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A comparative study of hydraulic elements of Sigiriya water gardens with Mughal Imperial gardens

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Abstract

The design of landscapes is the art of manipulating the surrounding by the man, interacting with natural features to meet his various requirements. Significantly, the garden landscape can be considered one of the paramount forms of landscape architecture s. A great variety of such landscapes can be found from different regions around the world since ancient times. Accordingly, Sigiriya water garden landscape and Mughal Imperial gardens constitute distinguished chapters in the history of a garden landscape displaying remarkable landscape characters, especially hydraulic engineering techniques. Although very few researchers (Bandaranayake, 1986, 1993, 1997; Bopearachchi, 1993) have pointed out apparent resemblances between the two garden types, they have not profoundly concern with the subject. Hence, identification of resemblances and contrasts between the two garden types in terms of basic hydraulic features is the purpose of this paper and the study is conducted with the aid of secondary literary sources and field observations. Based on the analysis of the data collected, it is seemed that both garden types have used engineering techniques as inside and outside water systems adhering to the geographical location and strived to fulfill man's requirements with the technology. So, both garden types were created with mostly similar hydraulic elements adapting to the surrounding

interacting with nature, delivering the never-ending relationship with the man and nature.

Keywords: **Garden landscapes. Sigiriya water garden, Mughal Imperial gardens, Hydraulic features**

Introduction

Landscapes mirror specific techniques of sustainable land-use, considering the characteristics of the natural environment. Garden can be demarcated as the defined landscape designed intentionally by man. Since the ancient times, various types of gardens were constructed by people, particularly the royals using contemporary technology along with unique features and water can be regarded as one of the primary elements of the garden landscape. The fortified garden city of Sigiriya is an ideal example of landscape design concepts that presents the Sri Lankan tradition of hydraulic engineering. The Mughal gardeners also have utilized their knowledge on engineering to build hydraulic systems of the gardens especially with the use of surrounding water sources. Both designers have displayed an extra concern in planning out the hydraulic elements within the vicinities, while exhibiting astounding engineering skills. Consequently, this is an effort to analyze and compare water management and water distribution techniques and special water features built to enhance the beauty of the two garden types in detail.

The Hydraulic engineering of Sigiriya has earned the attentiveness from many scholars. Bandaranayake (1990:46-48, 1993:12-17) and Ellepola (1990) have conducted a series of research. Dr.Charles aranavithana, Godakubura (1970: 91-133), Dr. Saddamangala Karunarathna and Dr. Roland Silva has done archaeological study on the hydraulics built within the

whole complex. Dr. Rose Solangaarachchi in her book '*Sigiriya Jala thakshanaya'* (2018) describes the technology of water system functions within the Sigiriya complex. Among the studies on the hydraulics of the Mughal gardens, 'Waterworks in Mughal Gardens' by Sadaf Fatma, 'Waterworks and Irrigation System by Iqtidar Hussain Siddiqui, can be considered as prominent. 'Mughal Gardens, Sources, Places, Representations, and Prospects' by Wescoat and Bulmahn sheds light on the origins, development and types of Mughal gardens with research on water works of the Mughal gardens. 'Mughal Palace Garden from Babur' by Ebba Koch, Elizabeth Moynihan's book 'Paradise as a Garden in Persia and Mughal India' has been considered as important contributions. 'The Gardens of Mughal India' by Sylvia Crowe and 'Gardens and Landscape Practices in Pre- Colonial India: Histories from the Deccan', edited by Daud Ali and Emma J. Flatt discuss the hydraulic technology and the garden technology.

The basis of my study; a comparison between Sigiriya water gardens and Mughal Imperial gardens has been done only by a handful of researchers (Bandaranayake, 1986, 1993, 1997; Bopearachchi, 1993), thus being the significance of this study. Bandaranayake (1993:25-26) draws attention to international parallelisms of Sigiriya gardens in correspondence with several garden traditions including Persians, Cambodians and Mughals. Bopearachchi (1993) argues that the Sigiriya gardens have parallelisms to those of the Persian garden tradition. He states that the garden layout of Sigiriya water garden is like the fourfold garden layout of Persian garden designs.

Aforesaid research about Mughal Imperial gardens and Sigiriya water gardens encircling numerous aspects uncover the world-renowned garden

features, significantly the hydraulic technology which ultimately becomes main aid to compile the following study.

Materials and Methods

The methodology adopted to compile this work was the analysis of data collected from primary and secondary literary sources including historical sources, various survey and excavation reports and the research papers of both national and international scholars and the data collected from the site observations. Eventually, a comparative study of collected data is done to derive a conclusion. Under this research, two key areas were focused. The main research area is the Sigiriya complex located in Sri Lanka whereas the other is the area encompassing the Mughal capitals in North India; Agra, Delhi, Lahore, Kashmir and Fatehpur Sikri.

