

The role of landscape design in improving the microclimate in traditional courtyard-buildings in hot arid climates

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ABSTRACT: Arab Islamic landscape design forms a unique source of inspiration for landscape architecture in barren open spaces in the Middle East. Arab Islamic gardens adopted a system marked by perfect responsiveness to the environment. The design of urban landscapes and gardens in Arab Islamic culture was similarly guided by the dictation of aridity. The need to provide shade, to prevent dust and to conserve water meant that urban open spaces and gardens were sheltered and enclosed. Alhambra in Moorish Spain and the Al-Suhaymi House in Islamic Cairo are two useful historical references for vernacular Islamic landscape designs. This paper presents an overview of landscape design considerations for the composition of vegetation and water and initial observations of their influence in controlling and improving the microclimate in courtyard buildings as a way of passive cooling in the Middle East region. This paper is a part of a Master's thesis in the field of passive landscape strategies at Wageningen University. The objective is to identify the comfort improvements potential of successfully-planned and integrated landscape design in traditional courtyard buildings. The layout and plant material of Alhambra, Generalife courts and Al-Suhaymi court in Islamic Cairo are examined and evaluated. This study demonstrates that in arid environments, the landscape planning, the composition of vegetation and water and choice of planting material all have important consequences in creating thermally-pleasant environments.

Keywords: landscape design, plants and vegetation, water ponds, passive cooling, microclimates, comfort, courtyard-buildings, hot arid.

1. INTRODUCTION

In most Islamic designs, the role of landscape design is highly appreciated. In examining traditional courtyard gardens, it is clear that the role of urban landscape design was not only restricted to a purely ornamental or theological function. It was additionally used to control and improve the microclimate around and inside the building. This paper attempts to present the role of landscape in traditional Islamic garden courtyards by analysing the design characteristics of Al Suhaymi house courtyards in Cairo and the layout of three courtyard gardens in Alhambra and Generalife palaces in Granada, Spain. Some physical parameter measurements regarding temperature and humidity were made, in addition to a shade study. In fact, shades in courtyard-buildings were insufficient in improving the microclimate during hot summers. Therefore, vegetation and water were used to compensate for the lack of improvement provided by the shade.

2. AL SUHAYMI HOUSE:

Bayt al Suhaymi is one of the most important examples of a Cairene traditional courtyard house representing the Islamic landscape design around the 16th and 17th centuries. This house stands in El Darb EL Asfar alley and is directly located off the famous Fatimid street called El Moez street. The house

witnessed several building phases before reaching its final layout, which covers 2000 square meters and includes 115 spaces distributed on five levels. The house is marked by perfect responsiveness to the environment and contains architectural elements of the traditional Cairean house. The bent entrance, which assures privacy to the house, leads to an inner courtyard surrounded by rooms and is overlooked by a *maqaad* (a roofed balcony facing the cool northern breeze) and a *takhtaboosh* (a space annexed by the court for receiving male visitors during the summer) (Fig. 1a). [1]



Figure 1: (a) Al Suhaymi house ground floor plan, (b) courtyard garden, (c) rear garden.

2.1 The House layout

By analysing the Al Suhaimy house layout, we find that this house layout was based on creating a passive ventilation system in order to ameliorate the microclimate. The passive ventilation system was created by locating two inner courtyards with two different pressures within the house. The north courtyard (Fig. 1c), called the rear garden, was a large open space and was meant to have low surrounding walls in order to keep the space sunny and relatively hot. The rear garden was designed to occupy 28 percent of the total plot area of the house with a 2.6:1.3:0.5 ratio (l:w:h). On the other hand, the south courtyard (Fig. 1b), simply called the courtyard, was a rectangular courtyard covering only 200 square meters and was designed to occupy only 10 percent of the total house area with a 1.8:1:1.3 ratio (l:w:h).

