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An Architectural-Morphological Analysis of the Mughal Gardens of the 16th and 17th Centuries: Engaging Cultural Forms as Strategies for Passive Design for Urban Sustainability

Nurul Syala Abdul Latip^{1*}, Puteri Shireen Jahn Kassim¹, Mustaffa Kamal Bashir Mohd Fauzi¹, Shaukat Mahmood²

¹International Islamic University Malaysia

²University of the Punjab, Lahore, Pakistan

* Correspondence: alnsyala@iiu.edu.my

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ABSTRACT

There have been discussions on how sustainability must eventually imply 'back to basics' and relive lessons from the past approach rather than employing 'high technology' add-on features. With that, there has been a resurging interest in the role of water in urban design and how it may have an impact on the climatical situation of an area rather than only for aesthetic and recreational activities. The paper summarises the outcome of a series of morphological ('shape and form') studies to analyses the 2D and 3D archetypes of enclosed Mughal Gardens during the 16th and 17th century of the Mughal period; and assess these in terms of links and relationships with sustainability parameters such as sustainable urban water design and passive cooling impact. The aim is to relook onto the use of Mughal models for both cultural and climatic strategies in the urban design of cities in hot climates. Historically the 16th-century Mughal design achieved its peak in the urban design phase and assumed a more monumental role with proportionate rules and hierarchical order. The paper goes into the detail description of such archetypes especially based on Shish Mahal in Lahore Fort and links with critical passive cooling impact as an urban mechanism and lessons learned for the modern context of cities that has the plaza and open spaces in between blocks. It is argued that the garden constituted not only a cooling but symbolic mechanism evolving from open to closed type. Significantly, the need to identify the structural relationship between garden archetypes and its role in cityscapes are very much crucial to the modern world in context. ...

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AN ARCHITECTURAL-MORPHOLOGICAL ANALYSIS OF THE MUGHAL GARDENS OF THE 16TH AND 17TH CENTURIES: ENGAGING CULTURAL FORMS AS STRATEGIES FOR PASSIVE DESIGN FOR URBAN SUSTAINABILITY

Nurul Syala Abdul Latip^{1*}, Puteri Shireen Jahn Kassim¹, Mustaffa Kamal Bashar Mohd Fauzi¹, Shaukat Mahmood²

¹International Islamic University Malaysia, ²University of the Punjab, Lahore, Pakistan

*alnsyala@iiu.edu.my

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Abstract

There have been discussions on how sustainability must eventually imply 'back to basics' and relive lessons from the past approach rather than employing 'high technology' add-on features. With that, there has been a resurging interest in the role of water in urban design and how it may have an impact on the climatical situation of an area rather than only for aesthetic and recreational activities. The paper summarises the outcome of a series of morphological ('shape and form') studies to analyses the 2D and 3D archetypes of enclosed Mughal Gardens during the 16th and 17th century of the Mughal period; and assess these in terms of links and relationships with sustainability parameters such as sustainable urban water design and passive cooling impact. The aim is to relook onto the use of Mughal models for both cultural and climatic strategies in the urban design of cities in hot climates. Historically the 16th-century Mughal design achieved its peak in the urban design phase and assumed a more monumental role with proportionate rules and hierarchical order. The paper goes into the detail description of such archetypes especially based on Shish Mahal in Lahore Fort and links with critical passive cooling impact as an urban mechanism and lessons learned for the modern context of cities that has the plaza and open spaces in between blocks. It is argued that the garden constituted not only a cooling but symbolic mechanism evolving from open to closed type. Significantly, the need to identify the structural relationship between garden archetypes and its role in cityscapes are very much crucial to the modern world in context. Through the abstraction analytical and descriptive relational morphology of the spatial configurations, the studies can suggest the idealized spatial system that can be used in urban design and complexes which later became a methodological and abstraction tool of sustainability to suit the modern contemporary world.