Results

1. Sigiriya water garden landscape

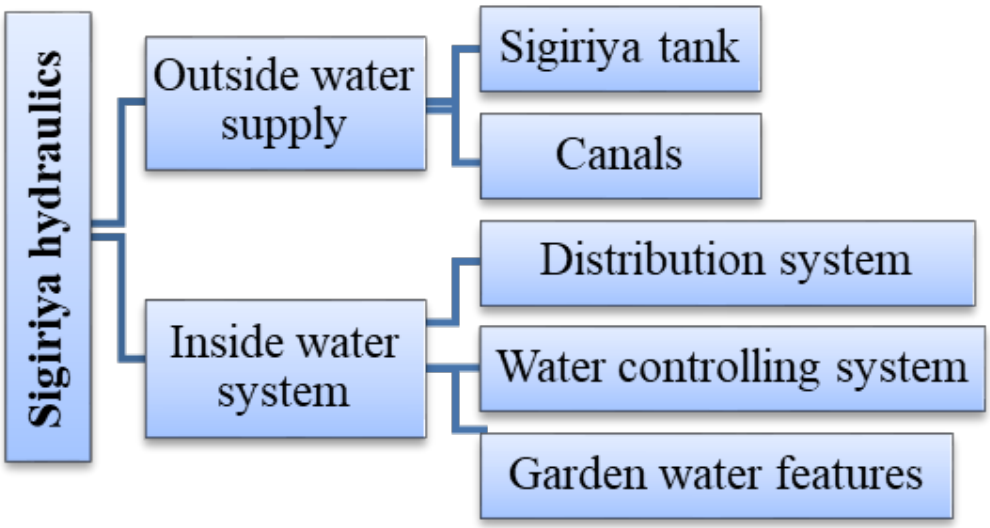
Well-executed hydraulics of Sigiriya water gardens exceeds even the present-day knowledge in constructing hydraulic features. According to Bandaranayake (1993), various sizes of ponds, interconnected conduits, cisterns, and other features constitute the water system that serve different functions within the Sigiriya premises.

- Water supply for garden vegetation.
- Surface drainage water control system to prevent erosion of terraces and gardens during the rainy season.
- Water courses and water-retaining structures.
- Cooling systems indicated by water-surrounded pavilions.

The ancient engineers who constructed the Sigiriya water system have incorporated several important concepts to irrigate the water features of the area, making the ultimate result a wonderful one. They have integrated micro and macro design in constructing the hydraulic network in the area. It can be considered a composition of specialized systems that were engineered to serve diverse needs of the Sigiriya complex. Based on the research done by personals, there are at least four water systems (two macro and micro) connected at Sigiriya premises;

- Sigiriya wewa located at the base of the rock.
- A series of moats, two on the west and one on the east, fed directly from the lake.
- The main water-retaining structures of the water garden located in the western precinct connected by underground conduits and fed by the lake and the moats.
- The water control and water-retaining systems begin with the rock-cut ponds and brick-lined cisterns on the summit of the rock and on the various terraces below, and end in the water gardens.

Accordingly, the hydraulic system of Sigiriya garden vicinity can be observed as follows *(Figure 1)*.



(Figure 1)

1.1. Outside water supply

The water supply system associated with Sigiriya wewa near the site is the main source of water to the Sigiriya garden. This system is considered as the macro hydraulic system of Sigiriya water garden landscape *(Plan 1*).

Apart from the seasonal raining in the area this continuous water source has been irrigated the entire complex according to the evidence revealed from the research. The Sigiriya Oya originating at the Northern end of Sigiriya Wewa can be regarded as the main canal to supply water to the complex *(Map 1).* Sigiriya oya run along the western boundary of the complex and collect outflow from the inner precinct along its downstream path. This connection at the lower end of the complex links the hydraulic systems of the inner precinct with the main irrigation system. A similar channel connection from the upper regions of the Sigiriya wewa irrigates the inner precinct.

1.2. Inside water system

The water distribution system is considered as micro hydraulic system within the water garden *(Plan 2)*. Water circulation through the area is controlled by the force of gravity, which creates a smooth flow into the lower areas where the supply is required. The horizontal distribution of the water is mainly channeled through underground conduits. So, the surface of Sigiriya vicinity can be imagined as a maze of water lines.

These underground pipes have noticeable characteristics. Their cross-sectional dimensions vary according to the volume of water pass through them. The base and sides of a typical conduit is constructed in stone and covered with a stone slab. The entire pipe is surrounded by packed clay which acts as waterproofing on the outside. It can be noticed that water conduits within the vicinity are made up of different materials such as brick, stones, and limestone.

Hydraulics of the water drainage system of the premises is designed with a mastermind skill as visible from the remaining evidence *(Plan 3).* The stepped landscaped gardens on the western area of Sigiriya water garden, transform their design character from the symmetrical layout seen in the water gardens of the lowest level to an asymmetric layout, close to boulder and terrace gardens, at the upper levels. The highest hydraulic pressure in the water distribution system can be also noticed at the lowermost elevation of the garden. Hence, the water gardens of Sigiriya were ideally placed within the final descending step of the slope of the western environs. The stepped terraces were used to regulate and activate different hydraulic elements arranged linearly in an East-West direction.

