# Virtual Reality and Virtual Diving Technologies: Innovative Tools to Promote Maritime and Underwater Cultural Heritage in the Red Sea, Egypt

تقنيات الواقع الافتراضي والغوص الافتراضي: أدوات مبتكرة لترويج التراث الثقافي البحري والمغمور بالمياه في البحر الأحمر، مصر

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## Abstract

Virtual reality (VR) is a synthetic, computer-simulated experience that imitates the real world and stimulates the users' visual and auditory senses. With the aid of developed exosomatic instruments and artificial intelligence, VR users may experience a genuine maritime and cultural heritage environment. Virtual diving (VD) refers to the application of virtual reality technology in the context of Underwater Cultural Heritage (UCH). VD allows diver and non-diver tourists to explore the underwater archeological sites, engaging them in an enjoyable experience. Therefore, this study examines how to take advantage of modern technology to promote the Egyptian UCH to be more reachable to large-scale tourism. The Red Sea is one of the most global sites for marine biodiversity. Five maritime and UCH sites in the Red Sea were chosen which are SS Thistlegorm, Wadi el-Jarf, Marsa Gawasis, Saadana Island, and Ain Sokhna. Researchers designed a spatial geo-database for study sites using Geographic Information Systems (GIS). A qualitative methodology approach was adopted through semi-structured interviews with managers and experts in some official institutions responsible for managing the Egyptian UCH. Results revealed that VR and VD technologies can be applied in particular sites compared to others due to some practical considerations such as water condition, accessibility, the possibility of monitoring the site, and the risk of heritage destruction. Experts have shown great interest in VR and VD, asserting that UCH in the Red Sea necessitates innovative marketing strategies. Eventually, some suggestions for exploiting VR and VD were proposed for managers and policymakers to promote the Egyptian maritime and UCH.

**Keywords:** Virtual diving technology; Virtual Reality; Maritime, Underwater Cultural Heritage; Red Sea; Egypt.

الملخص

الواقع الافتراضي (VR) هو تجربة محاكاة اصطناعية باستخدام التطبيقات التكنولوجية التى تحاكي العالم الحقيقي وتحفز حواس المستخدمين البصرية والسمعية وذلك بالاعتماد على مساعدة الأدوات الخارجية المتقدمة والذكاء الاصطناعي لتقديم تجربة حقيقة ممتعة. يشير الغوص الافتراضي (VD) إلى تطبيق تقنية الواقع الافتراضي في سياق التراث الثقافي المغمور بالماء. يسمح VD للسائحين الغواصين وغير الغواصين باستكشاف المواقع الأثرية تحت الماء في مصر، وإشراكهم في تجربة ممتعة. لذا، تحاول الدراسة الحالية تسليط الضوء على كيفية الاستفادة من التكنولوجيا الحديثة للترويج لمناطق التراث الثقافي البحري والمغمور بالماء لتكون أكثر قابلية للوصول إلى السياحة على نطاق واسع. ارتكزت الدراسة الحالية على منطقة البحر الأحمر الذي يعد أحد أكثر المواقع العالمية للتنوع البيولوجي البحري. حيث تم اختيار خمسة مواقع رئيسية للتراث البحرى والمغمور بالماء فى البحر الأحمر وهى SS Thistlegorm , وادي الجرف , مرسى جواسيس , جزيرة سعدانة والعين السخنة. تم إعداد قاعدة بيانات جغرافية مكانية – Spatial geo-database لمناطق الدراسة باستخدام برنامج نظم المعلومات الجغرافية GIS . كما تم استخدام المنهج النوعي من خلال مقابلات شخصية مع مديرين وخبراء في بعض المؤسسات الرسمية المسؤولة عن إدارة التراث الثقافي المغمور بالمياه والترويج السياحي له في مصر. أظهرت النتائج أن تقنيات VR وVD يمكن تطبيقها في مواقع معينة في البحر الأحمر مقارنة بالمواقع الأخرى بسبب بعض الاعتبارات العملية مثل البيئة المادية، وحالة المياه، وإمكانية الوصول، وإمكانية مراقبة الموقع، واعتبارات السلامة، ومخاطر تدمير التراث. إلى جانب ذلك، أبدى الخبراء اهتمامًا كبيرًا بتقنيات الواقع الافتراضي والغوص الافتراضي، مؤكدين أن مواقع التراث البحري والمغمور بالماء في البحر الأحمر تتطلب استراتيجيات تسويقية مبتكرة للترويج السياحي لها.

