter capital - to escape extreme weather of Delhi. According to Abdur Rehman in his article, "Garden Types in Mughal Lahore": "The Climate of Lahore is milder than that of Delhi and Agra because it is adjacent to Kabul and Kashmir". It is ideally situated at a crossroad, therefore it was famous among the Mughal elites.

[98] UNESCO-NORWAY Govt. of Pakistan Project – Lahore Fort Conservation , Drawing Prepared by Malik Maqsood Ahmed

Wind Direction of site:

The wind direction of Lahore varies with weather. In winter it is - from North East to South West. In summer, it is the reverse i.e. from South West to North East.

According to the given plan, the areas specified for this research are:

A. Shah Jahan's Quadrangle

Immediately west of the Jahangir's quadrangle is located an open court enclosed with buildings of the period of Shah Jahan on all the four sides. It is thus known as Shah Jahan's quadrangle wherein are located some of the most beautiful palaces manifest of the pinnacle of the Mughal art of architecture.

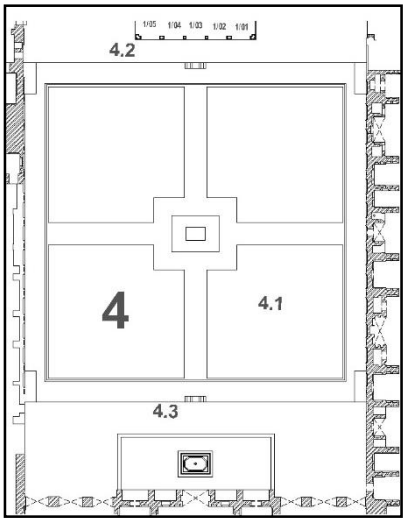

Figure23 : Plan of Shah Jahan's Quadrangle

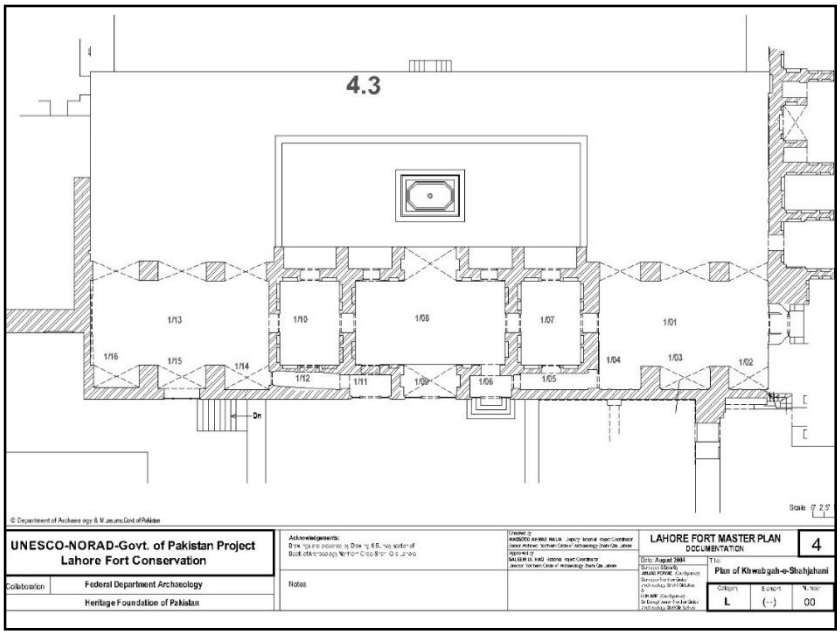

Figure 24 : Plan of Diwaan e Khas

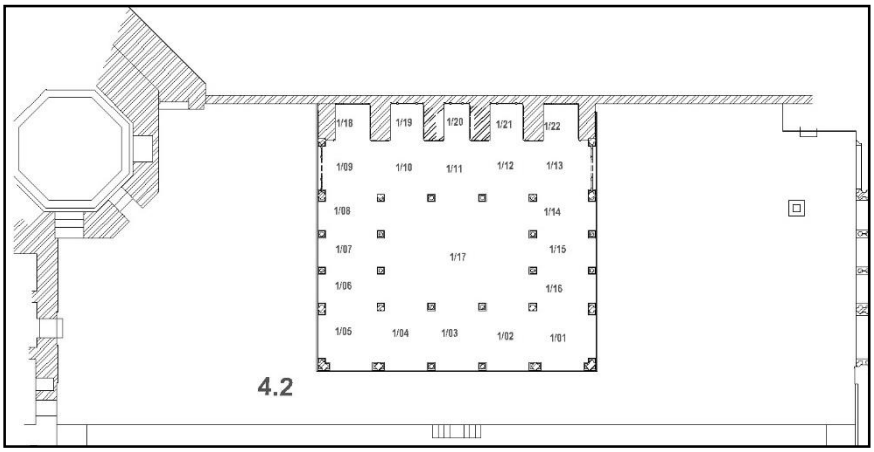

Figure 25 : Khwabgah-e-Shahjahani

Figure 26: A view of Shah Jahan's quadrangle

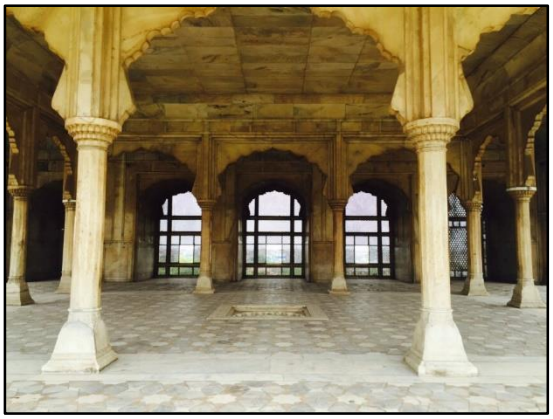

Figure 27: A view of Diwaan-e-Khaas

Figure 28: Front wall of Khawabgah-e-ShahJahani Jahani (Right wall)

Figure 29: Khawabgah-e-Shah

5. Paien Bagh Quadrangle:

Further on, towards the west – there is an area designed for the ladies of Harem. The court is an enclosed courtyard having a corridor running on its four side.

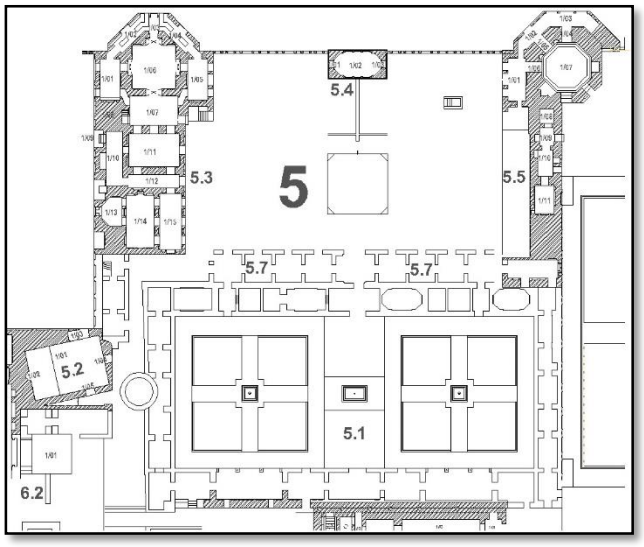

Figure 30: A plan of Paien bagh quadrangle

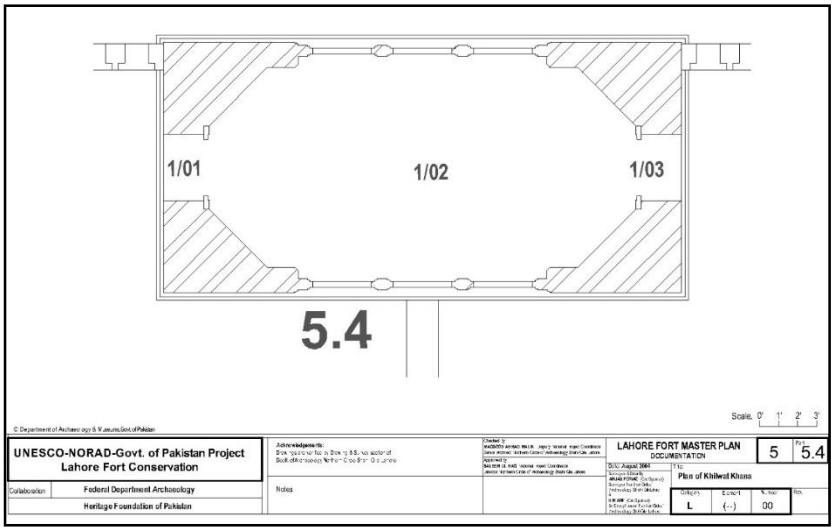

Figure 31: A plan of Khilwat Khana

Figure 32: Views of Paien bagh quadrangle

Figure 33: Windows and Lattice screens of Sheesh Mehal

Figure 34: Winter Rooms and Cross ventilation system of Sheesh Mehal

4.4. Factors affecting microclimate control in Lahore Fort

Following are the factors affecting and balancing the temperature of areas around Shah Jahan's quadrangle.