Various hydraulic features can be identified in the three divisions of water garden area. Garden No.1 which displays four-fold garden style

constitutes an island surrounded by four large ponds *(Figure 2).* The Sigiriya Wewa would have supplied water through an underground conduit to the pools. The four ponds of the garden are interconnected at their base. This linkage creates a single water system, with a uniform water level within all the units. Therefore, it became possible to feed the system of pools from a single point. Instead of a single outlet each of these pools contains several small openings. The reduced size and increased number of these outlets appear as the design of a sluice gate.

Most of the known water features of the Sigiriya precinct are in the area identified as the Fountain garden It is comprised of two long ponds which are located opposite to each other. There are also two 'serpentine streams' paved with marble slabs *(Figure 3)* and at the end of each stream, there are four fountains; two to each. Either side of the fountain gardens are the summer palaces which are surrounded by wide moats.

By maintaining the pools of the garden area at full capacity, the continuous operation of the fountains display may have been ensured by the designers. This could be made possible by connecting the pools to the main water line of the Sigiriya Wewa. So, if there was enough water in the storage pools, the system continued to function, causing the fountains and cascading streams to remain activated. This scenario is evident since the fountains of Sigiriya water garden are working effectively even today during the rainy season. More importantly, underground water conduits and complex sluice gate arrangement can be noticed at the midpoint of the garden area *(Figure 4).* Water manipulation at this center could have controlled the water flow within the display features of the garden.

The bathing pool identified as the Octagonal Pond is the significant hydraulic feature of the Garden No.3 area. According to the researchers, it is

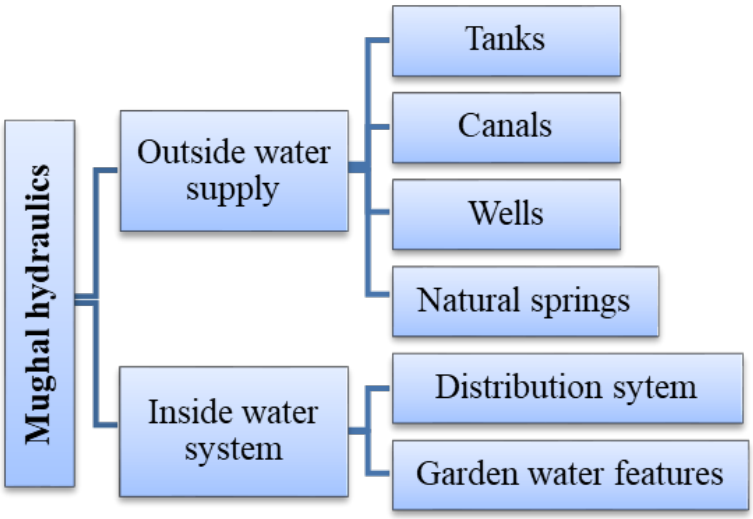
assumed that the pool was likely to have been refilled with fresh water supplied from the Sigiriya Wewa by tapping the underground conduit.

A concentration of water features, limited to a constricted section along the edge of the western precinct is the miniature water garden *(Figure 5*). The creators have attempted to reduce the design scale of this hydraulic display with shallow reflecting small ponds. So, clearly it was easy to maintain the water system with a relatively small amount of water, even without rain. A striking feature of this 'miniature' garden which is about 90m long and 30m wide, is the use of these water surrounds with pebbled floors, covered by shallow, slowly moving water (*Figure 6*). These may have served as a cooling device and at the same time great aesthetic appeal, creating visual and sound effects.

Thus, the Sigiriya water garden engineers have paid their attention on the visual aspects, garden layout and more importantly to the climatic conditions where they needed to retain more amount of water to maintain a cool environment within the Sigiriya premises.

02. Mughal Imperial gardens

Water became the central and connecting theme in the Mughal gardens since the beginning of Mughal garden creation, right from the time of Babur. The beauty of Babur's classic Chaharbagh or four-fold garden was the central watercourse and its flowing water (Koch, 2007). Most of the Mughal gardens were designed based on this layout; dividing into four quadrants by two axes comprised with water channels and pathways to carry the water under gravitational pressure. Consequently, the following water systems can be noticed (*Figure 7*).



(Figure 7)

2.1. Outside water supply

The most important aspect of the waterworks of gardens was the permanent source of water supply. The principal sources of water to the Mughal gardens can be identified as different forms as lakes or tanks, wells or stepwells, canals channeled from the rivers and natural springs.

Tanks were the most used outside water source to irrigate the gardens. Tanks have been used as a main source of water mostly in Northern Indian gardens. For an example Shalimar garden at Lahore can be pointed out.

Well as a water source was so common that sometimes despite rivers in proximity, they were used to irrigate the gardens. They were built as chambered wells and wells with stairs. The water lifting device for Mughal gardens from wells were the leather bucket, lifted by yoked oxen, the surface

wheel based on lever principle and Persian Wheel used in Fatehpur Sikri. This system can be seen in the gardens of Humayun's tomb garden at Delhi, Akbar's gardens at Sikandra, Shalamar Bagh at Lahore and almost in all the Mughal gardens of plain region (Mishra, 2003). Interestingly, it was not only in the plain area but in the hilly area like Kashmir where water was in abundance, wheel was used, just to make the pressure more intense.