الكلمات الدالة: الواقع الافتراضي؛ الغوص الافتراضي؛ ترويج التراث الثقافي البحري؛ التراث الثقافي المغمور بالماء؛ البحر الأحمر؛ مصر

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# 1. Introduction

Maritime and Underwater Cultural Heritage (UCH) are valuable components of humanity's history and heritage as they show how ancestors associated with oceans, lakes, and rivers (Nishikawa, 2021). UCH has huge marine and coastal tourism potential due to its remote position (Bruno et *al*., 2018). Over the past decade, national and international authorities have encouraged advancement and research initiatives, projects, and plans to make maritime and submerged archaeological sites more sustainable and accessible to tourists (Argyropoulos & Stratigea, 2019). Nishikawa (2021) elucidated that UCH aids sustainable development goals (SDGs) and community and economic development. Thus, the value and relevance of maritime and UCH sites should be extensively identified, promoted, and safeguarded.

Tourism is vital to coastal and maritime economies. Guérin (2001) noted that every EUR invested in heritage boosts economic growth by 12. It is frustrating that maritime and UCH sites are complex for underwater archaeologists who discover and conserve them and visitors who desire to dive and explore archaeological sites (Čejka, Zsíros & Liarokapis, 2020). Owing to many restrictions imposed by the marine environment and water, UCH sites, semi- or fully submerged villages, historic ports, and wrecks are not easily reachable, unlike terrestrial sites (Liarokapis et *al*., 2017; Malliri et *al*., 2019).

Previous scholars have stressed the importance of digital and virtual technologies not only for the long-term protection of World Cultural Heritage Sites (WCHS) but also for cultural heritage promotion and marketing for tourism destinations, as they enable tourists to become ad-prosumers (Chandra & Kumar, 2018; Ramos-Soler, Sara, & Alhama, 2019). In the context of maritime and underwater archaeology, virtual reality (VR) and virtual diving (VD) have emerged as innovative technological advancements that blend digital information with actual photos to transform what tourists see at heritage sites and submerged locations into an enjoyable experience (Rainoldi et *al*., 2018). Malliri et *al*. (2019) added that VR and VD technologies could aid in safeguarding on-land and underwater cultural heritage artefacts and creating an understanding of the site's historical value.

Virtual reality (VR) has the potential to transport visitors to a different environment and give them an authentic feel for what it would be like to be there. VR refers to a wide range of practices beyond cutting-edge hardware to create a simulated environment (Hofman, Walters, & Hughes, 2021). Virtual diving (VD) is a technological system that lets any user or tourist experience a realistic underwater environment, eliciting a unique and passionate response. One crucial aspect of VD is immersion, which controls the feeling of being " there," i.e., immersed in the experience. Users' sense of presence, the degree to which they believe they are participating in a reactive experience in an actual-world context, is a significant and critical factor in the success of VD systems (Haydar et *al*., 2011; Aristidou & Michael, 2014; Bruno et *al*., 2017). Consequently, virtual diving could comprehend, promote, and bring attention to shipwrecks, sunken towns, and old ports that are unreachable to the public due to the maritime environment and water depth (Liarokapis et *al*., 2017; Malliri et *al*., 2019).

However, despite the boom and growing interest in the late 20th century's technological advancements such as VR, AR, and mixed reality in tourism and heritage, the potential application of virtual diving (VD) in the context of underwater archaeology has yet to be thoroughly examined. To the authors' knowledge, research on adopting virtual diving technology in the context of Egyptian UCH, notably in the Red Sea, remains marginal. Despite the literature confirming the usefulness of the above visual and interactive technologies in promoting and marketing tourism and heritage (Benckendorff, Moscardo & Murphy, 2006; Han et *al*., 2013; Leue et *al*., 2015; Skarlatos et *al*., 2016; Rainoldi *et al*., 2018), studies exploring the benefits of these technologies have primarily focused on on-land

heritage sites such as museums and heritage buildings (Han, 2018). Few tourism researchers have argued generally different frameworks for cultural heritage digitalization and 3D modeling, arguing its importance for heritage conservation, documentation, and enhancement (El-Rifai, Mahgoub, & Ide-Ektessabi, 2016; Verykokou et *al*., 2016; Malliri et *al*., 2019; O'Brien, 2020).

Nonetheless, little research was conducted in developed nations to investigate the prominence of virtual diving as a system for exploring UCH, with a narrow focus on its promotional role (Bruno et *al*., 2018). One exception is Bruno et *al*. (2016 a)'s study, which discussed the architecture of a VD system that uses modern virtual and augmented reality to explore underwater archaeological sites. These studies can serve as a starting point for current research. On the other hand, UCH sites in the Red Sea have received insufficient attention; prior research showed a significant emphasis on underwater archaeological sites in Alexandria (Abd-el-Maguid, 2012; ELkady, 2017; Abuelfadl-Othman, 2019; Radwan, 2021). While scuba diving has been widely practiced in the Red Sea to explore its coral reefs, little is known about the region's ancient UCH sites, which could be attractive destinations for divers and cultural tourists.