1. *Vegetation and Water Bodies:*

The history of landscape architecture is evident that the gardens by Mughals are the optimum and the finest achievement. The finest features of natural and built environments are assimilated by gardens with the finest traditions of local and regional landscape design. In a case study of Shalimar garden , according to the authors, "They draw together human aspirations for worldly and spiritual order - merging the paradise-like potential of the world with symbolic representations of the paradise that awaits the faithful in the world to come." The aesthetic and functional needs of society are blended by Mughal gardens. A context for artists, on the one hand and for the society on the other hand- is provided by them.[99] The palaces built by the Mughals at Delhi, Agra and Lahore were full of gardens. Niccolao Munucci wrote of the Mughal palaces and forts, saying that *they were full of gardens with running water, which flows into channels into reservoirs of stone, jasper and marble. In all the rooms and hall of these palaces there are ordinarily fountains or reservoirs of the same stone of proportionate size. In the gardens of these palaces there are always flowers according to the season. There are no large fruit trees of any sort, in order to hinder the delight of the open view. In these palaces are seats and private rooms, some of which are in the midst of the running water. In the water are many fish for delight.*[100] Lahore fort is one of these palaces. S. Kausar in his article 'Meaning of Mughal Landscape' describes that the gardens of paradise has been the source of inspiration throughout the world. The traditions of

[99] S. Mubin, I.A.Gilani and W. Hasan ,Mughal Gardens in the city of Lahore- A case study of Shalimar Garden(Pakistan Journal of Science (Vol. 65 No. 4 December, 2013) p.511

[100] John Brooke , Mughal India : Gardens of Paradise (London : Weidenfeld and Nicolson , 1987) p. 157

formal gardens in the Indian subcontinent started with the arrivals of the Mughals. The Mughals are justifiably known as the great patrons of gardens.[101] New images to landscape were given by the Mughals. Landscaping was an integral part of Indian palaces and monuments. Trees, green areas and water body around a building improve the physical comfort along with the visual pleasure.[102] Mughals used the techniques of Gardens not only as a source of inspiration but also to improve the immediate surrounding environment of their surroundings.[103] The *Babur-nameh* includes many references to garden making, flowers and trees often mentioning wild flowers such as tulips, growing in the mountains. Babur gave prime importance to water in gardens. He believed no garden should be without water and, when necessary, would straighten a natural streambed to make it conform to the traditional garden pattern.[104]

Gardens can be categorized as four distinct classes:

a) Tomb Gardens
b) Palace Gardens
c) Plain Gardens
d) Terraced Garden [105]

Presently there are at least four well-laid gardens in the Lahore Fort:

i. In front of the Diwan-e-Aam
ii. Within the quadrangle of Jahangir

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[101] Abdul Rehman , Mughal Gardens : The Mughal Concepts of Gardens : An Inquiry into Shah Jahani Sources (Lahore :Ferozsons (Pvt.) LTD, 1996) p.115
[102] Neeta Mittal , Heritage Buildings An Inspiration for Energy Efficient Modern Buildings (India : CSIR- Central Building Research Institute, Roorkee)
[103] Asif Ali , Passive Cooling and Vernacularism In Mughal Buildings in North India: A source of inspiration of sustainable development (India : International Transaction Journal of engineering , Management and Applied Sciences and Technologies , 2013)
[104] Penelope Hobhouse , Gardens of Persia: Mughal Gardens (UK : Cassell Illustrated , 2003)
[105] R. Nath , Gardens and Garden Pavilions : History of Mughal Architecture (Delhi : Abhinav Publications , 1994) p.221

iii. Between the Chhoti Khawabgah and Diwan-e-Khas

iv. The Harem Garden.[106]

In Lahore fort (Shah Jahan's quadrangle) near Shah Burj is the Paien Bagh that is also known as The Harem Garden.

It was an adjacent garden for the royal harem residing in the Sheesh Mehal.[107] It is plan on a familiar *chahar bagh* style. The *chahar bagh* style is a Persian tradition followed by Mughals. *Chahar bagh*, or its abbreviated form *char bagh*, designates a cross-axial four-part garden, *chahar* meaning "four" and *bagh* "garden." Babur, however, applied the term in its widest sense, for architecturally planned gardens with intersecting raised paved walkways, platforms, and pools. It is also a mythical reflection of nature.[108]

According to Sajjad Kausar in "Meaning of Mughal landscape", "The theme of *Chahar Baghs* was elaborated by successive Mughal rulers. If the plans of Taj Mahal , Shalamar Garden Lahore and Red Fort at Delhi , all constructed during the fifth Mughal emperor Shahjahan's time , are compared , an interesting picture emerges."

The composition of Taj Mahal is of a single *chahar bagh*. The Shalamar Garden is composed of two chahar bagh. The comparison of Shalamar garden at Lahore and Red Fort at Delhi suggest the divisions and subdivision of chahar bagh. The chahar bagh style was common in Agra, Delhi, Kashmir, Kabul and Lahore. Topography, climate and building materials also played a vigorous role in the development of Mughal Landscape architecture."[109]

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[106] http://walledcitylahore.gop.pk/index.php/gardens-lahore/78-wcl-articles/119-garden-fort

[107] Masood-Ul-Hassan, Conservation of Lahore Fort Gardens: The Mughal Garden ed. By Mahmood Hussain , Abdur Rehman & James L. Wescoat (Lahore : Ferozsons (Pvt.) Ltd, 1996) p. 131

[108] The Persian Garden , (UNESCO Heritage Report)

[109] Sajjad Kausar , Meaning of Mughal Landscape (Cultural Landscape in 21st Century – UNESCO World Culture and Heritage , 2005)

The most interesting feature of *chahar bagh* style is the paved walkways, water, fountains and vegetation. After Babur the term *chahar bagh* seems to disappear in Mughal architectural style but in Shah Jahan's era – three kinds of *chahar bagh* styles are found.[110]

> "First the canonical cross axial *chahar bagh* which had made a grand entry in a rigorously geometric tomb garden of Humayun (1562-71). Second, the terrace garden, a linear composition planned in steps along a longitudinal axis, famous are the Shalimar gardens of Kashmir (1620 and 1634) and Lahore (1641-42). And third, the waterfront garden which I have identified as a configuration of a river front terrace upon which are placed the main symmetrically arranged buildings, and a *chahar bagh* on the landward side."

The garden (Paien bagh) is enclosed by the corridor on all sides. The Paien Bagh has the connection with Khilwat Khana from the North side. In the center there are brick platform and water tanks with fountain. On either side were smaller water tanks enclosed by a red sandstone railing. Now these has been turned into grassy plots and the railing is vanished. The four plots on each side are 24 feet square which are intersected by a brick on edge pavement 7'-9" wide. Abdul Hameed Lahori termed Mughal gardens as *bagh-i-bahisht, firdaus, bustan,* and *Gulistan* but did not give any further explanations to these terms. These gardens were designed for the use in the evening hours. Therefore the existence of moon and candle light is certain, inevitable and relevant in the physical design. The mutual interaction between a living organism and its environment is provided by plants. It possesses its own heat and water economies. Its respiratory heat is the result of metabolism which tends to raise its

[110] Ebba Koch , My Garden is Hindustan : The Mughal Padshah's Realization of a political Metaphor .

temperature, just as within animals. The lawns in Paien bagh quadrangle perspires, and the evaporation leads to cooling.[111] The cooling then effects the building surrounding the gardens and the area around the green portion i.e. the walkways of paien bagh, Khilwat khana, Diwan-e-Khas and Khawabgah e Shahjahani. Vegetation improves the quality of outer space and enhance cooling by evo-transpiration.[112] Vegetation is also effective in controlling the microclimate. Vegetation absorbs radiation for photosynthesis and cools the environment. They are helpful in shading the particular part of the structure. By releasing moisture, they help raising the humidity level.[113] According to J. Fernandes and J. Correia da Silva: " The aim of this strategy is to reduce the input of the solar radiation in the building and surrounding spaces by trees, bushes, grass and creeping plants. These are elements of extreme importance in regularizing and balancing the climatic conditions, reducing drastically the thermal amplitude around the buildings." These plants and green areas not only improves the quality of outer space but it also provides a good example of the mutual interaction between a living organism and its environment. It possesses its own heat and water economies. The respiratory heat produced by plants is the result of metabolism. It tends to raise its temperature. It perspires and its perspiration leads to cooling – since every gram of water given off requires between 570 and 600 calories from the plant, depending on the air temperature. Consequently, plants exert a reaction on the

[111] Hassan Fathy , Natural Energy and Vernacular Architecture: Environment and Architecture (London: The University of Chicago Press,1986)

[112] (ET) is the sum of evaporation and plant transpiration from the Earth's land and ocean surface to the atmosphere. Evaporation accounts for the movement of water to the air from sources such as the soil, canopy interception, and waterbodies.

[113] Govt. of India, Ministry of New and Renewable Energy. (n.d.). CHAPTER – 2, CLIMATE AND BUILDINGS. <http://mnre.gov.in/solar-energy/ch2.pdf>

microclimate of their environment and to some extent adjust their own temperature to their particular needs. [114]

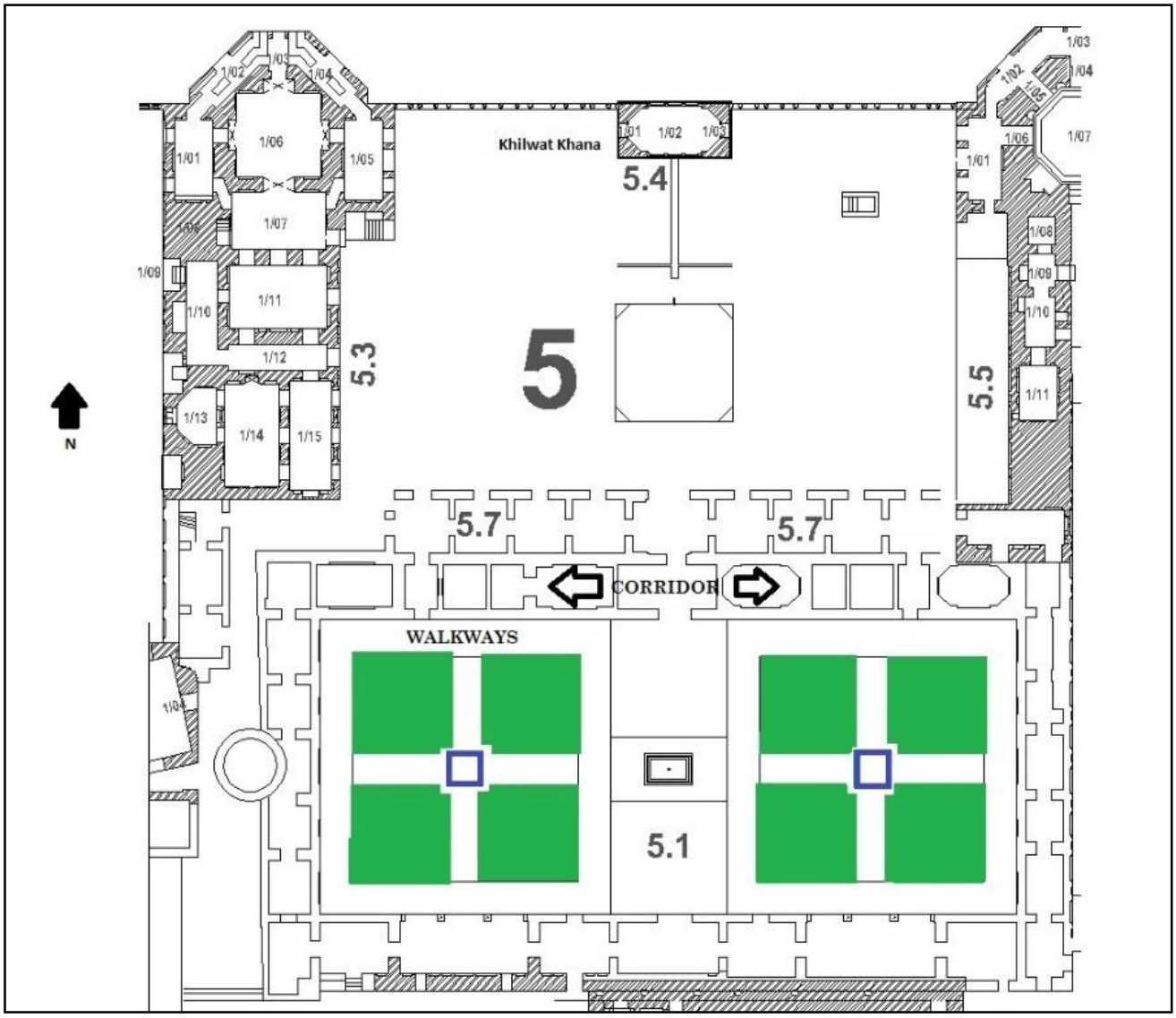

Figure 35: Plan of paien bagh quadrangle highlighting the green area

[114] Hassan Fathy , Natural Energy and Vernacular Architecture: Environment and Architecture (London: The University of Chicago Press,1986)

