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VIRTUAL REALITY AND THE ISLAMIC WATER SYSTEM IN CAIRO: CHALLENGES AND METHODS

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Abstract

The Nile River plays a central role in Egyptians' everyday life as the sustainable source of fresh water. Egyptians sought to regulate the Nile through the ages by inventing water systems suitable to monitor, measure and oversee the Nile's behaviour. Because of the high value of water in Islam and its link to agriculture and taxation, Muslim rulers paid attention to water projects for irrigation and delivery to the cities throughout Islamic medieval dynasties. Islamic Cairo has a variety of water systems reacting to two major factors. First: westward shifting of the Nile, according to topographic inclination, causing the waves cutting into the west bank to precipitate in the east. As a result, the founders (Sultans al-Naser Mohamed and al-Ghoury in particular) always built new water intake towers in response to this phenomenon. Second: the relocation of the capital of Islamic Egypt to Cairo and later to the Citadel northeast resulting in constant displacement further away from the Nile bank. Whereas 'Amr ibn al-'As built al-Fustat (641 A.D) close to the Nile, al-'Asakar (750 CE) and al-Qata'i (876 A.D) were built northeast of al-Fustat away from the Nile. When al-Mu'izz Ledin-Allah came to Egypt in 971 A.D, he blamed the commander of his army Jawhar al-Saqaly because of the city's location far from the Nile. The citadel of Cairo is the farthest capital of Islamic Egypt, because of the appropriateness of the fortified location on al-Muqattam heaps inside the newly built Citadel. Chronicles and surviving buildings provide a full narrative and accounts of water systems of the Islamic capitals in Egypt. Such knowledge and information enable a credible virtual reality model to create a realistic output for the tangibles and intangibles of the water system using the virtual reality application.

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INTRODUCTION

The Nile River plays a main role in the Egyptian life as the sole sustainable source of fresh water, so Egyptians have always sought to regulate the Nile through the years by inventing water systems suitable to the Nile's behaviour. This began after the Islamic conquest with the restoration of the canal that linked the Babylon area to the Red Sea - originally funded by the Roman emperor Trajan - at the behest of Caliph 'Omar as a way to link Egypt to the rest of the Islamic Empire (Al-Sayyad, 2011). Additionally, water has a high value in Islam to the extent that Muslims inherited and invented many ways to deal with water resources, either rivers or rainwater, through advanced techniques and calculations (Soliman, 2014). Muslim rulers paid attention to water as a sign of power and control, so they were keen on irrigation systems in Delta and Upper Egypt to supply fresh water to the cities all year - Cairo and its citadel in particular. This paper discusses the practicality and suitability of current information to enable the use of virtual heritage to interrogate, analyze and visualize the heritage of water resources management and operational systems in the medieval city. In doing so, this paper presents and analyzes the credibility of current knowledge and information on water heritage in Cairo in terms of what benefits the use of virtual heritage modelling, and visualization techniques would afford them.

Typography of the Cairene Nile

What we today call Cairo, or al-Qahira, is an agglomeration of four cities founded within the area. The name al-Qahira did not exist until the last of these was created in 969 A.D as the capital of Egypt under the Fatimid. Before this city came a succession of capitals beginning with early al-Fustat (641 A.D), the Abbasid foundation of al-'Askar (750 A.D), and the Tulunid establishment of al-Qata'i (870 A.D) (Yeomans, 2006) (Figure 1).

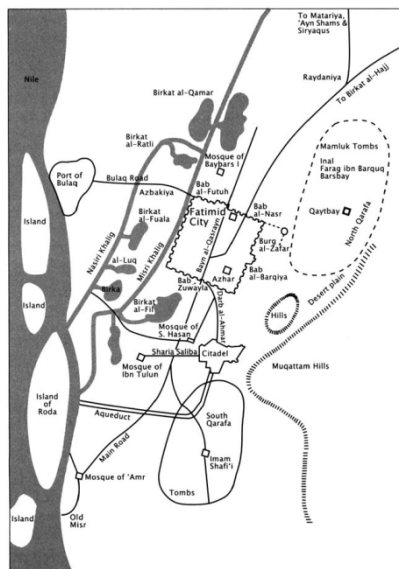


Figure 1. Islamic Capitals of Egypt (Source: Williams, 2002).

Al-Fustat was founded as the first Islamic capital of Egypt just after the Arab conquest of Egypt. Its location was a strategic decision by the Caliph 'Omar ibn al-Khattab in Medina, for although Alexandria was capital of Egypt at that time, the Caliph preferred to settle his troops in an area less remote from the Arabian Peninsula. 'Amr ibn al-'As, commander of the

Caliph's troops in Egypt, thus abandoned his plans to settle in the former capital on the Mediterranean. The new capital, at the apex of the Nile Delta, sat strategically near the Roman fortress town of Babylon. This site, at the junction of Upper and Lower Egypt, allowed easy communication with the Arabian Peninsula without crossing the Nile and its Delta branches (Abouseif, 1989).