The most important advance of the Mughal garden hydraulics was the construction of canals by harnessing rivers in Northern India. The canal Nahr-i faiz which provided water to the gardens near the capital Delhi was built under the reign of Shah Jahan. The canal Shahnaha, providing water to the gardens of Lahore, was constructed during the reign of Shah Jahan and took water from the river Ravi at Shahpur up to Lahore.

In Kashmir where the source of water was natural springs, the Mughals laid out canals to water their garden from the streams coming down from the surrounding mountains. Jahangir built a canal named 'Jui-i- Shahi' to water his garden Nur Bagh from Sind and Shah Jahan laid-out another canal named 'Shahnahr'. The gushing water of the natural springs was supplied to the gardens sometimes directly and sometimes through canals and made all the decorative features like fountains livelier.

To feed the Mughal gardens with water, two forces worked: the natural gravitational force and the artificial gravitational force. The natural gravitational force was applied in the naturally terraced garden like the gardens of Kashmir where steep mountain slope provided dramatic water landscape. Powerful streams and springs from the hills fell in the garden with strong force over water chutes, fountains and pools. The Mughals made artificial terraces even on the slightly slopping site to provide gardens the

artificial gravitational flow and after that the hydraulic pressure by Persian wheel made the flow smoother (Mishra, 2003; Moynihan, 1979)

2.2. Inside water system

Mughals have used wells, octagon, and square tanks in the corner of the garden to provide the water through water channels to the central tank and to the whole garden by cascading into different pools and fountains through terracotta pipes. A separate underground channel was also there which took water from the original tank to the central tank (Javed, 2009; Koch, 2009).

Water chute is a characteristic feature of Mughal gardens *(Figure 8).* They are made of marble or stone with the design carved as fish-scale and zig-zag pattern to produce a rippling effect (Mishra, 2003). These water chutes connect to the source of water through water channels. In Kashmir, where the source of water was natural spring, the ground was in the series of terraces and where waterfall became the striking feature, water chute looked much effective and magically beautiful. However, even in the plains with the slightest slope of only one or two feet, Mughals created charming waterfalls in their gardens.

The abundance of water in Kashmir enabled its gardens to create water shawls *(Figure 9).* The chadar, meaning white shawl of water, under the surface of crystal-clear water with niches is a mesmerizing water feature can be witnessed in the Shalimar garden at Kashmir (Mishra, 2003).

Fountain which added an aesthetic value to the background became one of the important features of the Mughal gardens *(Figure 10).* The raised water produced pressure to work the fountain. Apart from the canal water, the fountain, was also fed by independent arrangement which included wells and elevated large reservoirs outside the gardens. Generally, an earthen

conduit, made of glazed terra-cotta, supplied water to the fountains and around that pipe, brick was laid in lime mortal to protect the line. There were separate concealed terra cotta pipes for the fountains installed in the center of the pool (Mishra, 2003). In the excavation of the Mughal garden at Wah, a terracotta pipe for supplying water to the fountains has been unearthed. Usually, a weak gravitational force was provided for low fountain and high force for higher ones.

For all these hydraulic works a high-level water management was needed. Mughal engineers have used their knowledge in hydraulics in a very pleasing and effective manner. Thus, water played most important role in the Mughal gardens, whether as a pool, channel, and fountain or to irrigate the flower and fruit beds.

Discussion

Water plays a significant role in both gardens in functional wise and in increasing the alluring beauty of the landscape. The two garden types have constructed different water retaining structures and water flowing courses throughout the garden area. The hydraulics of the two gardens can be recognized under the main two divisions as an outside water source and inside water features.

The outside water source is prominent in the hydraulic system of both gardens. Sigiriya has a tank built in proximity and the Mughal gardens have built stepped wells in addition to the tanks using their unique technology. Both systems have used canals to supply water for the inside features of the gardens. Among the inside water features, fountains made of underground water pressure can be noticed in both and various sizes of ponds with well-formed drainage systems can be observed. To manage the water within the

vicinity both garden creators have used underground pipes made of terracotta which exhibit the extraordinary skills of the creators.

Although both gardens possess almost similar water systems, the designers have inter-mingled their unique engineering technologies in constructing water structures. In the Sigiriya water garden the water structures, especially the ponds have been built while interviewing natural elements such as rocks and boulders. It can be noticed that the bunds of the ponds are built connecting with the natural boulders pass through them. Simultaneously, the Mughal garden creators have used the terrain with slopes to design their water features such as the water shawls and chutes.

Conclusion

As concluding remarks, both the garden types have given consideration on the surrounding in building up the hydraulic systems within the garden precinct. The designers were more aware of the landscape features to meddle with the water noticeably. Retaining the cool in the environment to fight the harsh climate both creators have manipulated the natural water cooperating the mostly similar techniques. So, it appears that both gardens express similarities between the hydraulics showcasing the interaction of the human with the environment, though they are from different locations and different times.