Figure 36: A view of Paien bagh quadrangle

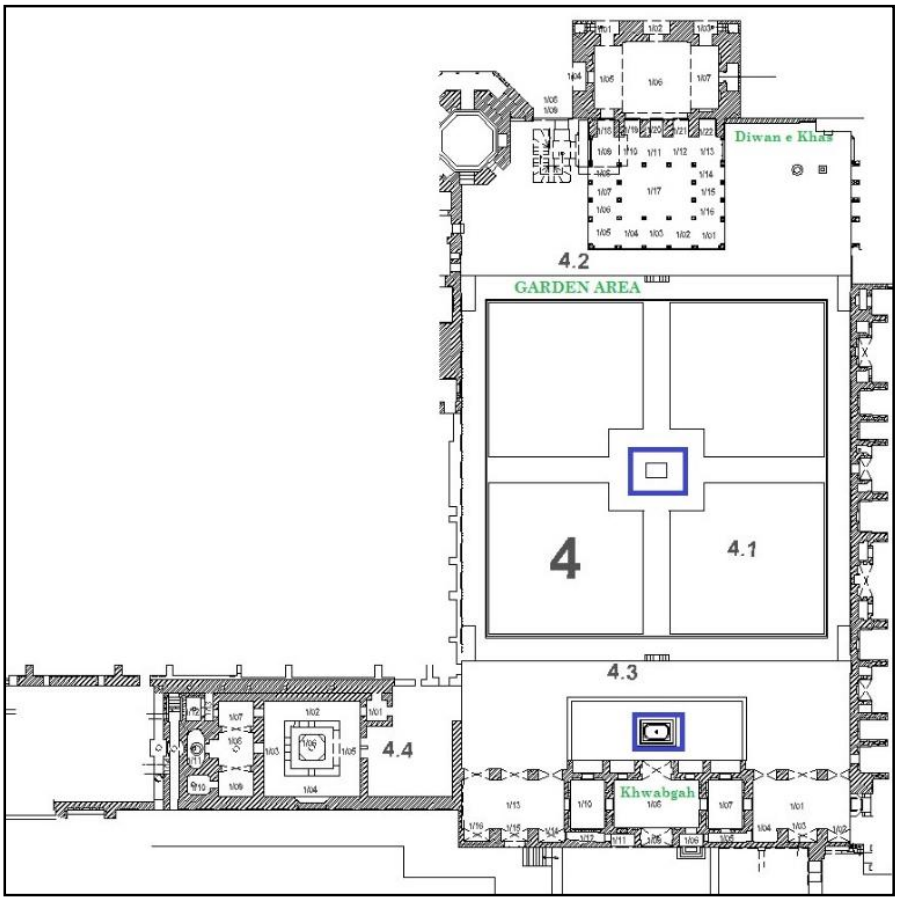

Figure 37: Plan of Shah Jahan's quadrangle- focusing on garden area and fountains

Figure 38: A view of Shah Jahan's quadrangle

In Paien Bagh there are three fountains, one in the center of the platform, and one each on its either side.

Figure 39: A view of Fountains in a row in paein bagh

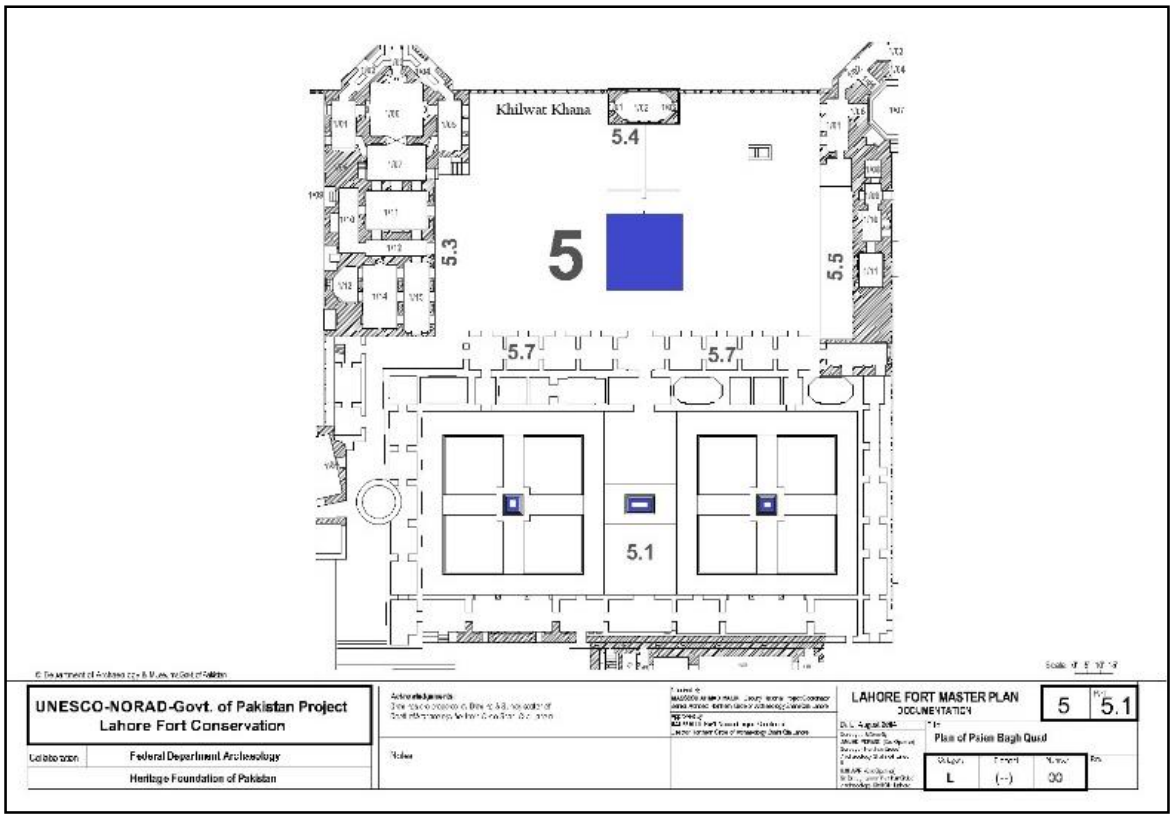

Figure 40: Plan of fountains in Paien bagh quadrangle

The great skills were shown by Mughals in infusing the Islamic idea with local tradition. They promoted relation in architecture and landscape design in place of Hindu idealism through the use of topographic and hydraulic features.[115] According to the researches of environment, architecture and climate control - The water bodies like fountains and water channels were added in the buildings which passes through the internal buildings to modify the internal environment.[116] In Khawabgah-e-Shahjahani, there are fountains inside the rooms to keep the temperature moderate inside the building. The air after passing through the green area, when enters the building – the water channels or the water bodies inside the buildings absorbs a large amount of heat for evaporation (as

[115] Abdul Rehman, Earthly Paradise : Mughal Gardens : History and Architecture (Habib ur Rehman Foundation , 2001) p. 79

[116] Neeta Mittal , Heritage Buildings An Inspiration for Energy Efficient Modern Buildings (India : CSIR- Central Building Research Institute, Roorkee)

water has a high latent heat of vaporization). Hence the cooled air then be introduced in the building.

Figure 41: Fountains inside the building of Diwan-e-Khas and Khwabgah-e-Shah Jahani

Figure 42: Fountain inside Khwabgah e Shah Jahani

The evaporation of water is useful in hot and dry climates because it raises the level of humidity.[117] Water has a moderating and regulating effect on the air temperature of microclimate. It retains very high thermal storage capacity, much higher than the building materials like brick, concrete and stones. It also has a cooling effect on the environs. The heat is taken up from the air through evaporation and causes significant cooling.[118]

Water is an architectural element which is extensively used in our ancient buildings and in garden of the Mughals. Water not only pleases the eye on a hot summer day but also provides passive cooling. Water improves the physical comfort by the evaporative cooling of the surrounding air. Rate of heat loss from the moving air depends upon the area of water in contact with the air and careful zoning of the sheltered spaces so that strips of the water could be strategically placed around the structure.[119]

Javad Samadi cited the significance of water in his article as: "Water pool in the middle of the courtyard with maximum dimensions stores the solar energy and decreases the heat of summer. This pool along with gardens, trees and boundless sky provide the limited but fresh nature." [120] Evaporation from the surface of the building or from objects within the interior can produce a cooling effect on the building which acts as a source to reduce heat.[121]

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[117] Govt. of India, Ministry of New and Renewable Energy. (n.d.). CHAPTER – 2, CLIMATE AND BUILDINGS. <http://mnre.gov.in/solar-energy/ch2.pdf>

[118] Solar Passive Design for new buildings : Water Bodies , http://www.teriin.org/ResUpdate/reep/ch_1.pdf

[119] Neeta Mittal , Heritage Buildings An Inspiration for Energy Efficient Modern Buildings (India : CSIR- Central Building Research Institute, Roorkee)

[120] Javad Samadi , Utlilizing the Central Courtyard of Traditional Architecture in Modern Architecture (Research Journal of Environmental and Earth Sceinces , 2014)

[121] Hassan Fathy , Natural Energy and Vernacular Architecture: Environment and Architecture (London: The University of Chicago Press,1986)

Figure 43: Fountain in courtyard in front of Khilwat khana

Evaporative cooling is also the part of internal environment in Mughal architecture. It had not been only an element of external spaces. The process is simple, air passing over water causes evaporation, and as a result of this process heat is absorbed and the air is cooled, increasing air humidity. So, the aim is to channeling breezes over the water pools before they enter in the building.[122] To enhance the process the pool or fountain is placed in the center of the courtyard or the building. The fountains are placed in the center of the quadrangle. The air when passes over the water in the fountains, it takes up heat and channelize the breeze before it enters in the Khilwat Khana. By the flow of cool breeze inside the Khilwat khana – it pleases the surrounding and gives a cool effect even in hot summers. Following is the plan showing the placement of fountain in front of Khilwat khana and the placement of fountain in Shah Jahan's quadrangle.