This passive ventilation design solution is confirmed by comparing the shade in the rear garden to the courtyard. During winter (21 December, 2:00 p.m.) I found that the amount of shade in the rear garden was more than 53% compared to 100% in the courtyard space. During summer (21 June, 2:00 pm), the amount of shade in the rear garden is more than 12% compared to 40% in the courtyard space (Fig. 2). Moreover, measurements have proved that when temperatures rise in the rear garden of the Al Suhaimy house, the air flows against the north prevailing wind directions during most daily hours. The wind flows from the south entrance, passing the courtyard and then into the *takhtaboosh*, with wind speeds of 1.3 m/s, and finally reaching the rear garden (Fig. 3b). On the other hand, during the stillness of the previously mentioned wind movement, the prevailing wind flows from the rear garden when the sun drops down after noon through the *takhtaboosh* to the courtyard with wind speeds reaching 0.7 m/s (Fig. 3a). [2]

2.2 Landscape design in Al Suhaimy house:

Based on the previous design theory, we find that the role of landscape architecture in this design was essential. By analysing the plan, we find that the landscape design aimed to emphasize the passive ventilation in the Al Suhaimy house. The Islamic landscape design considerations for the composition of vegetation and water included the following environmental-responsive design principals:

Quadripartite layout

References to the quadripartite design occurred more than once in the Koran; therefore, Islamic gardens adopted the geometrical and often symmetrical layout. Planning the layout was based on creating two axes perpendicularly crossing each other in the middle. The quadripartite layout was also considered as an environmental landscape design principle because the axes were planned as narrow water canals or walkways while the left rectangles were planted or used as water ponds. The quadripartite layout assured a combination between plant materials, water and pavement in courtyards, all of which improved the microclimate in the buildings.

In the Al Suhaimy house, the courtyard had a quadripartite layout with slightly raised narrow walkways leading to the focal fountain at the centre of the courtyard. The walkways created four relatively large planted rectangular shapes (Fig 4), while the rear garden had two different planned layouts. The left part of the garden followed a



Figure 2: Shade study of Al Suhaimy House courtyards (left) 21 December, (right) 21 June.

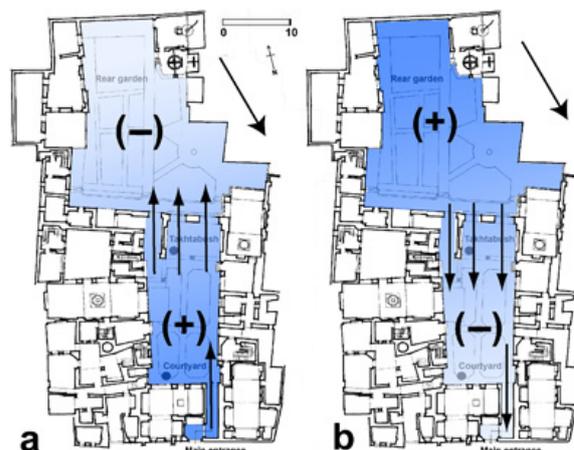


Figure 3: (a) air movement during noon, (b) air movement after noon.

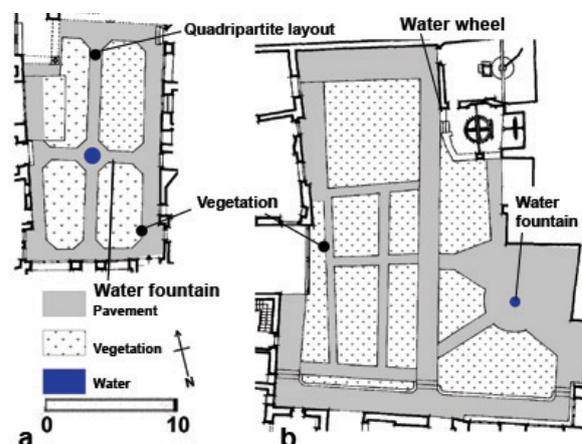


Figure 4: Landscape design elements in Al Suhaimy courtyard gardens (a) courtyard, (b) rear garden.

quadripartite layout, while the right part of the garden had circular planning with a well in the centre. The quadripartite design helped the designer to manipulate the site and create a variety for the water, vegetation and pavement composition.

Use of water

The Al Suhaymi house had a focal fountain in the courtyard and some other fountains in the halls. The focal fountain was located at the centre of the courtyard. Next, a water wheel in the north-east corner of the house supported the fountains and house dweller with water. Using the fountain inside the courtyards helped to create a cold air reservoir, in addition to humidifying Cairo's dry air. Using the fountains in the halls also helped in soothing the internal climate of the halls, reflecting the importance of having elements from the natural environment, such as water inside the house.