Islamic Cairo has a variety of water systems reacting to two major factors. First: westward shifting of the Nile, according to topographic inclination, causing the waves cutting into the west bank to precipitate in the east. As a result, the founders - Sultans al-Naser Mohamed (14th century) and al-Ghoury (16th century) in particular - always built new water intake towers in response to this phenomenon. Second: the relocation of the capital of Islamic Egypt to Cairo and later to the Citadel northeast resulting in constant displacement further away from the Nile bank. Whereas 'Amr Ibn al-'As built al-Fustat in 641 A.D close to the Nile, al-'Askar (750 A.D) and al-Qata'i (876 A.D) were built northeast of al-Fustat away from the Nile, which the location of Cairo clearly demonstrates. When al-Mu'izz Ledin-Allah came to Egypt in 971 A.D, he was disappointed in the commander of his army Jawhar al-Saqaly - founder of the Fatimid Cairo - because of the wrong choice of a location far from the Nile, the sole source of water. The citadel of Cairo is the farthest capital of Islamic Egypt, because of the appropriateness of the fortified location on al-Muqattam hills, which is located east of the Fatimid Cairo (already far from the Nile) for building a citadel. Muslim rulers of Egypt responded by conducting water to these capitals using water wheels and aqueducts, as well as storing fresh water in cisterns. Chronicles describe the efforts of those rulers, and many of their buildings survive, including the Nileometer (861A.D), the ruins of the Ahmed ibn Tulun's aqueduct and water wheel (876 A.D), and Saladin aqueduct (1187 A.D). Although all of these projects were important at the time of building, the most important surviving Islamic water facilities in Cairo are the al-Ghoury water intake tower (1508 A.D) and the al-Naser Mohamed aqueduct (1340 A.D) (Table 1).

Table 1: Maintained water system of historic Cairo (Source: Author, 2017).

Serial No.	Name	Function	Location	Direction	Period & date	Case
1	Nileometer	Nileometer	Al-Roda Island	South Cairo	Abbasid(861)	Exist
2	Ahmed Ibn Tulun	Water wheel	Qalat Al-Kabsh	South Cairo	Tulunid (876)	Ruins
3	Bir Umm Sultan	Intake tower	Basatin	South Cairo	Tulunid (876)	Ruins
4	Saladin	Aqueduct & well	Imam Shafii	South Cairo	Ayyubid (1187)	Ruins
5	Al-Naser Mohamed	Aqueduct	Out	South Cairo	Bahri Mamluk (1312)	Exist
6	Al-Naser Mohamed	Water wheel	Arab Al-Yasar	West to the citadel	Bahri Mamluk (1312)	Ruins
7	Qait'bey	Aqueduct	Magra Al-Euon	South Cairo	Bahri Mamluk (1312)	Exist
8	Qun'sua Al-Ghoury	Aqueduct & Intake tower	Fom Al-Khalige	South Cairo	Bahri Mamluk (1312)	Exist



Chronicles provide information about the shifting of the Nile stating that when al-Mu‘izz saw Cairo; he did not like its location and reprimanded Jawhar for not thinking of building it on the Nile riverside, on al-Rasad hill. Ibn Sa‘id, who counted Cairo’s remoteness from the Nile among the city’s drawbacks, explained that building it at a distance from the Nile flow was intentional for fear that the river would ruin its buildings. The Nile’s movement westward, which began in the 4th/10th century and accelerated during the early 8th/14th century, relieved al-Fustat and Cairo from the danger of the Nile’s uncontrolled flooding and made inhabitation of the banks of the river, the canals and the artificial lakes, more secure (Levanoni, 2010). Remote sensing and geophysics applications used in archaeological sites, including medieval Cairo, compound this fact through relevant research by NARSS and NRIAG in collaboration with the SCA.

EARLY ISLAMIC WATER FACILITIES BEFORE CAIRO

The reopening of the ancient canal to the Nile, al-Khalij al-Kabir or al-Khalij al-Misri, by ‘Amr ibn al-‘As was proposed with the idea of improving communication between Egypt and the imperial capital of Medina in H_ijaz, rather than improving the water supply to the city (Levanoni, 2010) (Figure 2). In addition, the canal’s mouth was located at some distance from the city, in a spot somewhat protected from the wide Nile by the island of al-Rawd_a. The growth of new suburbs to the south and north of al-Fustat followed where there was no protection from the torrent during the Nile floodwater, and to the east and northeast. Areas located some distance from the riverside were made possible by technologies that safely directed the Nile water through canals dammed by dikes at the riverside, and through aqueducts into open inland reservoirs, defined in the sources as lakes or ponds (Arabic: Birak, singular. Birka).