Acknowledgement

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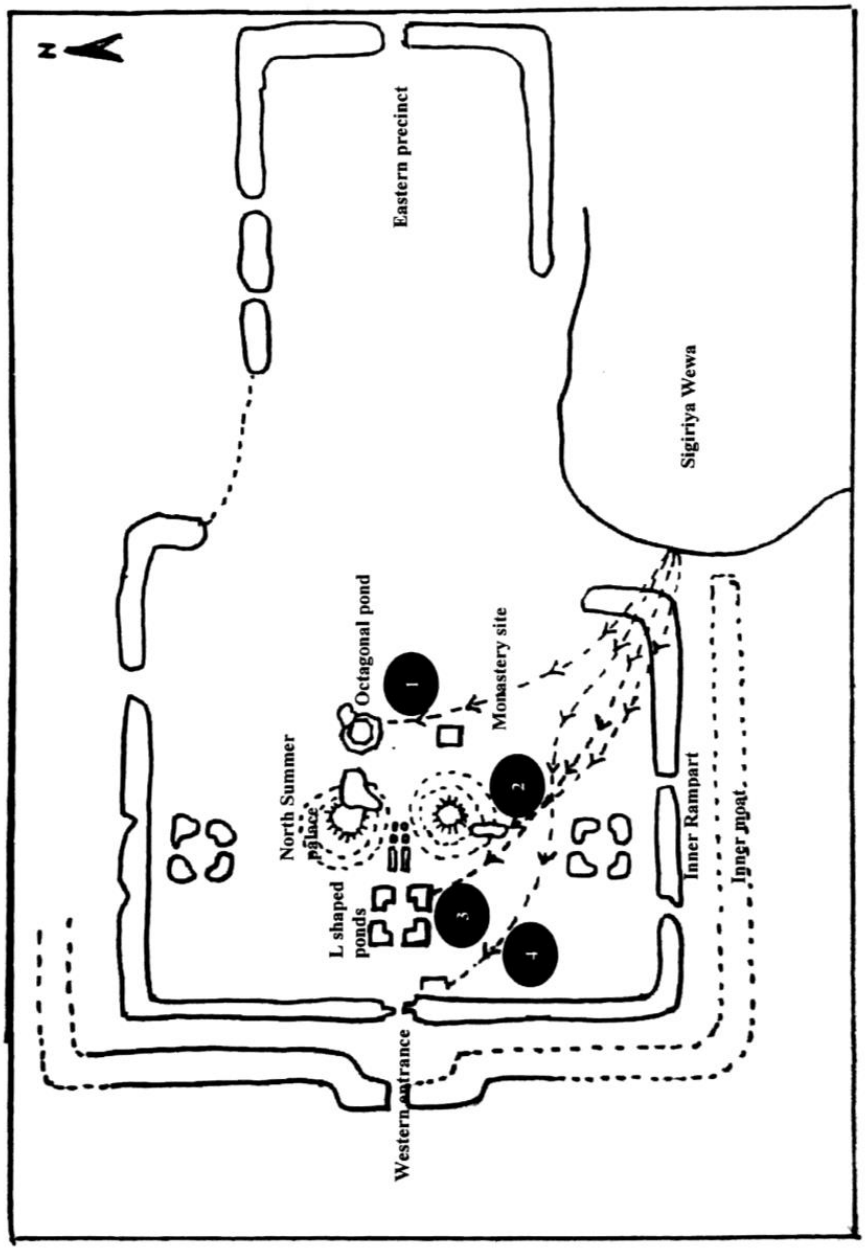
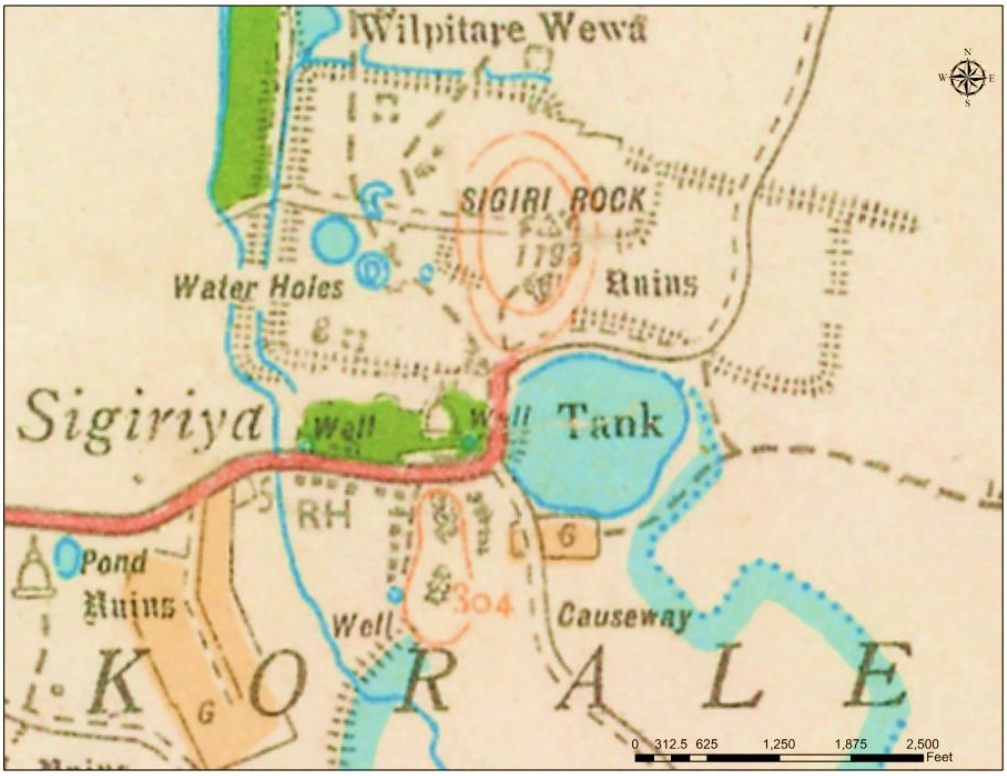
Annex