Following the considerations discussed above, the current research seeks to fill the research gap and contribute to the existing tourism and heritage literature by exploring how virtual diving technology could promote Egyptian UCH and diving tourism in the Red Sea. The study focused on some maritime and UCH sites in the Red Sea: SS Thistlegorm, Wadi el-Jarf, Marsa Gawasis, Saadana Island, and Ain Sokhna (Shaikhon, 2021). The Red Sea is one of the most stunning diving areas, with abundant marine life. Moreover, for millennia, it was a significant crossroad. This strategic waterway linking North Africa to the Middle East has an incredible number of sunken monuments and underwater cultural heritage (Ward, 2001; Khalil & Mustafa, 2002; Abd-el-Maguid, 2010; Shaikhon, 2021). Thus, the study seeks to address the following research questions:

*RQ1*: Can virtual technology (VR and VD) provide an opportunity to promote underwater cultural heritage sites?
*RQ2*: What are the key factors influencing the adoption of VR and VD technologies by concerned authorities?
*RQ3*: What are the anticipated advantages of VR and VD in promoting the Egyptian maritime and UCH in the Red Sea?

## 1. Literature review:

### 2.1. Virtual reality and Virtual diving technologies
The cutting-edge information and communication technology tools, such as virtual reality (VR), augmented reality (AR), and mixed reality (MR), that have proliferated in the digitalization era have been proven to consolidate visitors' experiences and learning processes at multiple heritage sites through intelligent systems, wireless communications, applications, and smart devices (Zarzuela, Pernas, Calzon, Ortega, & Rodriguez, 2013). Recently, due to the intangible nature of tourism services, marketers have relied extensively on visual imagery and sensory experiences to create a favourable destination image and boost visitations. Bruno et *al*. (2018) illustrated that the virtual diving system employs VR and the latest 3D reconstruction algorithms to provide virtual guided tours for maritime and UCH exploitation. It is based on the same ideas, fundamentals, and contexts as VR's ability to improve tourist experiences and promote heritage sites (Philbin-Briscoe et *al*., 2017).

On one side, VD is an excellent instrument to enhance diving tourism by enriching divers' and non-divers' underwater experiences and affording tour operators an innovative promotional method via designing a unique virtual tour of the site (Bruno et *al*. 2016b). Nevertheless, VD can attract both

diving and cultural tourists, who fall into two categories: anthropological and hedonistic tourists. Both types are affected by tourism experience-related sentiments (Beltrán-Bueno, M.; Parra-Meroño, 2017). It is anticipated that additional revenue would be provided to the country that hosts cultural and diving tourists as they spend lavishly. This increased revenue has the potential to be an engine of economic growth and sustainable tourism. Virtual diving may serve destinations in the tourism sector, through which they could advertise their underwater archaeology without harming their ecological and historical assets (Ramos-Soler, Sara & Alhama, 2019).

According to Pawaskar & Goel (2014), in tourism, innovative promotional techniques become essential for staying competitive, recruiting more customers, and meeting travellers' needs. Including VD in a destination's marketing strategy can significantly impact how curious travellers find and evaluate attractions. Cultural and scuba-diving travellers can get a feel for the site's vibe and potential feelings via a virtual tour. Based on the aforementioned, people will have a clearer mental picture of the site and more reasonable expectations of what to expect if they decide to go, putting them in a relative position to determine whether they intend to visit the UCH site or not

*Case studies*

***Previous scholars used VR and VD technology to visualize maritime and UCH. These frameworks promoted and increased cultural heritage value.***
Bruno et al. (2018) study implemented a VR system in South Italy's underwater archaeological sites, Capo Colonna and Cala Minnola. The first is in the Ionian Sea on the east coast of Calabria, 10 km from Crotone, where a Roman cargo ship dumped raw and semi-finished stone items at a depth of seven meters. The other is in Levanzo (the Aegadian Islands) in the Tyrrhenian Sea, a few miles off Sicily's west coast, where a Roman transport ship sits at 27–30 meters. Study findings verified that the suggested VR system may deliver a dynamic educational experience with a profound emotional effect and is preferred by numerous users.

Another example of using virtual technologies (VR and mixed reality) in the context of UCH was proposed by Škola et *al*. (2020). They hypothesized that the modern immersive archaeological VR application presenting cultural heritage from a submerged site would sustain high levels of presence, immersion, and general engagement. Participants who visited and explored a realistic 3D reconstruction of the underwater cultural heritage site of Baiae rated the VR experience positively on the questionnaire scales for presence, immersion, and subjective judgment. A high positive rating also concerned the psychological states linked to the experience (engagement, emotions, and the state of flow), and the experience was primarily free from difficulties related to the customization of the VR technology (technology adoption for the head-mounted display and controllers, VR sickness).

An additional illustration of this can be found in the research conducted by Chapman et *al*. (2006) on the VENUS (Virtual exploration of underwater sites) project. This project used mixed reality for a realistic visual representation of UCH to employ VR and AR tools to discover and reach deep UCH sites for archaeologists and the general public. Archaeologists could better understand the data using the virtual submerged location. At the same time, members of the broad audience could enjoy engaging virtual dives at the site.