Keywords: Archetype, Mughal Gardens, Water features, Morphology, Urban Sustainability

1. Introduction

It is increasingly realized that sustainability includes both a response to the climatic and cultural context of a place. To assess the cultural context, a morphological analysis of urban patterns from heritage legacies is necessary. While the climatic form is derived from an analysis of meteorological data, the cultural patterns and forms must be abstracted from a typological and morphological study. The interactions between architectural morphology or 'form' and environmental performance alone have been discussed in the various literature (Ratti, Raydan, & Steemers, 2003) however, to advance sustainability to the level of design practice, there is a need to analyses the link between form and

environmental performance in its specifics climatic context.

Hence, a systematic and deep study of heritage complexes in general and Mughal architectural morphology, in particular, are needed. This is due to the agenda of transformation to a more holistic concept and approach to urban water systems and urban water design. The present engineering and rational approach of urban water systems have to be re-looked in order to reconceptualise them towards sustainable agenda. Conceptually, elements from physical structures must be integrated holistically in the abstracted 3 dimensional of architecture morphology and urban space from the onset of design and planning.

2. Literature Review

Looking back to at Islamic civilizations, and ever since the origin of cities, man has used water not only for essential purposes but also for display (Cross, 1996) and in general, water elements which have different characters are used for two main purposes; "aesthetic" and "functional". The practices of everyday life in the traditional world must at present, constitute an area of 'urban' research which should be focused upon and relooked in terms of the supply, circulation, and use of water as conditioning elements to the urban context. (Swyngedouw, 2004)

Historically, Mughal gardens originated in Central Asia and extended into South Asia in the sixteenth through eighteenth century (Wescoat Jr, 1999) begin with the idea of creating a man-made reflection of the paradise as per vividly portrayed in the Quran. It has been a source of inspiration throughout the Islamic world and the provision of cool pavilions, flowing springs, rivers, gushing fountains, shady and fruits trees are part of the elements that appear in Mughal garden and many Islamic gardens. Since the paradise had eight divisions and based on this the concept the garden were divided into various eight numbers of terraces, lawn or quadrant divisions.

Literally, the Charbagh or Chahar Bagh means rectangular gardens cross-axial divided into four parts by pathway or water channels. According to Dickie, (1985) as he referred to the booklet entitled 'Some ancient garden of Lahore' by Dr. Dar, courtesy of Lahore Museum, distinguishes four kinds of gardens: (a) gardens attached to palaces or *havelis*; (b) gardens which serve as substitute royal residences, for the emperor to put up at when on a journey; (c) funerary gardens surrounding purpose-built mausolea; and, lastly, (d) pleasure gardens with baradari in the middle, the commonest category. (Dickie, 1985) further elaboration on the Mughal garden

mentioned that at the peak of Mughal power, there are some 50 gardens at Lahore which one was the largest garden in the world. Since the irrigated vegetation may have a profound impact to the Mughal gardens in terms of its aesthetic and religious value, it also plays an integral role in controlling the micro-climate conditions via the process of evapotranspiration.

Water architecture in India emerged from the ancient Indic practices connected with the spiritual embodiment with the water especially with its rivers in all forms but later developed within the rapid emergence of the urbanization and widespread of Islamic rule in India. In the Hindu interpretation of the sacred mountain Meru, rivers flow in all cardinal directions forming a "cosmic cross", similarly, the Mughals saw the Charbagh as a physical manifestation of the four rivers flowing from paradise (Krusche, Aijian, Anders, Dokonal, & Kapadia, 2010). This evolution also appeared in the Charbagh archetypal design. The use of water incorporated in the axial formation of the Charbagh which usually leading and ending at the central node of the garden itself in a form of a shallow pool (Figure 1).



Figure 1. In Shish Mahal courtyard, the axial water channel formation that leading to a central shallow pool reflects the actual manifestation of the original Mughal Charbagh. (Picture courtesy of <http://www.orientalarchitecture.com>)

Some but not all, Mughal build the garden near the river sources and create a systematic hydraulics irrigation structures to sustain the garden greenery and keep the gardens hydrated. As for the gardens that build far from the riverside, significance hydraulic systems for elevating the water are created associating with the distribution mechanism. This mechanism can be either the provisions of water raising houses, aqueducts and baolis.