[122] J. Fernandes, J. Correia da Silva, Passive cooling in Évora's traditional architecture (2nd PALENC Conference and 28th AIVC Conference on Building Low Energy Cooling and Advanced Ventilation Technologies in the 21st Century, September 2007, Crete island, Greece)

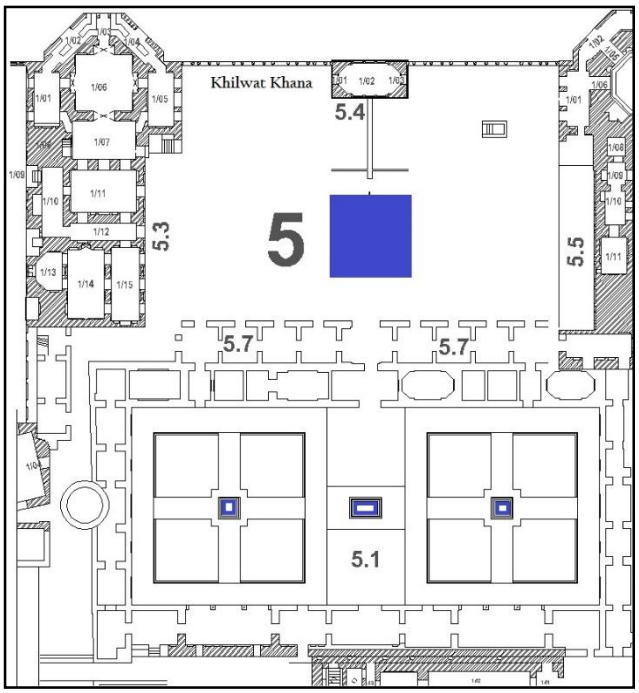

Figure 44: Fountains in Paien bagh and in front of Khilwat Khana

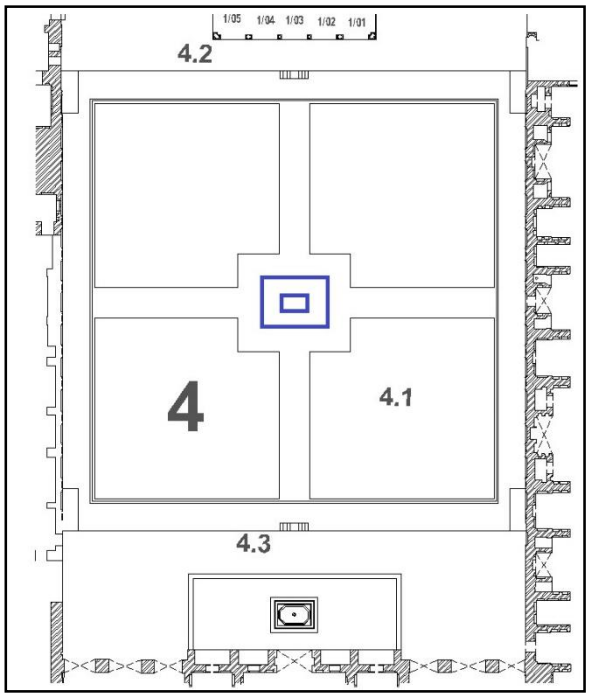

Figure 45: Fountains in Shah Jahan's quadrangle between chaharbagh

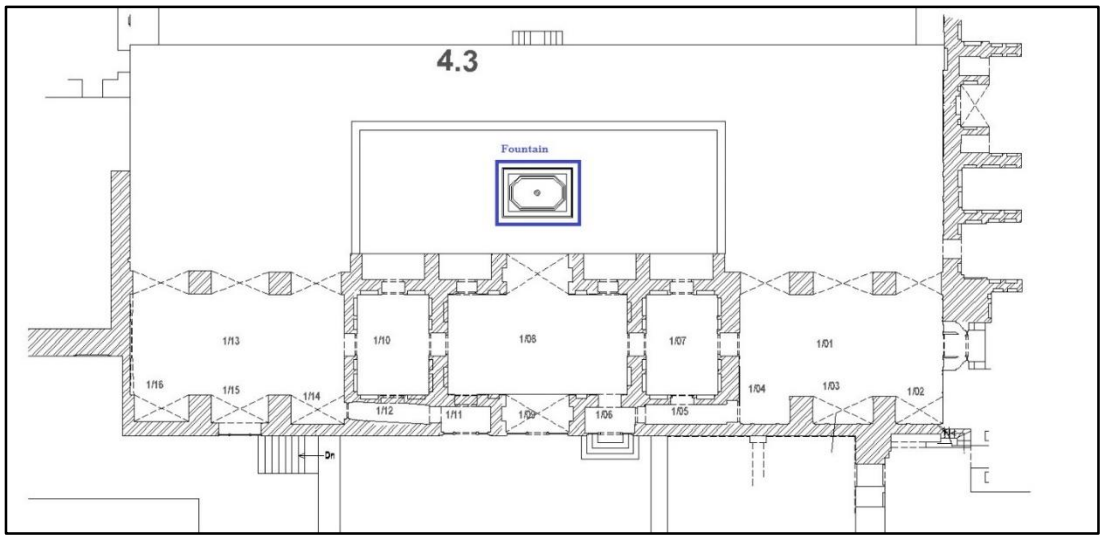

Figure 46: Fountain in front of Khwabgah-e-Shahjahani

Moreover, Water on the surface of a building has a tendency to evaporate. For every gram of water that evaporates, roughly 2500 Joule of heat energy is consumed. Wetting a building therefore helps to remove heat – in a process that is analogous to human sweating.[123] Fountain in front of Khwabgah- e-Shah Jahani when evaporates water, it makes the building wet and removes the heat produce by the sun. The water pressure was maintained by *salsabil.* It forces the water to come out of fountain head.[124] For beyond the psychological effect, the sound of the water has a relaxing effect, more significant in human comfort related with the capacity to balance and to reduce environmental temperature.[125]

[123] Evaporative Cooling of Buildings : Improving Energy efficiency (http://www.riorenewables.com/efficient-design/evaporative-cooling)
[124] Asif Ali , Passive Cooling and Vernacularism In Mughal Buildings in North India: A source of inspiration of sustainable development (India : International Transaction Journal of engineering , Management and Applied Sciences and Technologies , 2013)
[125] J. Fernandes, J. Correia da Silva, Passive cooling in Évora's traditional architecture (2nd PALENC Conference and 28th AIVC Conference on Building Low Energy Cooling and Advanced Ventilation Technologies in the 21st Century, September 2007, Crete island, Greece)

There are many symbols of heaven on earth. Water is one of them. The water in the pool because of its stagnancy reflects the sky. It is the place on the earth where we can see the depth and exquisiteness of the infinite sky. The tranquil and quiescent water omits the boundary between the sky and ground. The reflective and philosophical silence depicts ambiguous secrets. It gives a vision – as if a reflecting spirit has speared in them from nature. The clear and still water reflects an effective image – if visualized from verandah. Water bodies often occupy the biggest part in the courtyard. The water body with three fountains and four channels in front of Sheesh Mahal is an appropriate example.

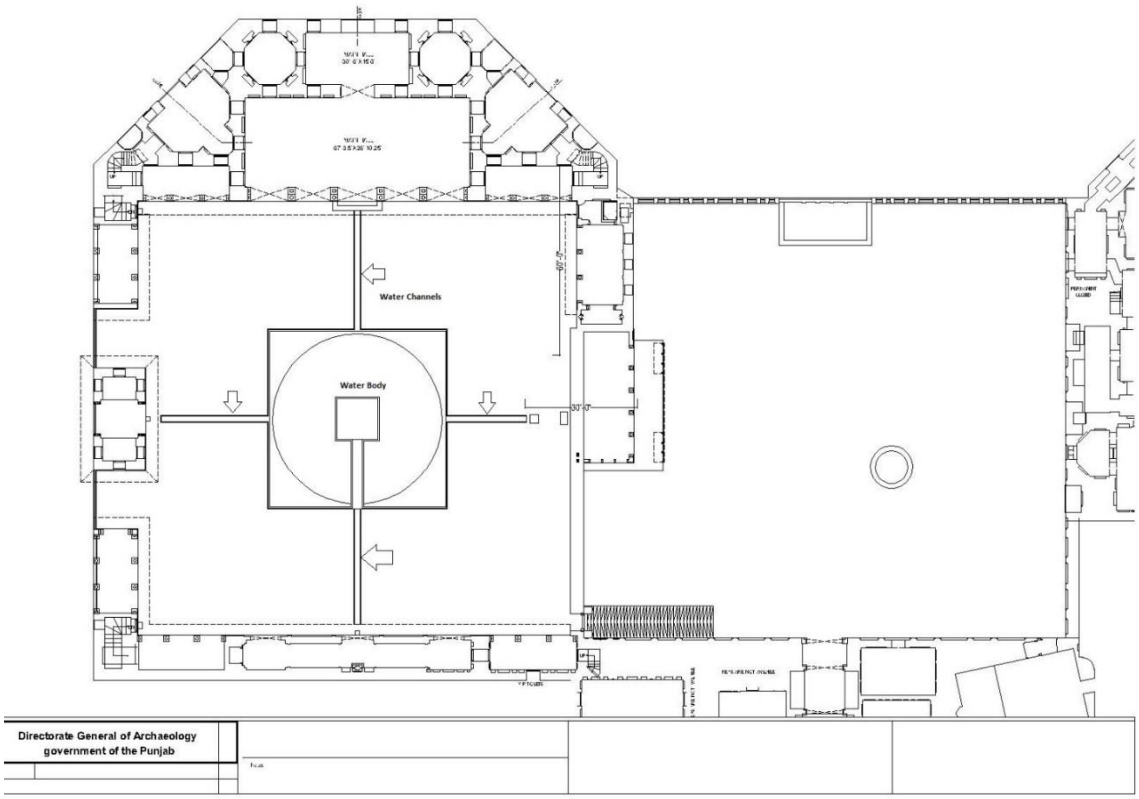

Figure 47: Large Central water body in front of Sheesh Mehal that controls the supply of wate

Figure 48: Water body with fountains in front of Sheesh Mehal

Figure 49: A close view of fountain in front of Sheesh Mehal

In some cases, pools divide the direct route to the main porch of the construction into two indirect lateral and side routs, in a novel and respectful manner. The change in climate has a distinct effect on pool.