Vegetation and shade

The courtyard and rear garden were both planted, but to serve the passive ventilation concept and create a relatively hot open area, the rear garden was mainly paved and planted with some flowers, medicinal herbs and palms. On the other hand, the courtyard was mainly planted with ground covers, evergreen trees and fruitful trees to provide maximum shade for the ground within the inner courtyard walls [3]. Moreover, greenery inside the courtyard and rear garden absorbed dust and dirt in the atmosphere in addition to reducing the amount of glare. This study measured the differences in temperature between the planted courtyard and the house roof and it was found that the temperature was between 4°C to 7°C lower in the planted courtyard. Furthermore, by comparing the relative humidity in the house inner courtyard with El Darb EL Asfar alley, the humidity in the house inner courtyard ranged between 11 to 19 percent lower than in the alley.

Walls and pavilions

In the Koran, paradise is described as an enclosed garden, surrounded by "walls" and accessible through "gates". In Al Suhaymi House, the courtyard was surrounded with thick high walls to achieve protection from the hot, dusty, and noisy environment, and to provide a refreshing shade and cool air, all of which are essential for human comfort. Moreover, the rear garden was surrounded by low walls in order to minimize shade and to create a hot open space. The surrounding walls of Al Suhaymi gardens are considered as part of an environmental landscape design element of the Islamic garden.

3. ALHAMBRA PALACE LAYOUT:

The Palace of Alhambra has always been praised for the balanced composition of architecture, vegetation and water. The hierarchical order and the symmetrical patterns that govern the organisation of the structure and the spaces in the Palace seem to have been applied to the use of fountains and channels, thereby creating an integrated architectonic ensemble of water and built elements. Most courtyards are rectangular with rectangular pools in

the middle. The courtyards are organised along quadripartite lines but the emphasis is on perspective, by letting its length exceed its width so that the look may roam freely in its contemplation. That is rather than take it all in at a glance, as would be the case with a normal courtyard where space is constricted by the urban location [4]. Two main courtyards that have been analysed in the Alhambra Palatial Complex are (Fig. 5):

- 3.1 Court of Myrtles or Patio de los Arrayanes.
- 3.2 Court of Lions or Patio de Los Leones.

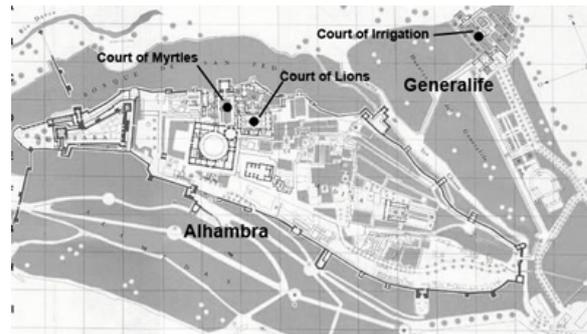


Figure 5: Alhambra Palatial Complex and Generalife.

3.1 Landscape design in the Court of Myrtles:

The Court of Myrtles is also called the Patio de la Alberca (Court of the Pond). This court is 36 meters long by 23.5 meters wide, and has a dimension ratio of 4.5:3:1 (l:w:h). In the centre, there is a large pond set in the marble pavement, with myrtles growing along its sides. The following landscape considerations were integrated in the courtyard's design:

Quadripartite layout

In the Court of Myrtles, the quadripartite arrangement is not present but still follows a geometrical symmetrical layout. The urban architecture takes up most of the courtyard axial and ample, and not only reflects the two porticoed sides but also cools the surrounding apartments during summer.

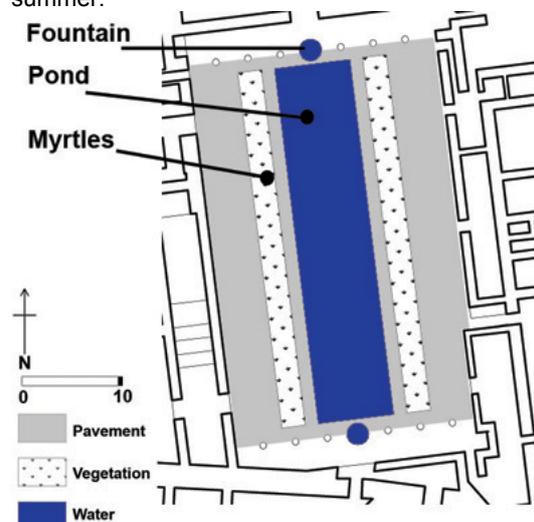


Figure 8: Landscape design elements in the Court of Myrtles, Alhambra.