In the case of Fatehpur Sikri the water are lifted in multiple elaboration stages as the prime sources of water came from the baolis (step-wells) located down the ridge (Figure2). According to (Sumra, 2012) the system for elevating water is an elaboration of the Persian rehaut system, sometimes called the Persian wheel. Chambers within the baolis and water raising houses contained wheels with shafts driven either by humans or cattle. These wheels, in turn, rotate shafts that drive a belt of earthenware water-filled pots, up to the next stage of the waterworks. This is an elaboration of the rehaut system which is frequently seen in medieval, and contemporary, India village wells and agriculture, where a bullock is used to raise water from the well to ground level.

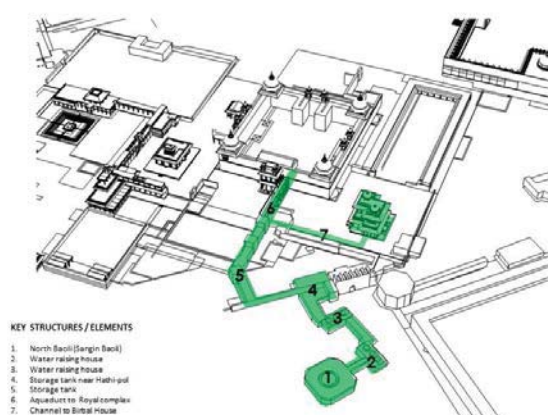


Figure 2. Multiple stages of water elaboration mechanism that lifted the water from the baoli in the lower ridge to the upper level of Fatehpursikri palace.

In the present day, provision of water as a cooling agent has been empirically proven in various literature. According to (Bagneid, 1989), during a one week period, the courtyard with the evaporative spray had a slightly cool to cool Predicted Mean Vote (PMV) 15% of the time. The results show the courtyard as being an effective microclimate generator. Apart from that, an integrated passive cooling strategies that apply in an enclosed space also play significant role in mitigating the heat retention as (Reynolds & Carrasco, 1996) concluded that a retractable shading over the courtyard, watering the patio's absorbent floor (i.e., evaporative cooling), opening the windows for night ventilation, and high thermal mass contributed significantly to the passive thermal cooling of the house.

In hot arid climate, it is necessary to control the flow of ambient air inside the courtyard in order to maintain the internal temperature of the building. The correlation between aspect ratio and cross ventilation is crucial in courtyard housing as demonstrated by (Das, Coates, & Gabbard, 2005). In his findings, aspect ratio calculated as the sum of an area of the courtyard floor over the average height of the surrounding wall. In hot humid climate, design consideration for thermal comfortability for courtyard design lies in the building proportion by making the courtyard deeper with thicker surrounding room wall. This methodology is preferred in calculating the water surface to courtyard ratio in analyzing the relative dimensional difference of water elements in the selected Charbagh.

3. Research Methods

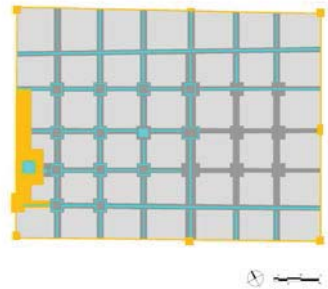
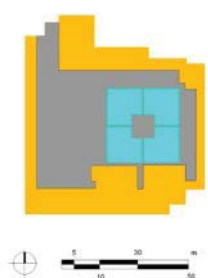
Selections of the Mughal gardens are based on the past literature on types of Charbagh under different Mughal ruler from 16th to 17th century. A collection of measured drawings is obtained from the past research and mapped as architectural morphology. Satellite images are also taken into account

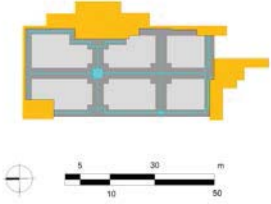
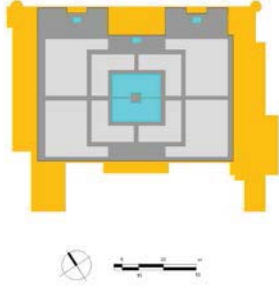
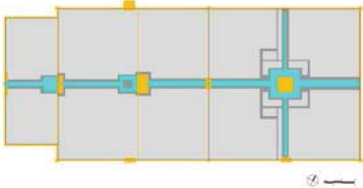
if the subject measured drawings are not available before convert into the simplified morphology map. (Table 1)