Research conducted by Pehlivanides et *al*. (2020) about the VIRTUAL Diver project aims to allow access to Greece's underwater treasures with a case study on Santorini Island by developing an innovative platform that offers unique interactive experiences. VIRTUAL Diver is a platform that uses a 3D authoring tool to manage multimedia content in a simplified way. The project further strives to be a new type of digital storytelling, engaging the user in unique underwater experiences. The

research results produced a successful instructive and entertaining cultural product to assist businesses and professionals involved in cultural tourism.

Yet another example of the use of virtual technology is the Underwater Virtual Museum of Malta. This is a comprehensive virtual museum and a platform designed exclusively for "displaying" underwater archaeological sites that are normally inaccessible to the public. It gives the opportunity to investigate shipwrecks around Malta in a virtual reality environment. The research findings revealed that the proposed VR system might raise awareness and hence contribute to a greater desire to preserve Malta's UCH. (Gambin et *al*., 2021)

A further study was conducted by Caciora et *al*. (2021) on the use of virtual reality for the historical wooden churches in Bihor County, Romania. A web portal with integrated 3D models with panoramic images in addition to an easily accessible and freely navigable website Bihor360 including both textual and graphic data were created. According to the research results, the VR experience helped increase public and local government awareness of the value of the historical wooden churches to tourists and the local economy.

Another VR unique experience was launched in 2019 by the Louvre Museum in Paris to explore the Renaissance painting Mona Lisa as part of Leonardo da Vinci's exhibition '*Mona Lisa: Beyond the Glass'*. Interactive design, sound, and animated images allow users to look around the Hall of Mirrors from a 3D perspective, stepping inside the painting and interacting with the whole setting. Through a journey back in time to the original setting, visitors were able to understand the story 'beyond the frame' and discover fine details about the painting, the artist, and Mona Lisa. The experience can be enjoyed in five different languages and is downloadable on VR app store VIVEPORT, iOS, and Android. The virtual experience proved useful as means of expanding the museum's existing devices, from the traditional wall labels to more recent audio and video guides, as well as making culture accessible to a wider public. (https://www.louvre.fr/en/what-s-on/life-at-the-museum/mona-lisa-beyond-the-glass-the-louvre-s-first-virtual-reality-experience accessed on 12/11/2022)

### 2.2. UCH and Tourism

Maritime and Underwater cultural heritage (UCH) are crucial resources for understanding human history, customs, and traditions. Although they are still undervalued today, they are a tangible witness of past human life that must be preserved to ensure its long-term accessibility to current and future generations. Hence, Maritime and UCHs must be recognized as a source of information that has a positive impact on cultural tourism chains and flows and may be related to sustainable tourism operations due to the existence of underwater historical or archaeological ruins and remnants. (Ford & Halligan, 2020)

Underwater cultural heritage (UCH) has been defined by the 2001 UNESCO Convention on the Protection of the Underwater Cultural Heritage as 'all traces of human existence having a cultural, historical, or archaeological character which have been partially or totally underwater, periodically or continuously, for at least 100 years' (Article 1. a). These human traces comprise three categories of remains including sites buildings, vessels, shipwrecks, and their contents, aircraft wrecks, submerged prehistoric cultural landscapes, submerged ports, and harbor installations. (UNESCO, 2001)

The relationship between culture and tourism is inextricable. According to UNESCO (2014), 37% of worldwide tourism is culturally motivated. Cultural tourism accounts for 35 and 40 percent of all overseas travel and is expanding at 15 percent yearly (Vrasida, 2021). The cultural heritage of each nation is an integral aspect of the global cultural heritage (UNESCO, 2014). It is a tourism revenue

source (Apaydin, 2015). It contributes to the blue economy via tourism and leisure activities. Various pieces of literature from the 1990s pointed out that culture tourists are typically well-educated individuals who value cultural authenticity and are willing to pay extra to see specific locations. With the modern conceptual framework for tourism, "experience" has emerged as a central notion (Conti, 2015). Tourists aren't typically motivated by a desire to learn more about a different culture; their primary objective is to have enjoyable experiences, which may involve heritage assets. Therefore, many nations such as Italy, France, Greece, and Malta have begun advertising and promoting UCH to spread knowledge about the importance of protecting the diverse and rich cultural history that lies beneath the ocean's surface and the economic benefits that can accrue from doing so (Koutsi & Stratigea, 2022).