These Birak functioned as water sources for the new suburbs that grew in their vicinity. They were filled once a year during the inundation and their contents gradually reduced, because of the drawing of water to wells and cisterns in the suburbs, natural evaporation and permeation into the ground. Since these reservoirs tended to dry up, their function often varied with the season (Levanoni, 2010).

MEASURING OF THE NILE FLOOD: (NILEOMETER)

The Abbasid caliph al-Mutawakkil commissioned the building of the Nileometer by Ahmad ibn Mohamed al-Hasib in 862 A.D (Figure 3). It is the earliest surviving Islamic monument in Egypt and is one of Cairo’s finest structures, exemplifying the architectural principle of fitness of purpose. The Nileometer measured the height of the Nile water during the annual inundation and its measurements were essential in determining irrigation policy (Yeomans, 2006). It is a stone lined pit, circular at the bottom and rectangular at the top, from which three lateral tunnels, at different levels, connect with the Nile from the east side. Twenty-four steps lead down to a landing, which faces four recessed arches. These pointed arches, framed with colonnades, are identical in form to those used by Gothic architects three centuries later. At the centre of the pit, is a marble octagonal measuring column with a composite capital held at the top by a timber beam and secured at the bottom in a granite millstone, while a modern wooden dome covers the whole unit. The measuring column is divided into nineteen cubits, with the sixteenth cubit mark representing the ideal flood level. Between 872 and 873 A.D ibn Tulun restored the Nileometer and removed Caliph al-



Mutawakkil's name from a band of Kufic inscription, a gesture which no doubt signified his desire to disassociate himself and Egypt from the Abbasid caliphate (Yeomans, 2006).



Figure 2. Khaliq al-Misri (Source: Flickr Groups, 2016) Figure 3. Nileometer at al-Rawd_a island by David Roberts, 19th century (Source: TinEye Products, 2017).

Ahmed ibn Tulun's aqueduct: Soon after ibn Tulun arrived in Egypt in 870 A.D, he moved the seat of government from al-'Askar to the suburb of al-Qata'i northwest of al-Fustat. Here, at the foot of the present Citadel, under the Air Dome, he created a new urban development inspired by Samarra. It covered over 1.6 square kilometers and included a mosque, government buildings and a palace complex adjoining a hippodrome. The city also had a hospital, numerous markets and bathhouses serviced by the aqueduct, which brought water from a spring in the southern desert in Basatin (Figure 4). Ahmed ibn Tulun's aqueduct was built by a Copt, and it formed one of a number of Ibn Tulun's hydraulic engineering projects, including the dredging of Alexandria's canal and repairs to the Nileometer at al-Rawd_a Island (Yeomans, 2006).



Figure 4. Ibn Tulun's aqueduct (Source: Author, 2017).

THE CITADEL OF CAIRO, AN INDEPENDENT WATER SYSTEM

Sultan Saladin, the founder of the Ayyubid dynasty, had reasonable circumstances to choose another site to build his capital: to keep him away from the conspiracies of the remnants of his Fatimid enemies in Cairo who overthrew their Shiite state; as well as to consolidate his independence in Egypt from his master Nur al-Din Mahmud Sultan of Aleppo if he tried to attack him; and undoubtedly the attacks of the crusaders who have been entangled since the expulsion from Egypt years ago. All these reasons pushed Saladin to choose al-Muqattam hill to build his famous citadel in 1176 A.D. (Figure 5).



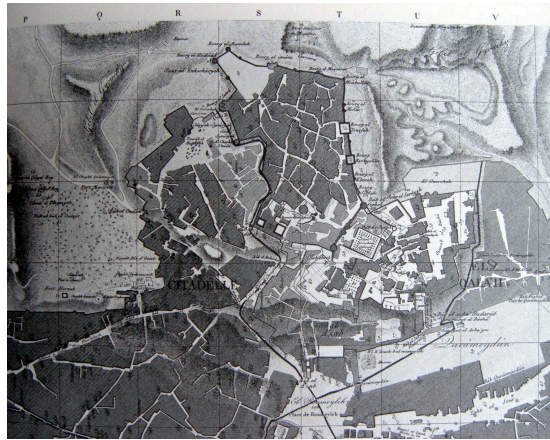


Figure 5. Napoleonic map of the citadel 1801
(Source: *l' Description de l' Egypte*, 2003).



Figure 6. The citadel of Cairo by David Roberts in
the 19th century (Source: TinEye Products, 2017).