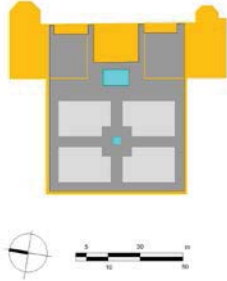
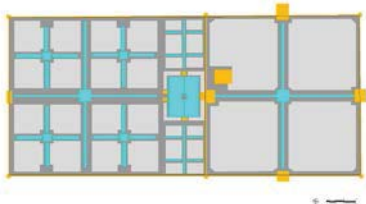
The spatial organization of the garden is labeled into 4 different colorized patterns which indicate to the subject's structures, pavements, vegetation and water features.

The relationship of sustainable urban water design and architectural morphology of each garden are analyzed via calculating the ratio of the water surface to the site context.

Table 1 Mughal Charbagh and its morphology characteristics

Name of Mughal Emperor	Name of Charbagh /Date of Construction	Site Plan	Morphology Analysis
Babur	Aram Bagh (1526)	 (Agra)	
	<i>Aram Bagh</i> Mughal oldest garden and built by the founder of Mughal ruler Babur in 1526. Situated on the bank of river Yamuna, the water is drawn directly from the river itself and store in the tank which later flowed down to the second and third terrace through a series of canals and cascades. Charbagh Architecture: Designed in three descending terraces, the water is funneled into network canals, cascades, and tanks/pool. Each cascade channeling the water to the pool and has stairs on both sides for circulation usage.		
Akbar	Anup Talao Courtyard (1576)	 (Fatehpur Sikri, Agra)	
	<i>Anup Talao Courtyard</i> It is known for its decorated central pool platform and built by sandstone and surrounded by stone <i>jali</i> balustrade. The pool was once filled with gold, silver and copper coins during the Mughal times to create a reflective effect in the pool. Charbagh Architecture: The courtyard is surrounded by the Khas Mahal, Khwabgah (Royal apartment) and Turkish Sultana house. The pool is made of red sandstone, square in shaped and has four narrow bridges that lead to the central platform.		

	Turkish Sultana Bagh (1571-1585)	 (Fatehpur Sikri, Agra)	
	<i>Turkish Sultana Bagh</i> Situating in the heart of Fatehpur Sikri, Turkish Sultana Bagh is built opposite the residence of Akbar Turkish queens called Salima Sultan Begum and Ruqayya Begum. □ Charbagh Architecture: The oblong char bagh situated in front of the Turkish Sultana Pavilion measuring 65m x 30m and lies immediately behind the Diwani Am (court of Public Audiences). The garden is divided by three intersecting <i>Khiyabans</i> (paved walkways) into six plot of unequal size.		
Jehangir	Jehangir Quadrangle (1618)	 (Lahore Fort, Lahore)	
	<i>Jehangir Quadrangle</i> The construction began with Akbar rules but completed under Jehangir in 1618. It consists some of the earliest structures in Lahore Fort. The size of quadrangle approximately 113m x 75m and considered the largest of all quadrangles in Lahore Fort. Strictly used for the imperial suites, it consists of Bari Khawabagh (Emperor sleeping chamber), royal apartments, haramsara (ladies apartments), Dalans and char bagh with fountains. The quadrangle also has Imperial subterranean retreat chamber underneath which built during Akbar times. Charbagh Architecture: In the quadrangle, a subdivision of many charbagh is designed with parterres and pathway with a large pool located at the center of the quadrangle with central <i>mah tabi</i> (platform) in the middle. The pool is accessed by a narrow bridge on the east and west side. The pool has an array of fountains aligned that provides a refreshing atmosphere to the quadrangle.		
	Shalimar Bagh, Srinagar (1619)	 (Srinagar, Kashmir)	