Plan 1

Macro hydraulic system of Sigirya water garden

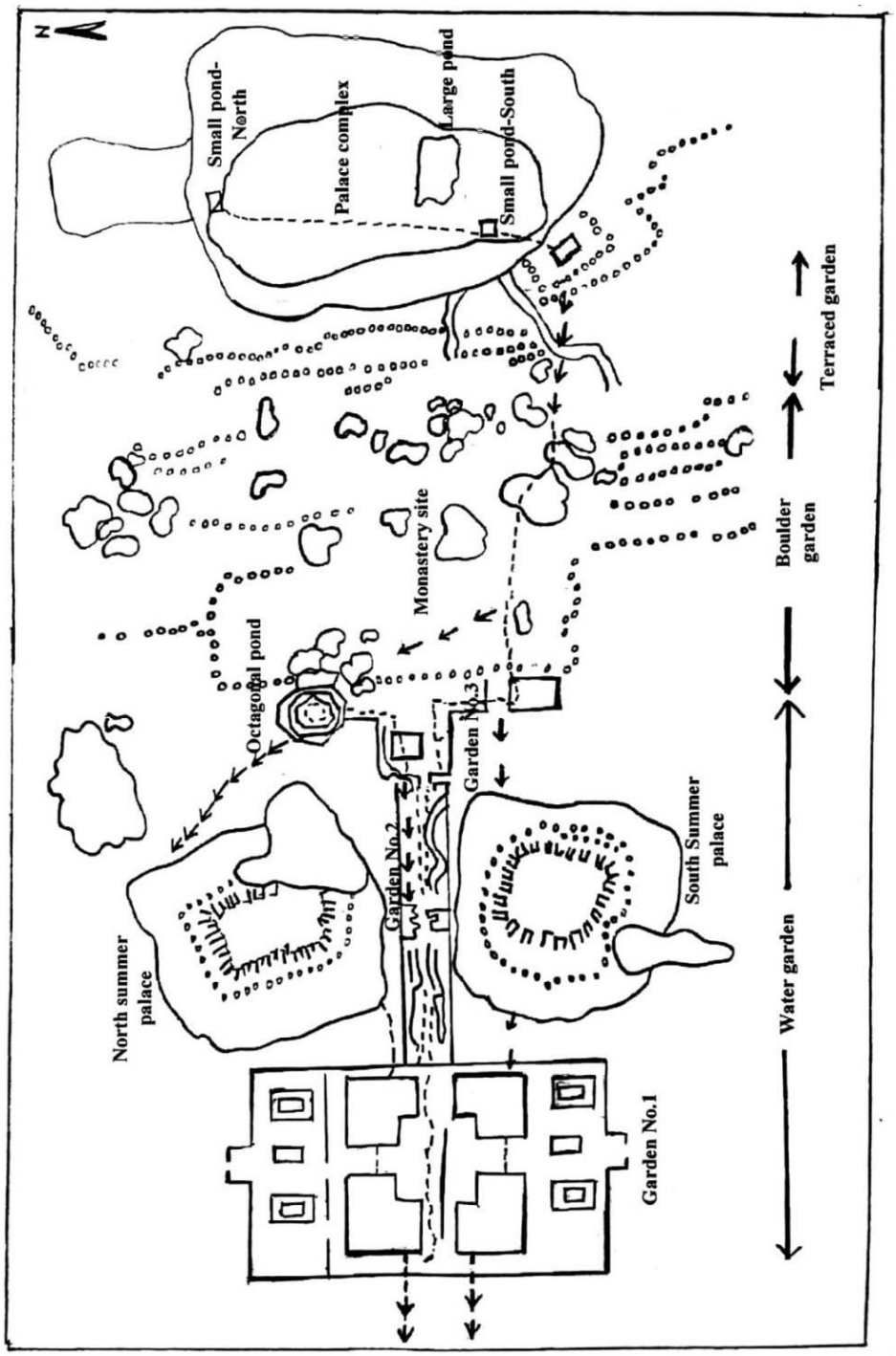
Source - Solangaarachchi. R, (2018), Sigiriya Jala Thakshanaya, Neptune publications.