This fortified site required a sustainable secured water source, therefore, Saladin ordered Baha al-Din Qura'qush the supervisor of the building process to carry this out (Figure 6). Qura'qush dug a well inside the citadel to provide a sustainable source of water which was known as Yusuf's well (Saladin's given name), and built aqueducts to conduct the Nile water to the citadel annually after the flood for preserving inside cisterns, to be used during a probable siege. It is probable that Yusuf's well existed in Fatimid times and was simply enlarged by Saladin (Figure 7). Cut 87 meters through the limestone down to the water table, this double-shafted well is a remarkable piece of hydraulic engineering (Yeomans, 2006). Recently another well had been explored, which could change the perception of the water system operation of the citadel.

Although Saladin is the founder of the citadel of Cairo, the first Sultan who moved to take it over as a centre for ruling Egypt is his nephew al-Kamil Mohamed ibn al-'Adil in 1207 A.D, who transformed it into a royal capital of Egypt instead of Fatimid Cairo (Temraz, 1994). The citadel occupied this place until 1864 when Khedive Ismail, the fifth ruler of Mohammed Ali's



dynasty, moved to Abdeen Palace as an official announcement of transferring the seat of government from the citadel of Cairo.

The Citadel today is roughly divided into the northern, southern and lower enclosures, and residential and administrative areas from the outside in the western enclosure were separate from the military compound in the north (Yeomans, 2006). The large space, maintained buildings and ruins, and historical chronicles reveal how much water was needed to accommodate the Sultan, royal family, troops, servants, slaves, and animals. This is not surprising by the estimates of the French campaign (1789-1801 A.D) where the number of cisterns of the citadel was about 14 cisterns, a small amount for residents of the citadel (Gomar & Sayed, 1988) (Table 2). Nevertheless, the internal water network of the citadel is still vague and incomplete.

Table: 2. Water system of the citadel (Source: Author, 2017).

Serial No.	Name	Function	Location	Direction	Period & date	Case
1	Yusuf	Well	southern section	East	Ayyubid (1187)	Exist
2	Saladin	Aqueduct & Well	Outside	South the Citadel	Ayyubid (1187)	Ruin
3	Al-Naser Mohamed	Aqueduct	Outside	South the Citadel	Bahri Mamluk (1312)	Exist
4	Al-Naser Mohamed	Waterwheel	Outside	West the Citadel	Bahri Mamluk (1312)	Ruin
5	Qait'bey	Aqueduct	Outside	South the Citadel	Burji Mamluk (1480)	Exist
6	Qun'sua Al-Ghoury	Aqueduct & Intake tower	Outside	South the Citadel	Bahri Mamluk (1508)	Exist
7	Unnamed	Well	Northern section	West	Unknown	Explored
8	Unnamed	14 cisterns	Both sections	Everywhere	Ayyubid, Mamluk & Ottoman	Explored & unexplored

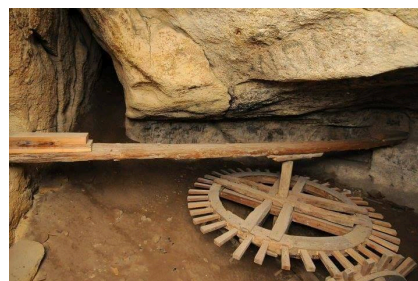
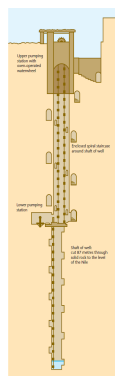


Figure 7. Yusuf's well- (Left) Section (Source: Yeomans, 2006), (Right) Recent situation (Source: Author, 2017).

During the successive Islamic eras in which the citadel was the official seat of rulers of Egypt, the delivery of fresh water was the main priority. Saladin, al-Naser Mohamed ibn Qalawun, al-Ashraf Qaitbay, al-Ghuri, all transferred water to the citadel, the seat of their authority. A project of al-Naser Mohamed in 1312 A.D established an aqueduct stretching from "Fom al-Khalij" (gulf's mouth) to the south of the citadel, where the waterwheel then raises the water to the highest point of the citadel. Al-Ashraf Qait'bay restored this aqueduct in anticipation of the growing Ottoman threat in 1480 A.D., surrounding the citadel. Responding to the topographic transformations of the Nile River in the west, Sultan Qun'sua al-Ghuri, the Mamluk Sultan before the last, established a water intake tower in 1508 A.D at "Fom al-Khalij" on the new Nile coast to deliver water directly to the citadel through al-Nasir Mohamed aqueduct (Figure 8). The intake tower has a hexagonal structure consisting of three floors, where six waterwheels "dawalib, s. dulab" mounted on the upper one, while the tower was connected to the Nile by a small canal "masrab", lifted the water to the aqueduct (Levanoni, 2010).