"In the warm climates, pools were often made in two sections and were located in the coming and going passage, so that the wind passing above the water of these pools may provide a cool and desired weather for the residents in the warm summer days."

Water not only effects the psychology or the aesthetic sense of human but it also has a remarkable effect on auditory and visual sense. "The sonic and aquatic properties of the water are other positive and effective aspects of pools. A fluid like water has the ability to reduce a remarkable amount of sonic energy in its fluctuations; and in fact the existence of water in the pool acts as a hidden barrier and blocking against the sound passing inside and outside the house. The magic power of water mostly presents itself through its view and sound." This is why often there are some fountains in the rectangular pools from which water falls naturally due to the water level difference, and presents a desired view and sound that brings happiness and joy. Water drops falling was always indicator of some angles playing with each other.

Following is an illustration of cooling effect in Shahjahan's quadrangle. The fountains in front of Khwabgah and Diwan-e-Khas not only controls the temperature and allow the cool breeze to blow but also helps in maintaining a peaceful visual and psychological environment. These are situated in between coming and going passages of the wind and provide the residents a calm and pleasant environment. The natural resources like water, plants, sun and wind – all provide a symphonic and pleasant set of environment efficiencies.[126]

[126] M. Shokouhian, F. Soflaee, F. Nikkhah , Environmental effect of courtyard in sustainable architecture of Iran (2nd PALENC Conference and 28th AIVC Conference on Building Low Energy Cooling and 969 Advanced Ventilation Technologies in the 21st Century, September 2007, Crete island, Greece)

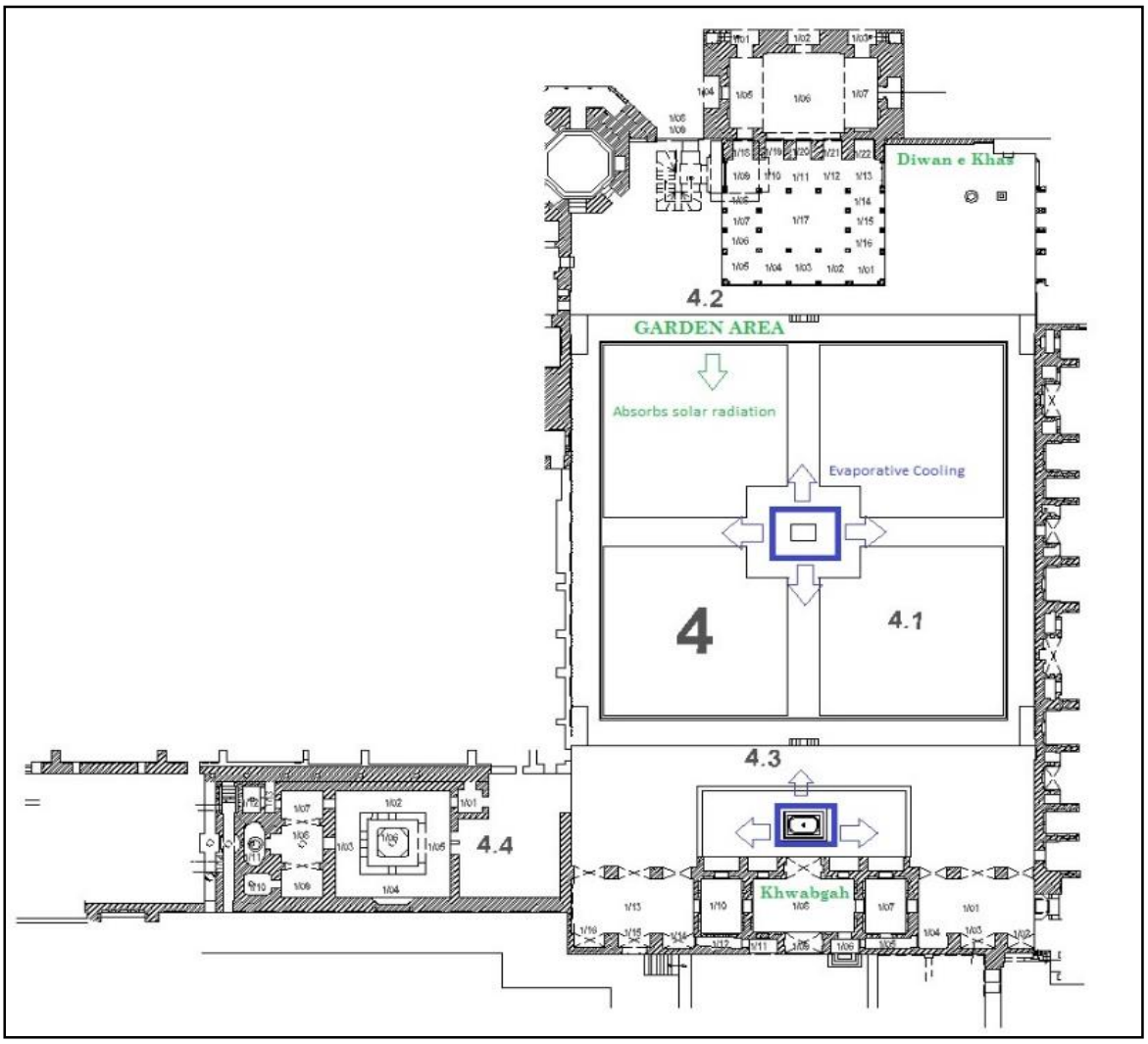

Figure 50: Shahjahan's quadrangle

An illustration of heat absorption and evaporative cooling

Figure 51: Fountains in courtyard in front of Khilwat Khana and Khwabgah-e- Shah jahani

i. Flow of River Ravi (In Mughal Era)

The difference between day and night temperatures can be reduce by large water bodies because they act as heat sink. Thus sites near oceans and larger lakes have less temperature variation between day and night, as well as in summer and winters, as compared to inland sites. The wind flow pattern of a site influence by the presence of large water bodies. According to Nazir A. Chaudhary – "The Ravi at one time ran close under the northern wall of the Fort, "This River," said William Finch, 1611, cometh from the East and runneth westerly by the North side of the city, upon which within the castle is the king's house in at the middle gate to the riverward ." The Ravi was so close to the town that Aurangzeb built a three mile embankment to protect it , and, thereby altered the river's course but pictures as late as 1854 show a small branch of the river still running near the Fort and cutting Chauburji minarets."[127]

Because of the direction and the flow of river Ravi – the temperature of the area that surrounds the Fort was moderate. Moreover, the flow of Ravi presents a beautiful view to be seen from the windows.

[127] Nazir A. Chaudhary , A Short History of Lahore and some of its monuments (Lahore , Sang e Meel Publications , 2000)

Figure 52: Direction of Flow of River Ravi

Water plays an enormous role within the surrounding limits of a city. It also constitutes a basis on which a city is truly urbanized and houses within it are acclimatized in land where water is cherished and valued as a rave gem.[128]

[128] M. Shokouhian, F. Soflaee, F. Nikkhah , Environmental effect of courtyard in sustainable architecture of Iran (2nd PALENC Conference and 28th AIVC Conference on Building Low Energy Cooling and 969 Advanced Ventilation Technologies in the 21st Century, September 2007, Crete island, Greece)

2. *Open Spaces*

i. Courtyards , Verandahs and Corridors

According to the research by Ahmed Qadeer, There are many types of architectural zones which moderates the outdoor and indoor climatic conditions without mechanical control systems. These zones are called transitional spaces. They can be closed such as atrium or semi closed such as balcony and porch or open such as courtyard and patio.[129] Openings play main part in solar passive buildings. There are two kinds of openings: Main openings and the semi openings. Main openings are in the form of courtyards and terraces whereas semi openings are in the form of verandahs. The uncomfortable weather factors can be faced with the apposite presentation of traditional houses and structures. Taking the climate criteria into consideration – it can protect the human from the hot and cold weather.[130] Courtyard is an appropriate place for connection of human being and the nature elements including water.[131]

A complex regulating system is created by courtyard houses which controls the microclimate, which historically worked and still works in a passive way; heat transfer processes are all natural without mechanical devices powered by non- renewable energy. It manipulates the architectural components in order to achieve the best inside thermal comfort, day and night from natural resources within the constraint of locally available resources. It is the end product of the sophisticated historical process of unconscious climate design.[132] The studies on climatic features of courtyard houses

[129] Ahmed Qadeer Ahmed , Energy Performance of Courtyard and Atrium in Different Climates
[130] Javad Samadi , Investigating the Courtyards of Traditional Houses and the Effect of Western Architecture (Turkey : Research Journal of Environmental and Earth Sciences , 2012)
[131] Mansour Nikpour, Shahrzad Shamsolmaali , Hamzeh Dehghani , Investigating the Role of Natural Elements in the Central Courtyards of Traditional Iranian houses in Hot and Dry Regions (Recent Researches in Energy, Environment and Landscape Architecture)
[132] Shahim AbdulRahiman M , Heating , Ventilation and Air Conditioning : Climate Design in the Arab Courtyard Houses (Calicut : National Institute of Technology)

indicates a seasonal movement around the courtyard according to the position of the sun.[133]

According to F. Soflaee and M. Shokouhian in their article "Natural Cooling system in sustainable traditional architecture of Iran":

"*The courtyard (Hayat-e-Markazi) in a hot dry and hot humid climates are usually the heart of the dwelling spatially, socially, and environmentally. Although, the size of the land, to some extent, is influential, the average sizes of the courtyards are generally determined according to the latitude. They are narrow enough to maintain a shaded area during the heat of the day in summer, but wide enough to receive solar radiation in winter*."