Use of Water

The Court of Myrtles is characterised by the rectangular 40- by 7.5-meter central pond. The large central pond creates a spacious courtyard, which reflects the porticos of the Comares, Comares tower, landscape and sky. At the ends of the canal stand two fountains in small circular bowls. The water flows from the bowls in channels carved out in stone before spilling into the rectangular pond. This configuration creates a continuous sound in the courtyard, while the water creates continuous movements on the pond surface, which was once a residence for golden fishes. (Fig. 6)



Figure 6: The court of Myrtles, Alhambra.

Vegetation and shade

The central canal of the Court of Myrtles is lined with two rows of the aromatic *myrtus communis* bushes located parallel to the walkways and planted with only four orange trees in the four corners. The myrtle was planted during the nineteenth-century restoration and is possibly authentic. We may also suppose that the myrtle was tall and the shrubs were rich in sweet-scented blossom. Next, two axial walkways paved by white marble are perpendicular on the north and south walkways, which are covered by the portico.

The shade study (Fig. 7) shows that during winter (21 December, 2:00 p.m.), the amount of shade in the Court of Myrtles is 77%, while during the summer (21 June, 2:00 p.m.), the amount of shade reaches only 25% of the total area. This means that the courtyard reaches a critical condition of solar radiation. It seems that the designer compensated for this condition by laying a large water pond in the courtyard. The recorded temperatures showed a difference between the temperature inside the court of Myrtles and outside the palatial complex. The temperature difference ranged between 4°C to 8°C. A difference in relative humidity was also found, ranging between 10 to 22 percent.

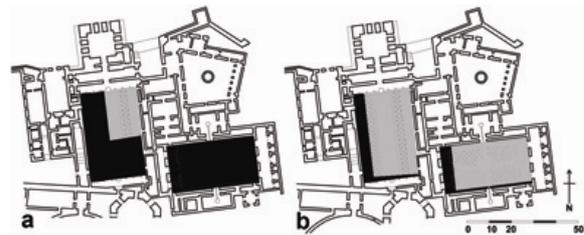


Figure 7: (a) shade study of the Court of Myrtles and the Court Lions 21 of December and (b) 21 June.

Walls and pavilions

As a walled city fortress, the courtyards of Alhambra are surrounded by massive walls. There are galleries on the north and south sides of the courtyard. The galleries on the south are 9 meters high, and supported by a densely decorated marble colonnade. Underneath it, to the right, is the principal entrance, and over it are three elegant windows with arches and miniature pillars. From this court, the walls of the Torre de Comares, the caliph's official residence, can be seen rising over the roof to the north and reflected in the pond. Moreover, by analysing the eastern and western façade, we discover that they are both simple, with very little openings in order to emphasise the axial setting of the courtyard.

3.2 Landscape design in the Court of Lions

The Court of Lions, with its fountain and its four axes channels, forms the nucleus of Alhambra Palace. The palatial courtyard is an oblong court, 35 meters in length by 20 meters in width, surrounded by a low gallery supported on 124 white marble columns. A pavilion projects into the court at each extremity, with filigree walls and a light domed roof, elaborately ornamented. The courtyard dimension ratio is 4:2:1 (l:w:h). The following landscape considerations were integrated in the courtyard's design:

Quadripartite layout

The Court of Lions has a typical quadripartite layout. The Court of Lions has a rectangular court bisected by both longitudinal and transversal axes. The long axis is emphasized by the pavilions placed at either ends.

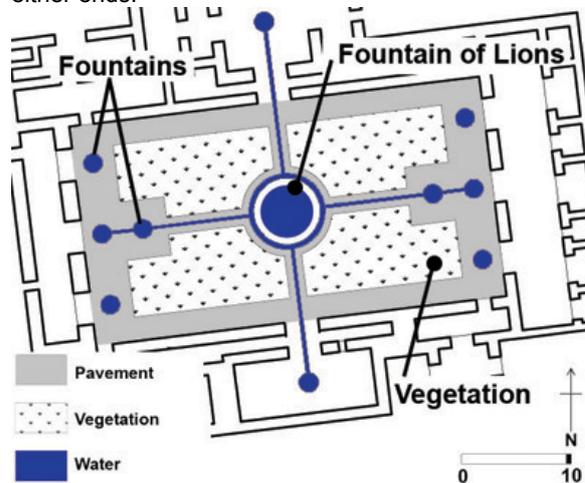


Figure 10: Landscape design elements in the Court of Lions, Alhambra.