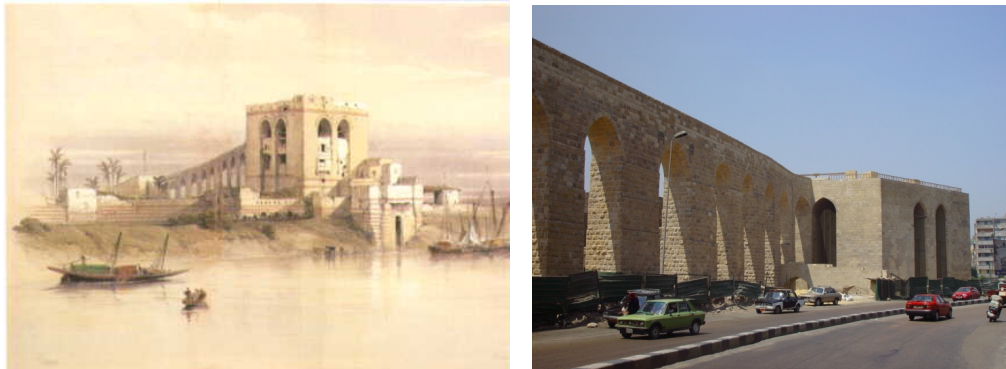


Figure 8. Al-Ghuri's water intake tower - (Left): Full structure during by David Roberts 19th century (Source: TinEye Products, 2017), (Right): Recent situation (Source: Author, 2017).

CAIRO AND SABIL: EVERYDAY WATER SUPPLY FOR THE COMMUNITY

Providing free pure water for the community is an ancient tradition in the eastern Arab world, in deprived zones in particular. This habit grew in Islam where water has a great religious value and providing free pure water for people and animals is considered a type of charity for God (Al-Husseini, 1988). Therefore, Sabil is an Islamic structure for an ancient function constructed according to Islamic ethics. The oldest survived Sabil in Cairo dates back to the Bahri Mamluk period that attached to the Madrasa of Sultan Qalawun in al-Mu'izz Street: this Sabil was built by order of his son Sultan al-Naser Mohamed in 1236 A.D for his father's soul, supervised by Prince Aq'oush - viceroy of Karak (Maher, 1979). Hassan Abdel-Wahab – the archaeologist – mentions that this Sabil was roofed with a dome mounted on a drum, covered with glazed tiles and inscribed with Thuluth calligraphy, in addition to punched windows in the transition zone, both of these features emerging for the first time. Unfortunately, nothing survived from this Sabil except its columns and the drum of the dome without the glazed tiles (Abdel-Wahab, 1994).



Figure 9. A Cairene Sabil-Kuttab by Pascal Coste in 19th - (Left): Facilitating water process (Source: Dotmsr News, 2017) (Right) Learning holy Quran inside the Kuttab (Source: Gallerily Group, 2017).

Sabil usually binds to *Kuttab*, which is a primitive type of elementary school that teaches orphan children about reading, writing, and the holy Quran (Figure 9). In response to this, Sabil typical has a design that consists of an underground cistern and two levels containing sabil and kuttab from which it derives its name. As a result, Cairo has a large number of Sabil-Kuttab in various architectural styles, ranging from Mamluks and Ottomans periods to Mohamed Ali's dynasty. Despite this diversity, these Sabils have the same traditional function since their inception, providing fresh water to passers-by beside *Kuttab*'s educational task (Figure 9).

TANGIBLE AND INTANGIBLE WATER HERITAGE

Mechanism of water: Steering, lifting, transporting, and delivering: all these actions were relevant to water conduction inside the urban area in medieval Cairo and needed integrated methods working with human and animal power for this purpose. This integration manifests in waterwheels which were used to lift from the Nile directly in Yusuf's well and al-Ghuri's water intake tower (Figure 10) but in different scales according to their purpose and function. In addition to *Shadouf* this crane, (Figure 11) invented by the ancient Egyptians was used to raise water from watercourses directly, on either one level or several levels of land according to the water level (Soliman, 2014). Furthermore, buckets and ropes were used for lifting water from the cistern and small wells in narrow space, because the large equipment - waterwheel or *Shadouf* – could not be used in that case as a plain manual process (Soliman, 2014).

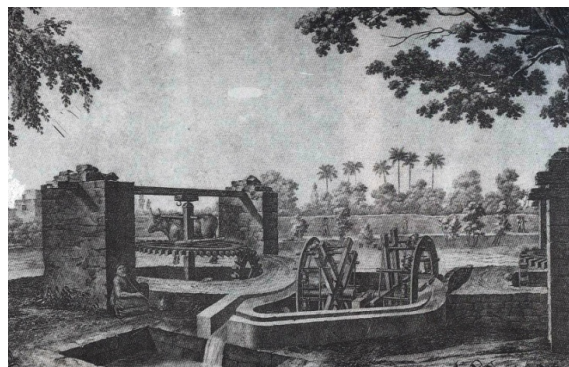


Figure 10. Water Wheel (Source: l' Description de l' Egypte, 2003).