	<i>Shalimar Bagh, Kashmir</i> ‘Adobe of Love’ as it is called; Shalimar Bagh is the largest Mughal garden in Kashmir built by Jehangir for his wife Empress Nur Jahan. Situated on the banks of Dal Lake, the garden covers approximately 35 acres with three major terraces layout. Charbagh Architecture: Conceptually, the garden laid out into three major terraces dominating by the axial water channel that runs from the top of the terraces to the lower part before dispersing into lake Dal. All three terraces are in lined with Chinar trees and fixed with water fountains. Decorated pathways are planted with Aspen trees alongside the main water channel. The first terrace (lower) is the public garden where the Diwani Am (public audience hall) built over the waterfall leading to the second terrace. The second terrace (middle) is much bigger in scale than the lower terrace has Diwani Khas (Private Audience Hall) on its center. Each hall is designed on the pool which axial channel passes through it. The third terrace is located at the higher ground restricted for the royal harem. The Zenana garden is full of Chinar trees and at the centre of the pool stands a black pavilion made of black marble surrounded by the water fountains. From the Black pavilion, two narrow water channels lead to the end of the wall of the garden to the small Baradari.		
Shah Jahan	Anguri Bagh (1637)	 (Agra Fort, Agra)	
	<i>Anguri Bagh</i> The ‘Grape Garden’ built in Agra Fort was used by the harem and become one of the many examples of the Mughal garden within the compound of royal residence/apartment. The three sides are built for the woman attendant and household. The Khas Mahal (Private Palace) located at the Northeastern part is the residence of the empress. Designed for a complete privacy and pleasant retreat, the garden is planted with grapes and flowers throughout the year. Architecture: The garden has two marble water tank which located the front of the Khas Mahal and another at the center of the char bagh itself which in a form of marble paved platform tank with a fountain at its centre, the steps leading to it on the east and west sides. From the tank in front of the Khas Mahal, a shallow channel leads the water to the center tank via cascade and decorated miniature pool. The garden is divided into four and planted only with a variety of shrubs and flowers with geometrical patterns.		
	Shalimar Bagh, Lahore (1637-1641)	 (Lahore)	

	<i>Shalimar Bagh, Lahore</i> The garden was constructed by Shah Jahan and originally had seven ascending terraces. Located near the Grand Trunk Road 5km northeast of the Lahore city. Charbagh Architecture: The garden measured approximately 600m north to south and 270m east to west and made on the concept of Charbagh. The garden has been laid on three terraces and elevated 4m on each other and each was named as Farah Bakash (upper terrace), Faiz Bakash (middle terrace) and Hayat Bakash (lower terrace). The concept of floating pavilion where water flows and cascades down over a carved marble slab are built like those in Shalimar Bagh in Kashmir. Across the waterfall on each terrace are built with iwan (pavilion) and at the end of the second terrace there's a marble structure called 'Sawan Bhadon'. The lower terrace constitutes of 16 smaller char bagh division where the higher terrace are built with single char bagh in a massive scale. A large central pool with dimensions of 50m x 68m has a royal platform in the middle connected with a causeway on the east and west.
Shish Mahal Courtyard (1632)	(Lahore Fort, Lahore)
	<i>Shish Mahal Courtyard</i> Shah Burj Quadrangle also known as Shish Mahal Courtyard located at the northwest corner of Lahore Fort served as a residence of the Empress. A simple form of rectangle courtyard with central shallow pool at the middle. The pool is surrounded by the Shish Mahal Palace, Naulakha pavilion, Musamman Burj (watchtower) and dalans (galleries). Subterranean sleeping chamber located underneath the courtyard floor with numerous water wall/cascade can be found. Charbagh Architecture: The courtyard resembled manifestation of the actual char bagh without any vegetation planted in it. The courtyard is subdivision by four narrow water channels runs from the southern dalan to the center shallow pool. The royal platform at the center of the shallow pool is bedecked with pietra-dura craftsmanship. The Courtyard surface is made of abri-stone (variegated) inlaid with imaginary of vegetation are based on the floral themes embedded on the facades of surrounding building.

4. Discussion

The Basically in the context of Fatehpur Sikri, the urban water system can be read in line with the framework of the urban design of Sikri which is essentially made of a continuous and compact pattern of squares and courtyards which are highly serviced (according to this time) so as to ensure complete comfort for the king and his royal courtiers. The hydraulic system was specifically built for this monumental complex and the system was holistically

fused with 'thermal' strategies such as 'pools of water' strategically placed in the path of incoming wind during dry seasons in order to optimise the evaporative cooling impact of water elements. At Sheesh Mahal the same strategy is employed, but there are not detailed and complex vertical water elements that contribute partially and totally to the achievement of thermal comfort for the ruler and members of his royal court.