Use of Water

Fountains found at both ends of the pool provided animation to the courtyard. The centre of the water arrangements is the Fountain of the Lions. The Fountain of the Lions is an alabaster basin supported by the figures of twelve lions in white marble. Water spurts out from the fountains from the sides of small, sunken bowls, located either inside the two halls on the north-south axis, or under the portico's projecting pavilions on the perpendicular axis. Then it runs to the central fountain in channels carved out in the stone pavement, after streaming down the steps of the hall's entrances, and forms a miniature cascade, carved also in steps, to spill in the dodecagonal basin at the base of the twelve lions. This pattern provides the physical continuity of the axes in the form of the unbroken channels. In addition, the inward orientation towards the centre is apparent, and is furthermore emphasized by the direction of the centripetal water flow. [5]

Vegetation and shade

There are no plants in the Court of Lions, but as there are great shell-fountains in all four squares, there would have been plants too, rather short in pots or in separate beds set at intervals between pavements. The pebble surrounding the pools today are unlikely to be original; excavated examples are tiled in terracotta with ceramic inserts forming a pattern. The garden survives as minor beds for climbing plants, particularly jasmine, although myrtle hedges might have bordered the pool, where space allowed. [5]



Figure 9: The Court of Lions, Alhambra.

The shade study shows that during winter (21 December, 2:00 p.m.) the amount of shade in the Court of Lions is 100% while during the summer (21 June, 2:00 p.m.), the amount of shade reaches only 23% of the total area. This means that the courtyard reaches a critical condition of solar radiation. It seems that the designer compensated for this condition in the courtyard through the use of vegetation and shade trees. Despite the pebble surrounding the pool, the recorded temperatures showed a difference between the temperature inside the court of Lions and outside the palatial complex. The inside temperature ranged between 2°C to 4°C lower than the outside temperature. A difference in

the relative humidity was also found ranging between 8 to 15 percent.

Walls and pavilions

The courtyard is paved with squared white marble tiles, and the colonnade with white marble, while the walls are covered 1.5 meters up from the ground with blue and yellow tiles with a border above and below enamelled blue and gold. The columns supporting the roof and gallery are irregularly placed, giving an artistic effect; and the general form of the piers, arches and pillars is most graceful. They are adorned by varieties of foliage. Around each arch, there is a large square of arabesques; and over the pillars is another square of exquisite filigree work.

4. GENERALIFE PALACE LAYOUT:

The Generalife, built during the reign of Muhammad III (1302-1309), was used as a Nasrid summer retreat. Separated from the Alhambra by a ravine, and overlooking the Nasrid palatial city, the Generalife is composed of terraces arranged on the hillside, with pavilions overlooking the courtyard and lush gardens. The sequence of courtyards in Generalife is based on laying the main courtyard at right angles to their common axes so that the sultan commands a spectacular view from his principal apartment. As Selle stated "The gardens of Generalife may best convey the true spirit of a Muslim garden; a true paradise, 'a place of delight' almost unequalled in any other garden in the west." [6]

4.1 Landscape design in the court of Irrigation:

The plan of the Patio de la Acequia is an oblong court, 49 meters in length by 12 meters in width. A channel that carries the water from the irrigation ditch of the Alhambra divides it lengthways. The channel is surrounded by several little jets and has a stone basin at each of its ends. The courtyard dimension ratio is 4:2:1 (l:w:h). The following landscape considerations were integrated in the courtyard's design:

Quadripartite layout

The plan of the Patio de la Acequia in the Generalife shows a medieval layout, with beds flanking the central water rill divided to make a quadripartite shape. The Acequia Court is located on the lowest terrace, and consists of a rectangular court divided into four quadrants by long water channels, with a basin at the centre. (Fig 10)

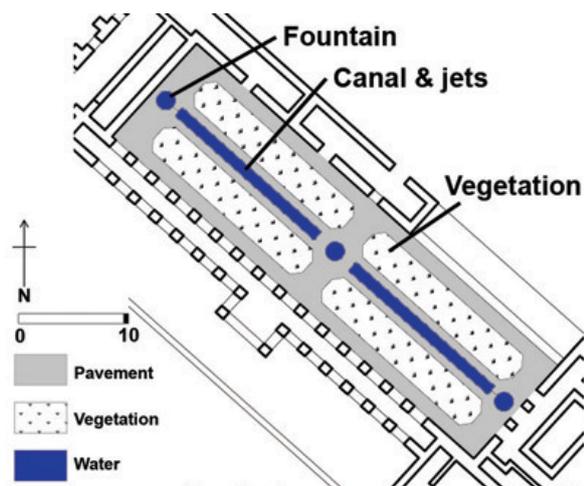


Figure 10: Landscape design elements in The Court of Irrigation, Generalife.