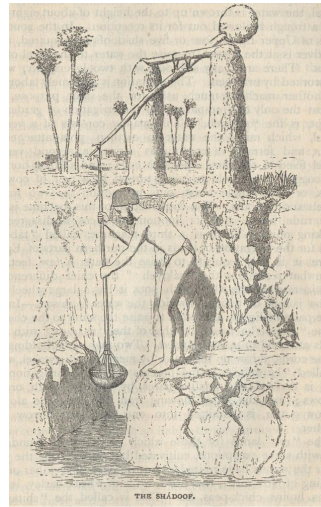


Figure 11. *Shaqouf* (Source: Lane, 1917).

Water handicrafts: Like all major humanitarian activities, water systems are associated with a number of supplementary crafts, such as skin bag maker (Figure 12), potter (Figure 13), buckets, and ropes. From the above, it is obvious how the fresh water was delivered to the major buildings in Cairo, while the water carrier (*Saqaa*) troop was responsible for delivering water to the urban area inside the city, Sabil in particular using the water skin bag made by another troop for a small price, and so on.



Figure 12. Skin bag maker (Source: Msry1 News, 2016).

However, the *Saqaa* clan includes two sections: men carry skin bags on their shoulders; and men carry large skin bags on animals, donkeys and camels in particular. With regards to this, Leonardo Frescobaldi and Simone Sigoli, Italian travellers who visited Syria and Egypt in 1384, relate that “it is believed that there are over 1500 camels for the supply of water to the city, for these Saracens are great consumers, and all the water they have comes from the said Caligine...And every camel that carries the said water is registered, and pays a certain duty to the Sultan for the water that is drawn from the river...”. This information indicates that in spite of its proximity to the Nile, Cairo suffered from “water scarcity” (Levanoni, 2010). At the end of the 19th century, Ali Pasha Mubarak estimated the number of *Saqaa* to be 424, while the number of houses *Saqaa* was 55 persons. This emerges to be two separate clans, although they perform the same work as watering (Figure 14), as evident from their

designation. The number of *Saqaa* who supplied water to houses started to reduce due to the establishment of the English Water Company in the late 19th century (Figure 15), while 424 *Saqaa*s were supplying water to the *Sabils'* cisterns that transfer water using large animals such as camels and mules (Mubarak, 1987). In addition to that, there were "*Saqaa shurba*" clans - as William Lane called them (1833-1835) - who were watering people in brass bowls (Lane, 1917).

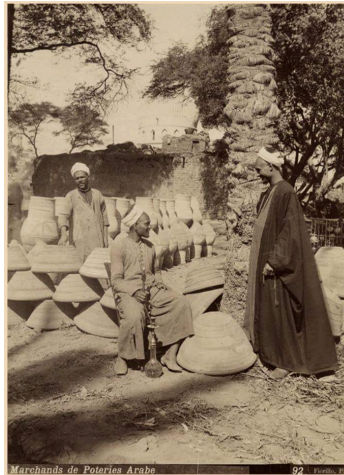


Figure 13. Pottery vendor (Source: Private collection).



Figure 14. Water transporting process- (left): Filling (Source: Flickr Groups, 2017), (middle): Carrying (Source: Lane, 1917), (Right): Home Delivery (Source: Flickr Groups, 2017).

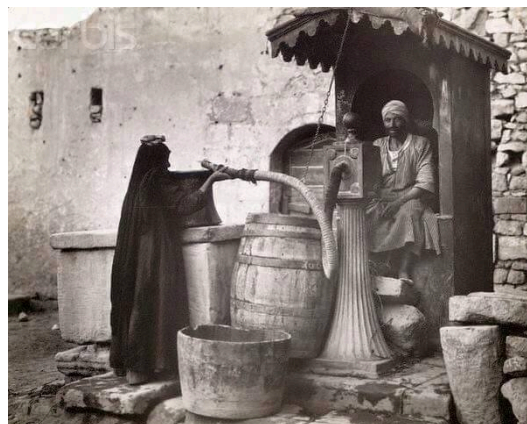


Figure 15. Saqaa of the English Water Company in the 19th century (Source: Flickr Groups, 2017).