A comfortable and a secure place can be made available by a courtyard within a house. It provides comfortable place and beautiful setting. A courtyard supplies some shade and increase the relative humidity of the courtyard space. Even without modern, mechanical heating or cooling systems, the courtyard house provides a comfortable living environment through seasonal usage of sections of the structure.[134]

A courtyard is a connecter of space elements with different functions and regulator of all needed changes in internal communication of building.

There are five forms of courtyard:

1) A building mass surrounds around the courtyard with square or rectangular geometry
2) A central courtyard with three open sides and one closed side
3) A central courtyard with two closed sides

[133] Ayhan Bekleyen and Neslihan Dalklo , Design with Climate-What Can We Learn from the past to Cope with Climate in Terms of Design Strategy and Usage Style of Courtyard Houses? (Middle-East Journal of scientific Research ,2012)

[134] F. Soflaee and M. Shokouhian ,Natural Cooling system in sustainable traditional architecture of Iran (International Conference "Passive and Low Energy Cooling 113 for the Built Environment", May 2005, Santorini, Greece)

4) A central courtyard Polygon in shape
5) A courtyard with remaining space of combining masses around them.[135]

The study of heat, ventilation and cooling system in Courtyard houses articulates the thermal performance of the courtyard houses. According to the researches on the houses having courtyard system, the courtyards comprise heat exchange processes taking place among the environment of three interrelated spaces.

a. The indoor space
b. The courtyard space
c. The external space

Concerning the indoor thermal environment heat is exchanged through

i. The inner envelope (courtyard walls)
ii. The outer envelope (external walls and roofs).[136]

Courtyard can reduce the floor warmth with the help of trees and water for evaporative cooling. The shaded areas because of trees and plants – also moderates the temperature.[137] The courtyard provides the required exposure to the sun which must be exactly determined. It provides also the required natural ventilation between the inside and outside. It is associated with the required humidity which provide more comfort for the occupants.[138]

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[135] Mohammadjaved Mahdavinejad , Abdolbaghi Moradchelleh , Sohaib Dehghani and Seyyed Mojtaba Mirhosseini, The Adoption of Central Courtyard as a traditional Archetype in contemporary Architecture of Iran (World Applied Science Journal ; 2013)

[136] Shahim AbdulRahiman M , Heating , Ventilation and Air Conditioning : Climate Design in the Arab Courtyard Houses (Calicut : National Institute of Technology)

[137] Faezeh Nabavi, Yahaya Ahmadi , Ai Tee Goh , Daylight and Opening in Traditional Houses in Yazd, Iran (- 28th Conference, Opportunities, Limits & Needs Towards an environmentally responsible architecture Lima, Perú 7-9 November 2012)

[138] Ali H. Al Jameel and Omar A. Al Hafith , Investing the Concept of Courtyard for Sustainable Adaptable Multifamily Housing (American Transactions on Engineering & Applied Sciences , 2012)

The verandahs in the buildings acts as buffer between outside and inside climate to protect people from heat and cold. The courtyards, verandahs and inner spaces in Mughal buildings provide an organization of activities from one place to another in relation to climate.[139] Verandas also provide transition from public to private spaces and shield the house from sun and rain.

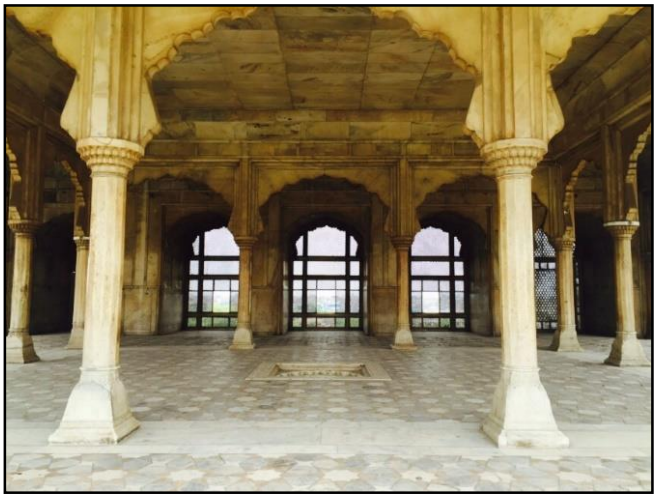

Figure 53: Open spaces of Diwan e Khas

Figure 54: Corridor in Sheesh Mehal

[139] Asif Ali , Passive Cooling and Vernacularism In Mughal Buildings in North India: A source of inspiration of sustainable development (India : International Transaction Journal of engineering , Management and Applied Sciences and Technologies , 2013)

Without mechanical means the ancient buildings are better than the newly designed buildings as it demonstrate the passive architecture of Mughals. Materials are chosen for construction according to the climatic characteristics of the place.[140]

Man's earliest cultures developed beside the mighty rivers of the Near East-the Nile, the Tigris, and the Euphrates- where the two life giving factors of water and hot sunshine enabled man's first civilization to grow, as seeds grow.[141] In the ancient times human activities and nature were largely dependent on each other. According to the researchers of sustainable architecture, it was discovered that all traditional elements work together cool the house in summer and create a warm environment in winter. The favorable result was the thermal comfort. Courtyard is also an essential element in thermal comfort.[142] The courtyard is an effective and operative device to stimulate air movement by convection.[143]

[140] Neeta Mittal , Heritage Buildings An Inspiration for Energy Efficient Modern Buildings (India : CSIR- Central Building Research Institute, Roorkee)
[141] Julia S. Berral , The Garden : In the Time of pharaohs (Italy : Mondadori-Verona ,1966)
[142] Mohammad Arif Kamal and Thamer Al Shehab ,Sustainability through Natural Cooling : Bioclimatic Design and Traditional Architecture (study of Civil Engineering and Architecture , 2014)
[143] Abdel-moniem El- Shorbagy , The Architecture of the traditional Arab Houses (https://architecture.knoji.com/the-architecture-of-the-traditional-arab-house https://architecture.knoji.com/the-architecture-of-the-traditional-arab-house/)

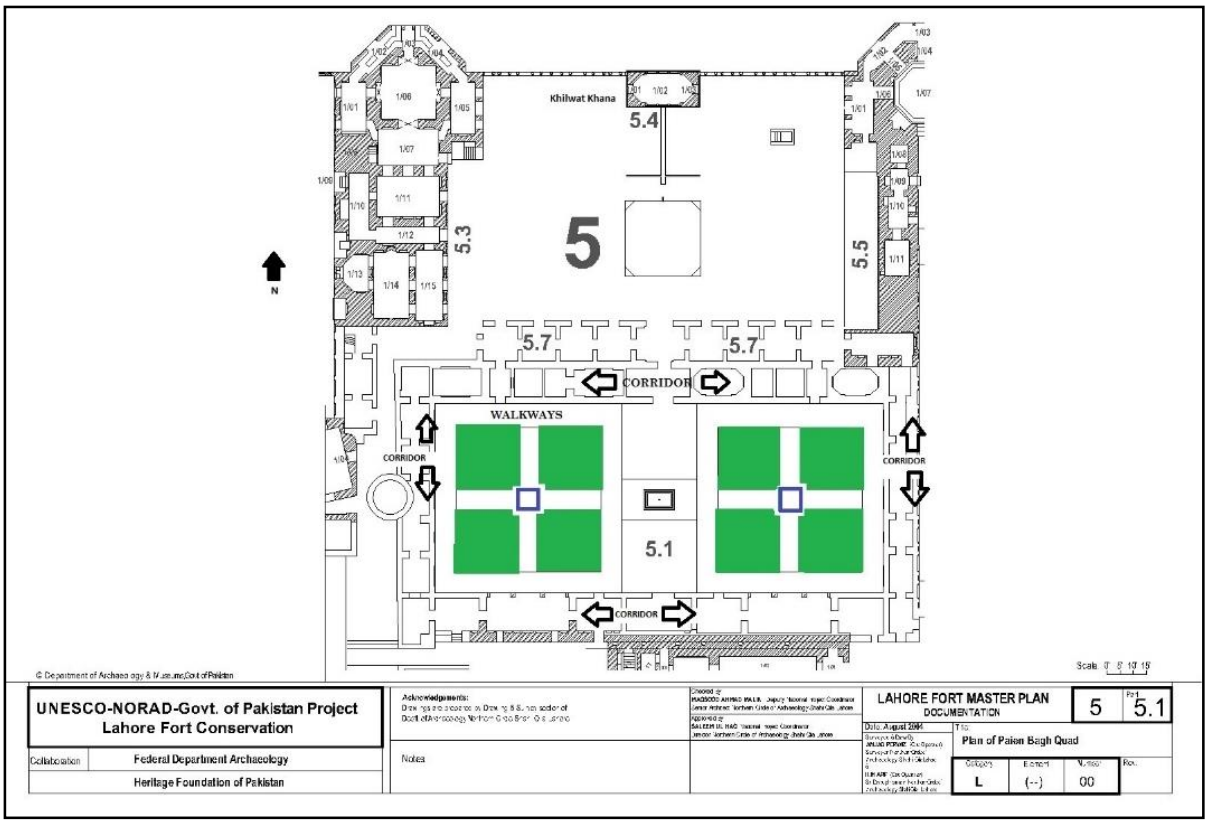

Figure 55: Corridors surrounding Paien Bagh

The amount of heat loss and gain depends upon the central organization around open places.[144] The cooling air supply became possible through the enclosed deep courtyard.[145] The study of passive solar feature of the building reveals that "The courtyard houses creates a complex regulating system that creates a microclimate, which historically worked, and still works, in a "passive way": heat transfer processes are all natural, without mechanical devices powered by non-renewable energy. The courtyard area regulates the climatic extremes. For example, the courtyard area in front of Shah Jahan's quadrangle – Khawabgah-e-Shah Jahani, in front of that quadrangle

[144] Javad Samadi , Utlilizing the Central Courtyard of Traditional Architecture in Modern Architecture (Research Journal of Environmental and Earth Sceinces , 2014)
[145] Javad Samadi , Utlilizing the Central Courtyard of Traditional Architecture in Modern Architecture (Research Journal of Environmental and Earth Sceinces , 2014)

draw day light and cool air from courtyard. It is considered as a climate moderator because it can moderate its own microclimate. According to the climatic researches : "A well designed courtyard house is cool during the day when ambient temperature is high and warm at night when it is low."