Map 1

Sigiriya wewa and Oya as the outside water supply to Sigiriya

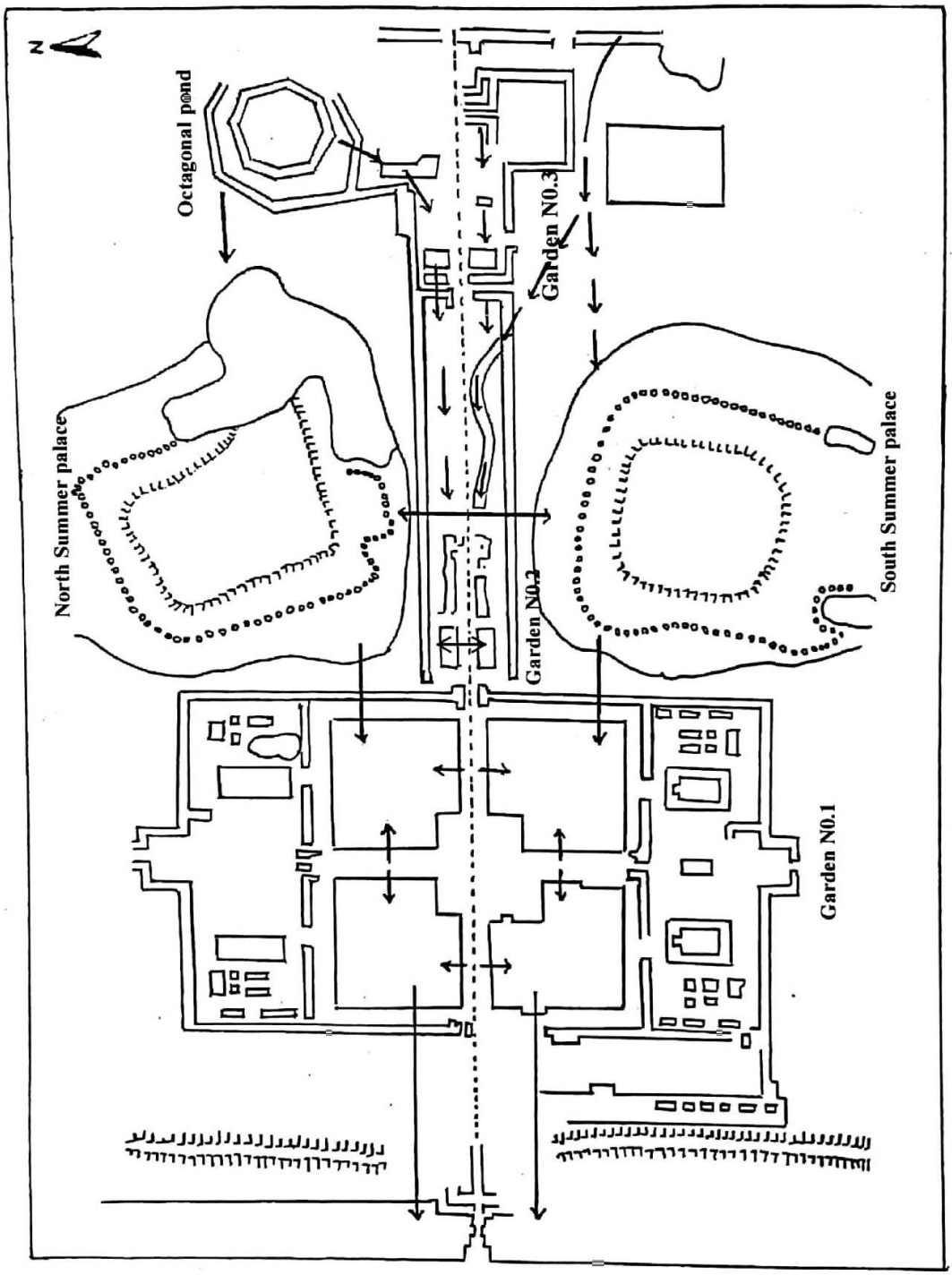
Source – Department of Geography,University of Kelaniya