Saqaa followed the *Sheikh* of their troop, where jurisprudence and *Hesba* books provide us with many conditions that were to be met, determined by the inspector of weights and "*Muhtashib*" who ordered and prosecuted. These conditions included:

- Filling the skin bags should be proximity to the Nile to keep away from places of dirt.
- *Saqaa* have to be honest: did not mix the Nile water with other salt water, and does not use new skin bag so as not to change the taste or colour and the smell of water from the effect of tanning, which has to be coated by a thick visible cover, so that avoiding dirt on people's clothes.
- The skin bag must be free from any holes that release water lacking which was considered cheating.
- It was prohibited to fill at night because of the difficulty of guardianship, and if this happened, *Saqaa* has to take care of it, in addition to many conditions in ethics of walking on the road, entry of houses, and clothing as well (Soliman, 2014).

Festival of the Nile flood: The Islamic version of ancient Egyptian festival reflects the relationship between the Egyptian people and the Nile regardless of religion. This event aims to announce the revival of Egypt through the annual flood, which deserves to be an appropriately formal and popular festival indeed. Medieval Cairo started the ceremony when the Nileometer observer informed the ruler that the Nile flood had reached up to the perfect level - 16 cubits on the column scale (Figure 18) - then the ruler goes to the Nileometer in al-Rawd_a Island with his cortege, including the commander of the army, well-known princes and the four religious judges, in addition to grand merchants.

The festival was launched when the Sultan broke the lock dam to release the water in to the *Khalij* "the grand canal" and sailed in a decorated torpedo boat to launch the festival, before finally spending that night in recital of the Quran and holding a royal banquet (Figure 16). Additionally, common people would sail in the canal using small boats and hold festivities such as eating candy and shooting fireworks, while clowns performed their folklore competitions (Qarheli, 2010).



Figure 16. The Nile flood festival- (Left) Nileometer at al-Rawd_a island (Source: Author, 2017), (Right): Celebration on Khalij bank at Bab al-Shaeria, by Pascal Coste in the 19th century (Source: Cairo Walking Tours Group, 2016).

Modern models in virtual heritage are becoming more advanced and effective, thus are increasingly facilitating the handling of virtual heritage inputs and outputs. In the case of water systems in Historic Cairo one of the most complicated issues is due to the multiplicity of stages of water heritage since the Nile flood, until it was transferred to the royal and

residential urban contexts. This complicated process includes many phases; lifting the Nile water using water wheel, camel, donkey and water carrier in transportation in the case of the population context. Furthermore, in the royal context (Cairo Citadel mainly) it is more complicated according to the power of the Sultan, as happened when al-Naser Mohammed ibn Qalawun established his Intake tower and aqueduct for delivering water to the citadel. Additionally, the governors expanded the water storage of the citadel cisterns in the Ottoman period, dependant on associated craftsmen such as skin bag makers, Saqqa, carpenters of water wheels, pottery makers, and venders.

Producing virtual water heritage became easier through previous virtual heritage outputs, where discussion and outputs of relevant reports show expertise in various aspects of virtual water heritage. For example; in the Temple of Venus, Baalbek, Lebanon a virtual heritage project featuring a digital recreation of the Roman temple (Berger, 2016). Recreation concept works to put a full perception of missing elements in water heritage sites that are not allowed in reality according to the world code of conservation, while Info-graphic reconstruction of Roman aqueducts in Italy is equivalent to virtual water heritage in VHC project (Caius, 2010; Barragán, 2009).

Virtual environments, which are embedded with cultural heritage and represented through digital media are often categorized as "virtual heritage" (Beng-Kiang & Hafizur, 2009). The conservation of the historic waterfront to improve the quality of life in old Dhaka is an equivalent model for Khalij al-Misri as none exist to consider the watercourse and observation of the westward movement of the Nile course, for example (Rahman & Imon, 2017). Additionally, the virtual reality model of the northern sluice of the ancient dam in Marib/ Yemen, is appropriate to study heritage water installation under any condition (maintained or ruined) using a combination of digital photogrammetric and terrestrial Laser scanning for archaeological applications (Kersten, 2007), which would mainly be applicable for Yusuf's well, al-Naser Mohamed's aqueduct and water wheel, and al-Ghour'i's water intake tower.

CRITICAL VIES OF VIRTUAL MODELS OF WATER SYSTEM

Recently, new media and digital devices facilitate virtual reconstructed historic sites or virtual heritage sites for visitors, travellers or even for a resident. Although virtual heritage poses great potential to reconstruct our ancient heritage and memory, many critics often blame high cost, development complexity, inaccessibility of technology complexity in usability and high maintenance for prohibiting widespread dissemination, distribution and use of virtual heritage media. Some authors have also identified different weaknesses within the interface and delivered contents (Beng-Kiang & Hafizur, 2009).