Use of Water

The water supply to the Generalife, channelled through the tops of the walls, runs diagonally across the steep hillside to fall to feed canals and jets in the patio gardens. But the new feature here is the water stairway, which has not been seen in Islamic garden designs before. The water stairway is between two towers and has streams above and in the middle. The upper one is watered from the upper part, the middle one from the middle part, and the lowest one from the lowest part, all in a strictly regulated amount.

The highest terrace of the complex is linked to the lower levels by a stairway whose water-channel balustrade connects three circular landings, each with its own shallow basin and jet at its centre. Each landing provides dramatic views over the landscape, juxtaposed with the visual play of water and stone.

Vegetation and shade

In the painting of the *Patio de la Acequia* by Ludwig Hans Fischer, which was painted in 1885, stands tall cypresses and aromatic Mediterranean plants which no longer exists. (Fig. 11)



Figure 11: Court of Irrigation (a) now, (b) in the past with a cypress tree.

Today, the court does not retain authentic planting, but we find summer flowering annuals instead. Ibn Luyun's fourteenth-century poem gives clues to the planting organization of the gardens when first constructed. He advised that "next to the reservoir plant shrub whose leaves do not fall and which rejoice the sight; and somewhat farther off, arrange flowers of different kinds and farther of still

evergreen trees and round the perimeter climbing vines . . . and under climbing vines let be paths which surround the garden to serve as a margin". The courtyard garden was so dense that the sunrays could not make contact with the ground and any breeze blowing over it, day or night, is instantly impregnated with perfume. [7]

The shade study shows that during winter (21 December, 2:00 p.m.), the amount of shade in the Court of Irrigation is 100%. During the summer (21 June, 2:00 p.m.), the amount of shade reaches only 29% of the total area (Fig. 12).

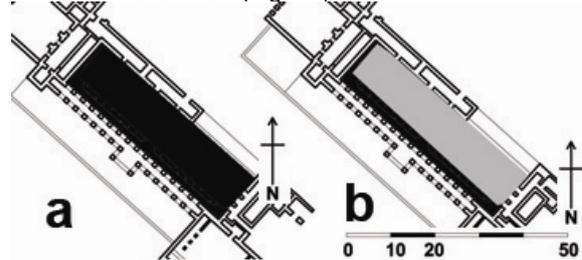


Figure 12: (a) shade study of the Court of Irrigation at the 21 of December and (b) 21 June.

This means that the courtyard reaches a critical condition of solar radiation in summer. It seems that the designer compensated for this condition in the courtyard through vegetation specifically and shade trees. If a row of tall cypresses existed as shown in Fig 11.b, the shade would cover at least 80% of the total area (21 June, 2:00 p.m.). However, the recorded temperatures showed a difference between the temperature inside the court of Irrigation and outside the palatial complex. The temperature was lower in the Court of Irrigation ranging between 3°C to 7°C lower than outside the complex. A difference in the relative humidity was also found; ranging from 12 to 22 percent.

Walls and pavilions

The Acequia Court has a gallery with a balcony, which runs along the west side of the court, providing dramatic views of the landscape and of the Alhambra. A pavilion on the north end also contains a balcony, and overlooks the Albaicin quarter of Granada. The three-storied pavilion on the southern end of the court was used as a residence. Both pavilions open onto the Acequia Court through arcades.

5. CONCLUSION

The result of this paper demonstrates that landscape design helped to improve the microclimate in the courtyards of Al Suhaymi house, Alhambra and Generalife palace. The courtyards were used as cool air reservoirs to improve the microclimate. The landscape design-elements such as the quadripartite layout, water, vegetation and walls were all integrated in the courtyards as a way of passive cooling. The shade studies proved that in cases where shadows were insufficient in the courtyards, shading trees, vegetation composition and water were used to compensate for this lack.

One may conclude that, the above results showed that the landscape design principles inherent to the traditional courtyard buildings can make a valuable contribution to contemporary design.

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