To further boost coastal economies, preserving underwater cultural heritage (UCH) is also a promising avenue for growth in the tourism industry (Bruno et *al*., 2018). Various nations have enacted legislation to enable access to this largely untapped resource in response to an increasing understanding of the significance of UCH in particular (Vrasida, 2021). Historical buildings and locations and marine and UCH sites are the cornerstones of tourist attractions, making promoting and preserving these cultural artefacts a top priority. Maritime and UCH sites are appealing choices for cultural tourism. Although many sites remain unavailable to the general public while they are still in their original locations, a significant fraction of those sites, if properly maintained, may be accessible to the average visitor without jeopardizing their potential to be preserved (Conti, 2015). Numerous artefacts that are part of the cultural heritage of the ocean have been brought to the surface and shown in museums on land. After UCH has been properly valorized, cultural tourism, scuba diving tourism, and cruise tourism are three types of tourism that have the potential to expand particularly effectively (UNESCO, 2014; Lazaretou, 2014).

**2.3. Maritime and UCH sites in the Red Sea**

The Red Sea's rich maritime and underwater cultural sites have left a variety of archaeological remains of great value and highest importance for understanding the development of human culture and civilization. Similarly, historical shipwrecks provide crucial information on past cultural interchanges, trade, local life, and the environment. It should be highlighted that the study sites under consideration fall within the 2001 UNESCO convention's definition of cultural heritage sites, which are those that have existed for more than 100 years. The ancient harbors Wadi el-Jarf, Ayn Sokhna, and Marsa Gawasis are categorized as maritime cultural heritage sites. Still, Saadana Island shipwreck and the harbor of Wadi el-Jarf are considered underwater cultural heritage sites since they are either partially underwater as the submerged pier of Wadi-el-Jarf, or totally submerged like the Saadana Island shipwreck. The following section examines the five selected study sites in the Red Sea exploring their location, history, and importance.

**2.3.1 Ancient Harbors**

One of the oldest commercial routes in the world is the Red Sea, which has hosted ships transporting products from and to Egyptian territory. Ancient harbors and shipwrecks provide unexpected physical evidence for trade in a part of the Red Sea whose significance is less well documented and understood than commerce further south. (Brouwer, 1991, 1992; McGowan, 1994)

**a.   Wadi El-Jarf Harbor**

At present, there are three well-known ancient Egyptian ports that are situated on the western Red Sea coast: Wadi el-Jarf, Ain Sokhna and Marsa Gawasis. The three harbors have been constructed

before the New Kingdom. (Becktell, 2014) The earliest of which is Wadi el Jarf, which is situated on the western coast of the Gulf Suez approximately 24 km south of the modern town of Zafarana. It lies at the foot of Southern Galala mountain which is located close to the Wadi Deir leading to Saint Paul's Monastery, about 5 km from the present-day Red Sea coast. The site is located about 100 km to the south of another ancient Egyptian harbor, Ayn Sokhna. (Tallet & Marouard, 2014)

Wadi el-Jarf, the most ancient Egyptian submerged harbor complex was discovered in 2008 by a joint team of the University Paris-Sorbonne and the French institute in Cairo, (IFAO),[1] and excavations of the site were first brought to attention in 2011. Archaeological and epigraphic sources discovered at the site indicate that the harbor was brought into operation during the reign of King Snefrw and was extensively used by expeditions under his son and successor king Khufu from the Fourth Dynasty (c. 2600-2500 BC).  (Gardiner, Peet, & Cerny, 1952) The harbor was mainly used to reach by boat the Sinai Peninsula, to Serabit al-Khadim and Wadi Maghara, the principal mining areas for turquoise and copper. (Tallet & Marouard, 2016)

The seaport consists of remains of water installations in the form of a massive L-shaped pier facing north and measuring 200 m from east to west and 200 m from north to south. The pier consists of an on-land section and a submerged section that does not exceed a depth of two meters. It was intended to provide shelter against the wind and currents for boats, and it is most certainly currently the oldest remains of an artificial port built in a maritime environment. Near the port, several buildings had also been constructed to temporarily house the teams that were sent on expeditions. (Tallet & Marouard, 2013, 2016)

From an archaeological perspective, Wadi el-Jarf offers a distinctive collection of artifacts and an extraordinary glimpse of the material culture from the first part of the Fourth Dynasty. A set of more than 100 boat anchors, which had been carefully stored there awaiting reuse, were unearthed at the site. Furthermore, an impressive system of storage galleries, comprising more than thirty cavities had been dug in good-quality limestone. These galleries are where the ancient wooden boats had been stored after having been dismantled.[2] (Tallet & Marouard, 2016)



The land part of the pier after the excavation
After, Tallet, 2015, fig. 42



The storage galleries at Wadi El-Jarf
After,
https://www.ifao.egnet.net/recherche/archeologie/ouadi-el-jarf/ (accessed 7/11/2022)

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[1] The excavations at the site of Wadi el-Jarf are a joint project co-directed by Pierre Tallet from the University of Paris IV La Sorbonne and El Sayed Mahfouz from the University of Assiut and Grégory Marouard from the Oriental Institute, University of Chicago and Damien Laisney from the Maison de l'Orient et de la Méditerranée, the French Foreign Office, the CNRS, the IFAO, the French Ministry of Foreign Affairs, the Honor Frost Foundation and French companies such as Vinci, Colas Rail, and Total Egypt.