In the case of Governmental Organizations such as the Egyptian Ministry of Antiquities that rely on self-financing for their activities, it is important to adopt a mechanism to protect intellectual property rights for heritage presented by virtual reality, which is difficult to control. Failing to provide such a mechanism exposes the organization to a loss of an assumed financial source, in addition to falling under the law of the state, which is a waste of public money. Virtual Heritage threatens the tourism movement, which is a source of national income for many countries. A tourist may only visit a virtual site or museum without moving to a live site, which is considered an obstacle to the spread of this advanced technology. In this context, heritage organizations must establish an international mechanism guaranteeing the financial and moral rights of those countries by establishing a charter to regulate the



exchange of information. However, virtual heritage would be applied to limited promotion and education in such a way as to ensure that the tourist or researcher is not excluded from visiting the museum or site. Footage for a project was filmed in Caerwent, where the first Roman town was founded almost 2000 years ago, and is considered a perfect model for a perfect purpose appropriate for a heritage focused Governmental Organization. This promotional piece is part of a bigger project where virtual reality devices will be placed in museums to bring in younger museum audiences to experience Roman culture in Wales. The model we have created in Maya will be the model used in the museum, making use of Oculus Rifts and iPhone apps (Cart Best Video, 2016).

VISUALIZING AND CHALLENGES OF WATER HERITAGE

Chronicles and surviving buildings provide full information about the water system of the Islamic capitals of Egypt ready for virtualization to create a realistic output for the tangible and intangible aspects of water heritage using virtual reality application, although these amounts of information still need more investigation as an independent project. In this case visualizing this information supports a full perception to reveal overlaps of the water heritage of historic Cairo, because of the adjustability of those applications, which is appropriated with the methodology of archaeological research that considers water systems a challenge. On the other hand, conservation processes that take place in water system sites is so difficult to deal with, regarding to world code of conservation - Venice 1964, in particular. Venice Convention calls for the preservation of the authenticity of archaeological sites and buildings without completing the missing elements of the building, but only in cases of necessity. Additionally the site often cannot be reused in the original function; this concept does not enable non-specialized audiences to visualize how heritage water systems operate. Here, the importance of virtual reality as a compensatory method of missing elements gives a perfect perception for everyone.

In this respect, organizations working in the field of preserving cultural heritage, especially governmental organizations such as the Egyptian Ministry of Antiquities, rely on their own funding, which is not often allowed to expand spending in some non-financial projects, water heritage sites in particular. In this case, virtual reality is a benefit as a low-cost technology to transform those sites into developed projects aiming to placing these sites on the touristic and educational plan.

CONCLUSION

Virtual reality is a promising technology for preserving the cultural heritage properties and reviving the tangible and intangible aspects of water heritage, which contains the secret of human life itself in several aspects.

Visualizing the archaeo-historical data for students in all educational stages, students of history and archaeology particularly, facilitates handling with unseen events or a distant archaeological site. Virtual heritage is an adjustable method, where the user can correct his information continuously and in a limited time, rather than the printed books that require to be corrected and reprinted, resulting in misinformation due to loss of time and money.

World conservation code, the Venice Convention of 1964 in particular, obligates preservation of the archaeological heritage aiming to conserve the archaeological raw material as the main target of the conservation process. One of these codes prohibits the completion of



missing fragments of an object; otherwise, it loses its values. On the other hand, reconstruction of demolished monumental buildings should follow the same code. These restricted rules could hinder the sustainable development of the cultural heritage properties, especially in the non-profit governmental organizations, the Egyptian Ministry of Antiquities for example that count on self-financing related to tourism income. In this case, virtual heritage dissolves this conflict by reconstructing the cultural heritage property additionally to reducing the cost of the conservation process without real effect, using new attractive factors to the Islamic water system of Cairo aiming to develop that remarkable type of architecture and put it on the tourism map.

Saqaa clan, handicraft, moral values and songs related to water that are considered intangible heritage, have mostly disappeared because the community no longer needs them. In this context, the importance of the intangible heritage to the old city and the moral values associated with them is evident. Virtual reality is an appropriate method for reviving the intangible heritage through visualizing values related to water.

The Islamic water system of Cairo permeates the poor urban context, surrounded by a poor uneducated community that does not think of anything except earning their food. Threats rise day by day directly related to the poverty rate. Community engagement in the conservation or rehabilitation process for heritage properties is the best way for the maintenance of the cultural heritage, but first the community needs to interact with fascinating and easy methods aiming to raise awareness within the community about the value of the remaining water system artefacts.

Responding to previous conclusions, it is recommended to build up a professional lab for virtual reality studies and projects in major universities and institutions of Egypt to provide expertise for students and graduates of virtual reality, additionally it is recommended to supply the schools with these advanced methods loaded with adjustable information for cultural heritage. Furthermore, the major cultural governmental organizations should build up specialized units for many aspects mainly, heritage conservation, tourism attraction, and to raise awareness of community.

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