In courtyards, the cool night air is stored until mid-hours of the next day. The plants in the courtyards absorbs direct solar radiations. The courtyard functions three normal cycles:

1. The first cycle force the cool night air to descend into the courtyard. The night cool air fills the surroundings of the rooms. This cooling remains in the room until the late afternoon.
2. The second cycle starts around the noon. The sun radiations directly strikes the courtyard floor. Some of the cool air starts to rise and some leaks out of the surrounding rooms. The convention current is set up in the room which may afford further comfort. The role of chimney is-then played by the courtyard.
3. The third cycle begins when the courtyard floor and the house from inside gets warmer. Further convection currents are set up by the late afternoon. The cool air that has been trapped within the walls of the rooms spills out by sunset. The air temperature falls rapidly as the sun sets. The courtyard begins to irradiate to the clear sky and cooler air begins to descend into the courtyard.[146]

Hence, the new cycle begins again.

[146] Megha Jain and Dr. S.P.Singh, Solar Passive Features of the Heritage Building: the Case of the Gohar Mahal, Bhopal (Civil and Environmental Research , 2013)

ii. Ventilators and Windows :

The history of invention of ventilation system cannot be exactly dated but it was first came into the concept of architecture when the early men used fire inside the building. They discovered the need to remove smoke as well as to supply air to keep the fire burning.[147] For that purpose they invented openings inside the buildings. Another mode of heat loss is ventilation which occurs when hot air escapes through an opening in the roof or a wall to be replaced by cooler air from outside.[148]

As Gupta said – An old building is cool even in hot summer afternoon. Its coolness always impresses the visitor. As they stay there for long it forces them to think about the genius minds of the people of that time – how those people created such comfortable buildings without the aid of modern scientific knowledge. The feeling of comfort is a subjective perception. It varies from person to person and from one culture to another culture. Ventilation is needed for coziness, comfort and hygiene. To avoid the interior space from being heated, it is essential to treat the air before it enters the buildings.[149] The natural ventilation aims the physiological comfort and implies a voluntary act of the occupants seeking a more comfortable atmosphere.[150]

Traditional buildings were designed according to the microclimate control of the specific region because heat and cold control the thermal comfort in the houses and this different from one place to another. The natural technologies applied in these buildings

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[147] J. Kuhnl- Kinel, The History of Ventilation and Air Conditioning : is cern cern up to date with the latest technological developments (http://st-div.web.cern.ch/st-div/workshop/ST2000WS/Proceedings/techno2/jkk.pdf)
[148] Hassan Fathy , Natural Energy and Vernacular Architecture: Environment and Architecture (London: The University of Chicago Press,1986)
[149] Vinod Gupta , Energy and Habitat : Indigenous Architecture and Natural Cooling
[150] J. Fernandes, J. Correia da Silva, Passive cooling in Évora's traditional architecture (2nd PALENC Conference and 28th AIVC Conference on Building Low Energy Cooling and Advanced Ventilation Technologies in the 21st Century, September 2007, Crete island, Greece)

have sustained human life for many decades and are purely for heating and cooling purpose. Examples of these techniques are:

Fire chimneys, courtyards, wind towers, *mashrabya* (lattice screens).[151]

Today we find openings in historical buildings with no glass, the local builders designed apertures or the openings to serve one function only. The number of apertures determine their function. Different openings in a building combined together to meet the needs of light, ventilation and view.[152]

Natural ventilation is the outcome of wind forces and temperature difference. The air flow in the building can be affected by size, proportion of window and orientation with respect to sun movement and wind direction. A small window on a huge wall, as we see in most of the Mughal buildings allows the wind to move inside the building with a greater force. Tapered windows with smaller section inside helps in increasing the velocity of the air entering in the building. The air while entering into a wider space causes sudden expansion that decreases the temperature inside the building.[153] The hot air rises up in a domed space and the vents near the ceiling allow hot air to escape.[154]

To keep the internal space cool is an important task in controlling the microclimate. Lattice screen or jaali is an important feature in maintaining the temperature. *Jaali* is frequently used in Mughal architecture. Large apertures were filled in by the screens

[151] Mohammad Arif Kamal and Thamer Al Shehab ,Sustainability through Natural Cooling : Bioclimatic Design and Traditional Architecture (study of Civil Engineering and Architecture , 2014)
[152] Vinod Gupta , Energy and Habitat : Indigenous Architecture and Natural Cooling
[153] Asif Ali , Passive Cooling and Vernacularism In Mughal Buildings in North India: A source of inspiration of sustainable development (India : International Transaction Journal of engineering , Management and Applied Sciences and Technologies , 2013)
[154] F. Soflaee and M. Shokouhian ,Natural Cooling system in sustainable traditional architecture of Iran (International Conference "Passive and Low Energy Cooling for the Built Environment", May 2005, Santorini, Greece)

that let the air in and some light too. At times, built-in shuttered openings was also seen in *jaalis* for view.[155]

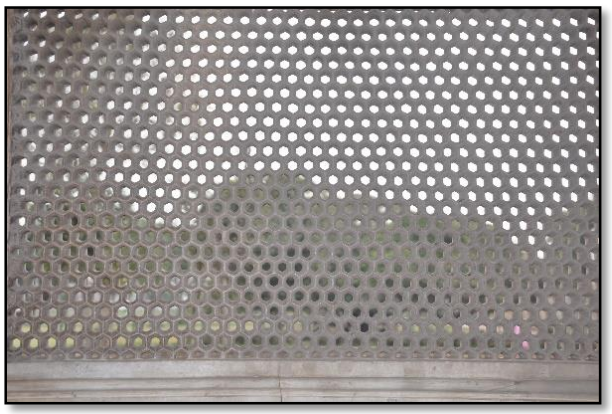

Figure 56: Lattice screen (Jaali) in Shah Burj

It is a prominent element in ventilation system. It provides privacy. The airflow is also controlled by these *jaalis*. *Jaali* in Mughal buildings mostly have a low sill or sometimes without sill so that air could move near the flow. These lattice screens control the passage of light, air flow, reduce the temperature of the air current and ensure privacy.[156] To control the amount of light and air and to graduate the contrast between shade and light, the size of the interstices and the diameter of the balusters are adjusted.[157] Thus lattice screens became an important device which was used to cover openings as well as to achieve thermal comfort and privacy in a house. It is an excellent solution to the climatic requirements, allowing adequate ventilation by the cool sea

[155] Vinod Gupta , Energy and Habitat : Indigenous Architecture and Natural Cooling
[156] Muhammad Arif Kamal, The morphology of traditional architecture of Jeddah: Climatic design and environmental sustainability
[157] Hassan Fathy , Natural Energy and Vernacular Architecture: Environment and Architecture (London: The University of Chicago Press,1986)

breeze access the house, as well as providing shade for the interior spaces by reducing the bright glare of the sun.[158]

Figure 57: Lattice screen in Khwabgah- e- Shah Jahani

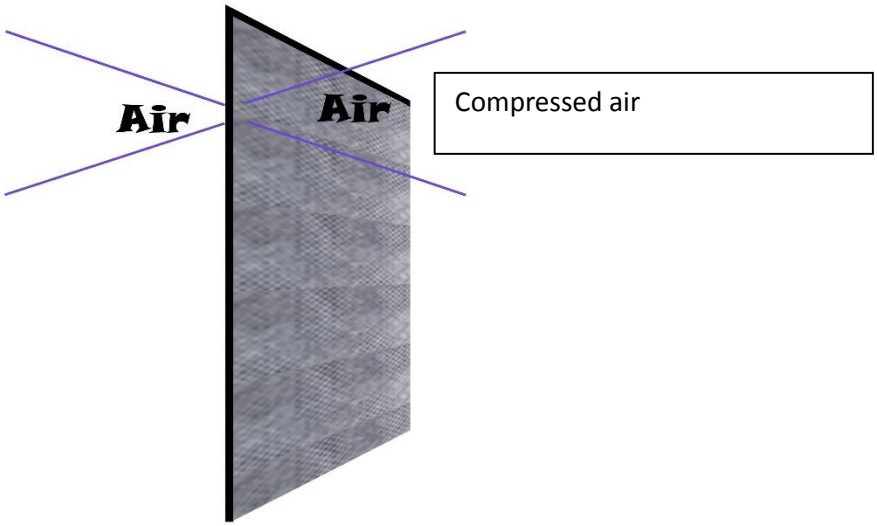

Figure 58: A sketch of the mechanism of lattice screen

Keeping in mind the hot and humid climate of Lahore, cross ventilation system was preferred in buildings. Cross ventilation system is a system of ventilation in which the

[158] Muhammad Arif Kamal, The morphology of traditional architecture of Jeddah: Climatic design and environmental sustainability

air enters from one side of the building and leaves on the other side. The ventilation air moves from the windward side to the leeward side.[159]