[2] The ancient Egyptians had to cross the eastern desert by transporting the wooden boats that one wished to use there, and which had to be reconstructed on the shore. To avoid this painful and delicate operation as much as possible, these boat elements were not brought back to the Nile Valley once the expedition was over. They were left
in place, with the rest of the equipment necessary for these expeditions, sometimes for several years, waiting for their reuse. It is for this reason that the most characteristic element of these intermittent ports is the presence, at a short distance from the coast, of a system of galleries-stores. (Tallet & Marouard, 2016)

Boat anchors discovered at Wadi el Jarf
After, Tallet & Marouard, 2014, figs. 17-18

Inside the galleries, abundant material dating from the beginning of the 4th Dynasty as ceramics, tools, seals, pottery, and boat fragments was discovered. Yet the most remarkable discovery was that, during the 2013 excavation campaign, of a very large archive of papyri that had been left at the entrance of one of these galleries. It is the oldest known inscribed papyri yet discovered in Egypt. A part of it has been connected to the construction of the Great Pyramid at Giza. Merer's diary, the daily report of a minor civil servant who is undoubtedly an eyewitness to the construction of this prestigious monument, provides valuable information on the transport of building materials that were intended for the Great Pyramid. The presence of these archives in the site confirms the close link between this harbor's development and Khufu's site in Giza, the port having undoubtedly made it possible to provide copper necessary for the tools of the builders of the monument. (Tallet, 2017 a)
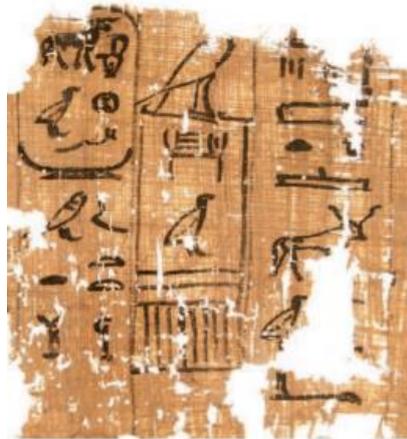


Papyrus fragment from Wadi el-Jarf bearing the name of King Khufu.
After, Tallet, 2015, fig. 27

## b. Ayn Sokhna Harbor

Ayn Sokhna is another ancient Egyptian port situated on the western bank of the Suez Gulf, about 120 km east of the modern city of Cairo. In antiquity, the harbor has been used mainly as a crossing point to reach the southern area of the Sinai Peninsula on the other side of the gulf. Ayn Sokhna is indeed the closest red sea harbor to the city of Memphis, which was one of the ancient Egyptian capitals. In addition to its advantageous position and proximity to a significant administrative center, the site enjoys other privileges. There are no coral reefs nearby, the port is protected from the prevailing north wind, and has a source of drinking water which is surrounded by a small oasis grown up around the hot spring that gave the location its name. (Abd el-Raziq, *et al.,* 2002)

The archaeological site has been under excavation since 1999 by Mahmud Abd el-Raziq, Georges Castel, and Pierre Tallet (Abd el-Raziq, 1999; Abd el-Raziq, et *al*., 2002). Archaeological remains

excavated at the site such as seal impressions, showing the names of kings of the 4th and 5th Dynasties indicate that the area was extensively used in antiquity. It demonstrates two main phases of occupation of the site dating first from the Old Kingdom between Khafra and Pepy II, then from the beginning of the Middle Kingdom between Mentuhotep IV and Sesostris I. The ancient site was also occupied during later periods; in the Byzantine era, Coptic monks built modest hermitages on the historic site, which was still inhabited at the time. (Tallet, 2012, 2015)

As at Wadi el-Jarf, then later at Mersa Gawasis, the excavations have highlighted the presence of ten galleries or cavities 15 to 20 m long, dug in the sandstone since the Old Kingdom and have been reused during later phases of the occupation of the site. These large warehouses were intended to shelter expedition members and for storing equipment during expeditions. It also provided a space where the activities of the teams (housing, kitchen, storage of foodstuff, various workshops) took place during the occupation of the site. These galleries provide archaeological and textual information summarizing a whole part of the site's history. One of the most beautiful examples of these sources is a hieratic inscription, painted on a layer of plaster at the entrance of one of the galleries. It mentions an expedition to the mining area in South Sinai dating from the reign of Djedkare-Isesi and was led by the "troop leader Sedhotep". The excavations of the galleries have also yielded exceptional remains of two Egyptian seagoing ships dating from the beginning of the Middle Kingdom. (Tallet, 2012). Other important expedition-related facilities were discovered below the site, on a natural outcrop close to the sea. Remains of several successive buildings have been unearthed, the most important of which dates to the Old Kingdom. The archaeological site was also occupied by a remarkable set of metallurgical workshops which provide a better understanding of the techniques used in the Middle Kingdom to obtain copper from malachite. (Abd el-Raziq, et al., 2002)