Based on the water morphological analyses of these two predominantly architecture of Mughals, one can relate the forms and functions of each water structures in its own place. The vertical and horizontal water structures have its own implications and effects not only to the psychological but also to the physiological impacts. To the vertical water structures.

That found mostly indoor or semi-outdoor (corridor/loggia) and in the sleeping chamber tends to work as a dramatic cooling effects by the continuous flow of water on the wall through the chevron shaped waterwall. The tiny splashing creates fast evaporative cooling impact and by optimizing the wind induced ventilation strategy, it allows the summer winds to funnel natural breeze throughout the living spaces thus cooling off space in no time. Visual delights of the water splashing create psychological calmness to the occupant and symbolically adding movement effects inside the building. A movement effect usually makes the building look much more alive and celebrated.

Horizontal water morphology is known to be the oldest water features in the northern India. The function is more towards the storing and supply of water throughout the inhabitant area (city/fort). Large reservoir tends to serve the water supply and sometimes for recreational needs. The creation of step well is sometimes associated with the annexation of multiple summer retreat chambers with a series of flight of staircase from ground to the water source. These chambers are often designed custom for royal purposes. Others are merely a series of steps towards the water sources. A simple step well without any chambers is for public usage. As for the small tanks, it is built for aesthetics and religious purposes. In Lahore fort, massive tanks and pools are scattered around the fort for the purposes of lowering the surface temperature. Every corner of the

fort is designed with either a well, pool or water tank in variable sizes, shapes and volumes. Mughal emperors are often participated in the event involving music, art, and literature, thus indulged themselves by listening or watching it on the platform surrounding a pool. Although the platform is raised in the middle of the courtyards, surrounding by the only man-made pool, the mini comfort zone can still be achieved surrounding that sitting platform. This gives a clear picture of the importance of horizontal water morphology trust in combating the extreme heat in both regions by scattering water structure throughout the area.

5. Conclusion

The basically sustainability requires a mindset that needs a paradigmatic shift from the completely empirical to a more holistic approach. To achieve sustainable goals, urban systems need to incorporate and include urban water systems which have a wide range of benefits including both environmental and socio-cultural and the very conceptualisation of urban design and architecture must relook at not only how water systems are functional but are aesthetic and symbolic as well. Both Islamic world view and hence its heritage put water as a central pivot role in the cultural mindset and urban life. There is an immaculate and vivid reference to the fountains in the Quran, *“The righteous are amidst shades and fountains (of Heaven)”*, *Al-Marsala: 41*, there is also a reference to the four rivers of paradise and one of these four rivers is that of pure water, *“Is the description of Paradise, which the righteous are promised, wherein are rivers of water unaltered, rivers of milk the taste of which never changes, rivers of wine delicious to those who drink, and rivers of purified honey, in which they will have from all (kinds of) fruits and forgiveness from their Lord, like (that of) those who abide eternally in the Fire and are given to drink scalding water that will sever their intestines”*, *Muhammad: 15*

Hence a systematic and deep study of heritage complexes are needed due to the agenda of transformation to a more holistic concept and approach to urban water systems and urban-water design- from the present engineering and rational approach of urban water systems in order to reconceptualise towards sustainable agenda, there is an urgent need for a more holistic water urban approach, there must be a transformative change and outlook whereby urban water systems should no longer be considered as 'leftover' elements from physical structures but elements which must be integrated holistically in the 3 dimensional concepts of architecture and urban design from the onset of design and planning. This new approach must even be inclusive of and broaden to, see water with a symbolic meaning which are integrated into an architectural solution. These may need abstract geometrical basis and references which are essential to the more spiritual and social aspects of water elements which constitute many communities and cultures throughout the world. These should include not only looking at 'water systems' and elements per se but should be reconceptualised into 'water –garden' systems, the garden landscape, the alignment with waterfronts and the symbolic and socio-historical meaning of rivers, including the strategic and symbolic significance of water.

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