Plan 2

Micro hydraulic system of Sigiriya water garden

Source - Solangaarachchi. R, (2018), Sigiriya Jala Thakshanaya, Neptune



Plan 3

Water drainage system of Sigiriya water garden

Source - Solangaarachchi. R, (2018), Sigiriya Jala Thakshanaya, Neptune

Figure 1 *Water features of Garden No.1*

Figure 2,3 Two long ponds in Garden No.2

Figure 4 Fountains of Garden No.2

Figure 5 Octagonal pond in Garden No.3

Figure 6 Miniature water garden

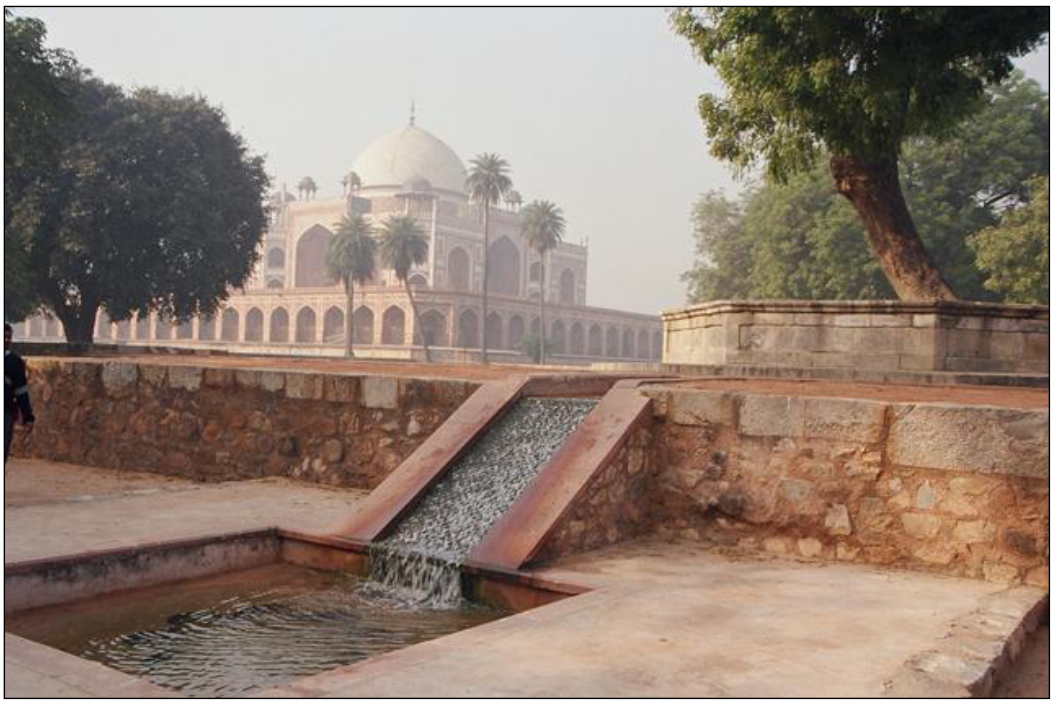


Figure 8 Water chutes of Mughal garden (Humayun's Tomb garden)

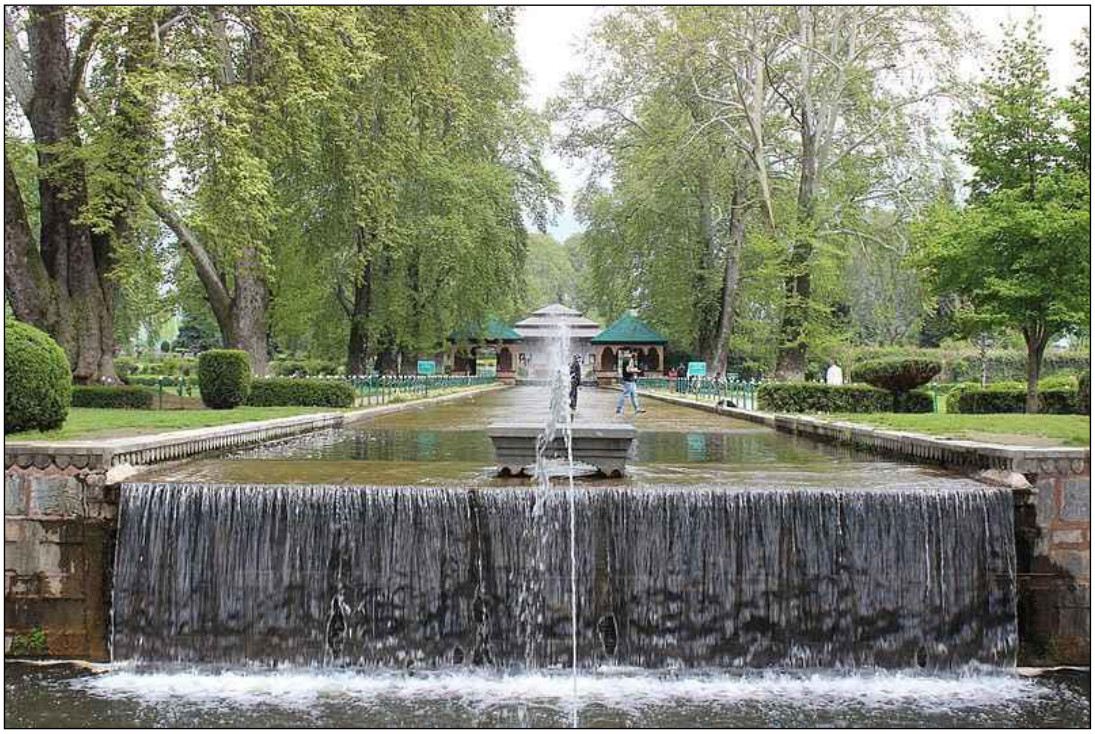


Figure 9 Water shawl of Mughal garden (Shalimar garden at Kashmir)

Figure 10 Water fountains of Mughal garden (Shalimar garden at Kashmir)