The site's most noticeable feature is an inscription-bearing rocky panel overlooking the site. It is where most of the archaeological remnants are concentrated. About fifty inscriptions, written in hieroglyphs, hieratic, Greek, and Coptic, suggest the occupation of the site over a long period of history. The Middle Kingdom is the ancient Egyptian period that is best represented in the inscriptions. Various official records on missions that were carried out at the site provide the precise year of a king's rule, the objective of the expedition, and the supervision. The name of the last ruler of Dynasty 11, Mentuhotep IV, is inscribed on the most ancient of these stelae. It mentions an expedition comprising 3,000 men. Under the reign of his successor Amenemhat I, this time around 4,000 men were engaged in a similar mission. Additional rock inscriptions provide information on expeditions under Amenhotep I and Amenhotep III during the 18th Dynasty. (Tallet, 2015).



Rock inscriptions of Amnemhat III at Ayn Sokhna
After, Tallet, 2015, fig. 11

## c. Marsa Gawasis Harbor

The harbor of Marsa Gawasis is the earliest discovered ancient Egyptian port, yet it is the latest chronologically of the three ancient Egyptian harbors. The site is situated at the mouth of Wadi Gawasis 23 km south of the modern port of Safaga and 50 km north of Quseir, near the shortest overland route from the Nile Valley in Upper Egypt to the Red Sea. (Ward & Zazzaro, 2009; Tallet, 2015)

The site was discovered in the mid-1970s by Abdel Monem Sayed, a professor at Alexandria University. (Sayed, 1978) In 2001, excavation of the harbor installation was started by a joint team of the University of Naples "L'Orientale" (UNO), Boston University (BU), and the Italian Institute for Africa and the Orient (IsIAO). (Ward & Zazzaro, 2009; Tallet, 2015)

Marsa Gawasis, anciently called *Saww*, was the staging point and harbor for the ancient Egyptian seafaring expeditions to the land of Punt which is situated about 1200-1300 km south of this port somewhere in the region of modern-day Eritrea, Djibouti, and Somalia. The sea route to Punt was an alternative to the river and land routes, however, it was less commonly used due to the logistical challenges of such expeditions and the dangers of long-distance travel to and from the southern Red Sea. During the Middle Kingdom, the sea route from Marsa Gawasis was preferred because of the control of the southern Nile region by the Kerma Kingdom (Nubia) who greatly restricted river-overland access to the land of Punt. In the early New Kingdom, Egypt conquered Kerma and gained control of the Upper Nile, allowing seafaring expeditions through both river-overland and sea routes from Mersa Gawasis. The harbor was abandoned by the late New Kingdom as a result of the bay's complete silting up and due to falling sea levels. (Bard & Fattovich, 2010; Tallet, 2015)

Voyages to the land of Punt were launched to obtain exotic animals, ebony, elephant ivory, gold, and frankincense necessary for religious practice and rituals. Epigraphic sources and archaeological remains demonstrated that the site was occupied during the late Old and Middle Kingdoms, especially during the reigns of Amnemhat III and Amnemhat IV as well as the early New Kingdom. One of the best-documented expeditions to the land of Punt was sent by the New Kingdom Queen Hatshepsut (c.1500 BC) in the ninth year of her reign. It was conducted by the queen's Chancellor Nehsi and it comprised five ships accompanied by 210 men. Hatshepsut commemorated the details of her successful voyage on the walls of her funerary temple at Deir-el-Bahari. (Bard & Fattovich, 2010, 2011; Tallet, 2015)

Other material evidence of seafaring expeditions at Mersa Gawasis includes the remains of cedar wooden beams used in the construction of ships. These ship timbers remain an outstanding feature of the site providing crucial information and unique insights into ancient Egyptian shipbuilding techniques. Among the remains were cargo boxes used for storing the 'wonderful things of Punt', as inscribed on one of them. Moreover, the site offers a distinctive collection of other remains including a collection of ropes of different sizes and limestone boat anchors, ceramics, and pottery vessels. A large number of inscribed seals and stelae bearing the ancient name of Punt provide historical information about various royal expeditions. Most of these artifacts were discovered inside rock-cut caves as the storage galleries found at Wadi el-Jarf and Ayn Sokhna and used for shelter and storage for equipment. (Bard & Fattovich, 2010, 2011; Tallet & Mahfouz, 2012)

Robe remains from caves at Marsa Gawasis
After, Bard & Fattovich, 2010, fig. 6.