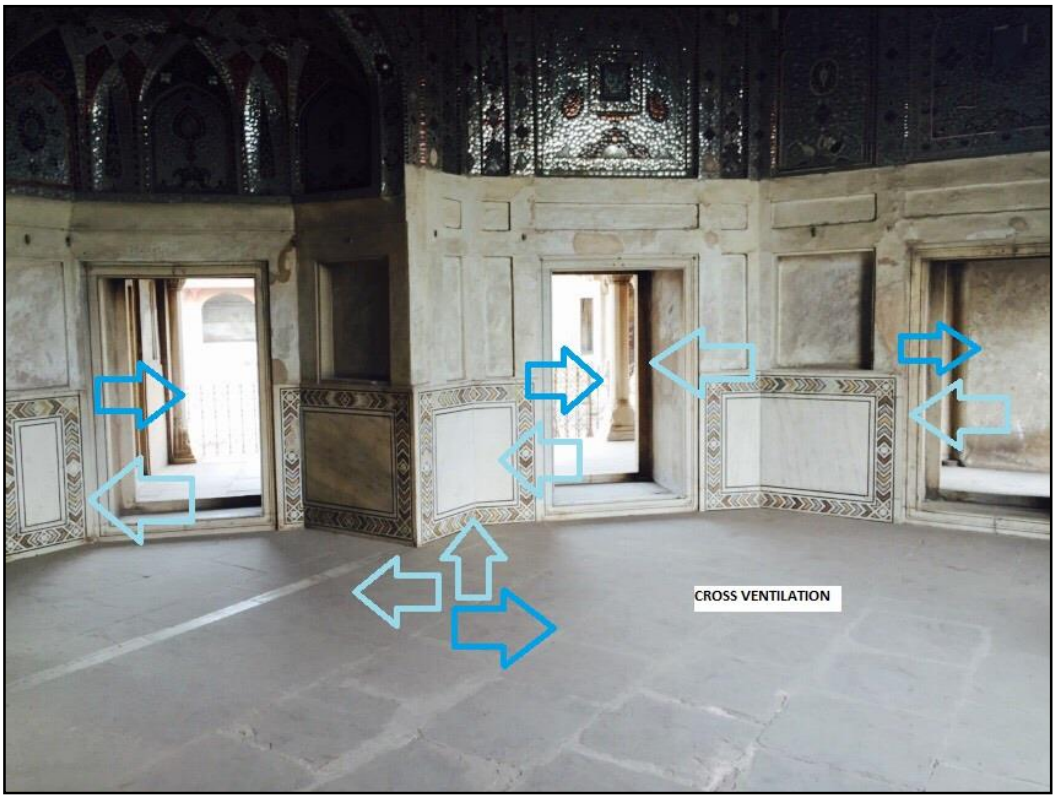

Figure 59: Cross Ventilation in Sheesh Mehal

Figure 60: An image of Cross Ventilation (technique) in Sheesh Mehal

[159] Tommy Kleiven , Natural Ventilation in Buildings : Architectural concepts , consequences and possibilities (Norwegian University of Science and technology : Department of Architecture Design , History and Technology , 2003)

Ventilation in buildings generally has three main purposes:

1. To preserve least air quality
2. To remove heat
3. To enhance thermal comfort and provide observable air movement

In winters only preserving least air quality is required. The Mughals were one of the geniuses of history. For winter use chimneys were made where fire was burnt and an opening was left inside the fire place to let the smoke out. Moreover, winter rooms were made on both sides of the main rooms.

Figure 61: Winter Rooms inside Sheesh Mehal

iii. Wind Catchers

The Earth's major source of heat and light, the sun also creates the secondary climatic elements of wind and humidity that affect physiological comfort.[160] One of the most important element in studying climate is wind. A difference in pressure is created by

[160] Hassan Fathy , Natural Energy and Vernacular Architecture: Environment and Architecture (London: The University of Chicago Press,1986)

wind currents that not only effects the natural ventilation but also the air temperature inside the buildings.[161]

Wind has many natural properties. It is the vibrant icon of the air, a carrier for light, indicator of heat and moisture properties. The flow of air provides lightness, softness and the ability to rise. It has not only natural properties – but it is blessed with the spiritual properties as well i.e. an icon of human being's invocation to God and his blessings.[162]

Wind catchers are architectural bulks that are built with different heights over the houses. The fresh air can let in and a well-ventilated house can be enjoyed by using a wind catcher.[163] In Mughal architecture – with reference to Lahore Fort, wind catcher is the term used for the structure that catches wind and give it a new direction. For example,

In Sheesh Mehal – there are open places that let the air in.

[161] B. Ahmadkhani Maleki, Wind Catcher :passive and Low energy Cooling System in Iranian Vernacular Architecture (International Organization on TPE (IOTPE) :International Journal on "Technical and Physical Problems of Engineering")

[162]Mansour Nikpour, Shahrzad Shamsolmaali , Hamzeh Dehghani , Investigating the Role of Natural Elements in the Central Courtyards of Traditional Iranian houses in Hot and Dry Regions (Recent Researches in Energy, Environment and Landscape Architecture)

[163] Sepideh Alaghmand, New Wind catcher as Natural Ventilation in Sustainable Architecture (Switzerland Research Park Journal , 2013)

Figure 62: Open spaces in Sheesh Mehal for light and ventilation

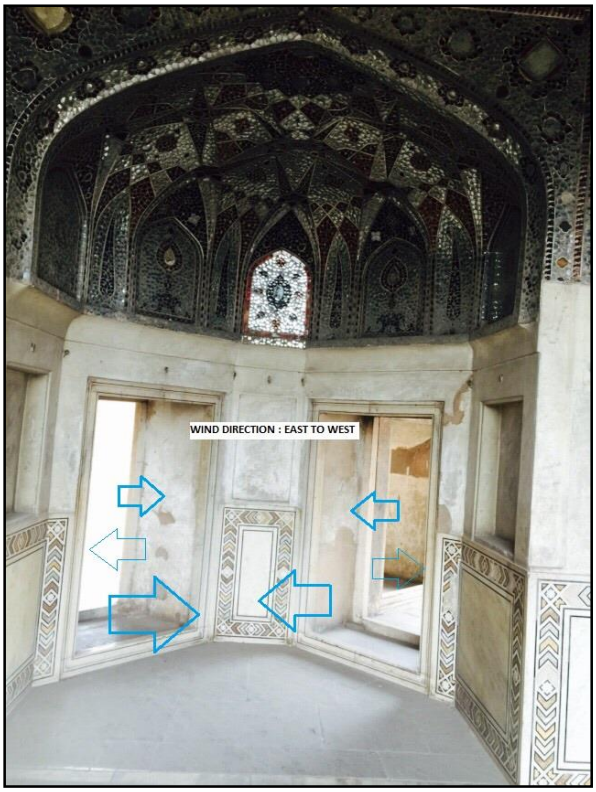

Figure 63: Wind Catchers in Sheesh Mehal

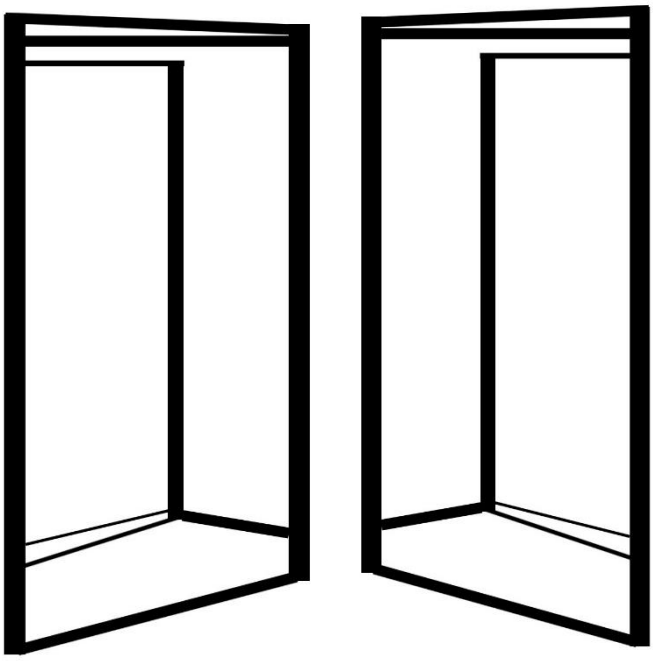

Figure 64: A sketch of wind catcher in Sheesh Mehal

CONCLUSION

5.0. CONCLUSION

Man is slave of the nature as well as the master of the nature at the same time. There is no surprise that physical surroundings help in shaping a culture. People are not only dependent upon the environment but with the passage of time; the slave of nature also utilizes the environment according to his requirements. Hence the energy given to man by nature is a blessing as well as a disturbance – it depends upon man how to utilize the non-dwindling resources. Mughal Architects are legendary for their creativity. The architecture of Mughals was based not only on the aesthetics but also on their imaginative designs. These designs were based on a variety of experiences in the field of geometry, hydraulics, and other building sciences. As ventilation system is one of the perspective of the research. Natural ventilation is the outcome of wind forces and temperature differences. Fire chimneys, courtyards, wind towers, lattice screens – all are the elements of ventilation in Mughal architecture. Construction of openings in the buildings of Shah Jahan's quadrangle helps in increasing the velocity of the air. The marvelous mechanism of the openings in the form of lattice screen and a small window on a huge wall (that allows the wind to move inside building with greater force) made the Mughal Architecture prominent. Hence we can associate ventilation system of Shah Jahan's quadrangle (Lahore Fort) as an example of signature "Mughal Microclimate control system. According to the findings of the research – Mughals were fond of natural beauty and greenery, all the buildings (with reference to the case study) were surrounded by lawns and gardens having fountains and water bodies inside and outside them. Therefore they are justifiably known as the great patrons of gardens. New images to landscape were given by the Mughals. Landscaping was an integral part of Mughal palaces and monuments. Trees, green areas and water body around a building improve the physical comfort along with the visual pleasure. Mughals used the techniques of

gardens not only as a source of inspiration but also to improve the environment of their immediate surroundings. If we study and observe the significance of landscaping in architecture we would come to know that the mutual interaction between a living organism and its environment is provided by plants. It possesses its own heat and water economies. Its respiratory heat is the result of metabolism which tends to raise its temperature, just as within animals. Vegetation improves the quality of outer space and enhances cooling by evo-transpiration. Vegetation is also effective in controlling the microclimate. Vegetation absorbs radiation for photosynthesis and cools the environment. They are helpful in shading the particular parts of the structures. By releasing moisture, they help raising the humidity level. Hence it reduces the input of the solar radiations in the Mughal buildings and its surrounding spaces. Therefore, we can say that the Mughal architects used landscaping and plantation to keep the internal and external environment cool as well. According to the researches of environment, architecture and climate control - The water bodies like fountains and water channels were added in the buildings which passes through the internal buildings to modify the internal environment. In Khawabgah-e-Shahjahani, there are fountains inside the rooms to keep the temperature moderate inside the building. The air after passing through the green area, when enters the building – the water channels or the water bodies inside the buildings absorbs a large amount of heat for evaporation (as water has a high latent heat of vaporization). Hence the cool air then be introduced in the building. Water is an architectural element which is extensively used in our ancient buildings and in gardens of the Mughals. Water not only pleases eye on a hot summer day but also provides passive cooling. Water improves the physical comfort by the evaporative cooling of the surrounding air. The use of water bodies inside as well as outside the buildings proved

that Mughals were master in retaining and regulating temperature along with satisfying their aesthetics by adding beauty through fountains, water channels and pools.

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