### 2.3.2 Shipwrecks

The two shipwrecks Saadana Island and SS Thistelgorm under investigation are widely known amongst the diving community, particularly SS Thistlegorm which regularly appears in those "top ten" dive lists. However, both shipwrecks, their history, and their valuable cargo remains are hardly known outside of the diving community. Bringing such iconic and popular shipwrecks to the surface and telling their tales as 360 videos and 3D models is vital to the non-diver community.

### a.  Saadana Island Shipwreck

As one of the world's oldest commercial routes, the Red Sea has long served as a port for ships transporting products from China and the Far East to the Mediterranean and Europe. The products were transported throughout the Ottoman Empire by ship from the Red Sea to Suez, the Mediterranean, and other points. Nearly two and a half centuries ago, an Ottoman ship dating to the 18th Century, 50 m long was carrying around 900 tons of cargo sadly rammed into a coral reef just off the coast of Egypt and sank more than 100 feet beneath the Red Sea. The ship presumably sank in the 1760s since this area of the sea is challenging to sail due to its shallow waters and the large number of corals. Today the shipwreck lies in a curve of a fringe reef to the north of Saadana Island on the eastern Red Sea coast about 35 kilometers to the south of Hurghada and 15 kilometers north of Safaga (Haldane, 1994, 1996). The Saadana Island shipwreck covers an area of nearly 50 x 25 meters at a depth of 28 and 40 meters. The ship's origin is uncertain because it does not resemble other ships from this era. However, its contents provided insight into the extensive and varied trade that took place during this period, and how Egypt's ports served as a bridge connecting the east and the west. (Haldane, 1994, 1996; Ward, 2001)

The vessel's cargo included more than 600 porcelain artifacts from the Chinese Qing Dynasty's Kangxi period. The porcelain cargo is unique among Chinese export wares and was intended for the Middle Eastern market. Excavations revealed also small clay water jars, more than one type of large storage vessel and tableware, cooking pots, glass liquor bottles, copper wares, organic products including coffee, coconut, olives, and hazelnuts as well as a wide variety of spices like pepper, cardamom, nutmeg from India, and frankincense from Oman, in addition to more personal items such as pipes and jewelry. (Brouwer, 1991, 1992; McGowan, 1994)

Chinese porcelain from Saadana Shipwreck
After, https://en.unesco.org/silkroad/silk-road-themes/underwater-heritage/sadana-islands-shipwreck

The discovery date of the ship is unknown; however, the shipwreck was first investigated in 1994 by the Institute of Nautical Archaeology in cooperation with Egyptian authorities and institutions. To date, this is the first and only project of its kind that has been conducted in Egypt. The work involved excavating artifacts from the wreck, studying the timber, as well as the origin of the ship. So far, about 4,000 objects that have been stored in the Alexandria Laboratory for Submerged Antiquities have been excavated, cataloged, cleaned, and conserved by archeologists of the joint project of INA-Egypt and the Supreme Council for Antiquities of Egypt. A small collection of artifacts along with three anchors were discovered at the site of the shipwreck. (Haldane, 1996; Ward, 2001) Recently a large number of ceramics and porcelain are displayed in the Museum of Hurghada.

### b. SS Thistlegorm

SS Thistlegorm is one of Egypt's most important shipwrecks and one of the greatest and most popular diving destinations, attracting thousands of divers from all around the world. It is considered one of the world's most dived sites over the last 25 years. In fact, SS Thistlegorm with its remaining artifacts combine to create an extraordinary and unique underwater 'World War II Museum' that should be preserved for future generations. (Brown et *al.*, 2020)

SS Thistlegorm was a British-armed Merchant Navy ship with a gun platform built by the famous Joseph Thompson & Sons in England. During World War II in May 1941 the ship departed from Glasgow sailing for Alexandria via south Africa. On reaching the Red Sea the ship had to anchor up for two or three weeks to enter the Suez Canal awaiting further instructions. Thistlegorm was packed with essential supplies for the British Army to support the allied war effort in Egypt. The cargo included materials for war such as trucks, vehicles, aircraft spaces, motorbikes, ammunition, weapons, locomotives, and railway wagons. On the 6th of October, the ship was attacked by a German Heinkel He111 aircraft, dropping two bombs causing a massive explosion and tearing the vessel into two parts. The ship immediately sank, and 4 members of the crew were lost. Today, the ship is upright at a depth of 32 meters down at the bottom of the Red Sea with much of the midship superstructure extensively damaged which makes it accessible to most divers. Fortunately, numerous items of the ship's cargo are still in situ. (Middleton, 2009; Kean, 2009)

The ship was discovered in 1955 by the famous marine explorer Jacques Cousteau by using information from local fishermen. Following the discovery, the site was forgotten until the 1990s when diving resorts began to develop at Sharm El-Sheikh and Hurghada. Since then, the shipwreck was considered an official location for diving and started to attain an international reputation as one of the most remarkable diving destinations. However, this popularity has come to a cost with crowds of divers affecting the structure of the wreck, looting a range of its content in addition to dive boats

that visit and moor at the wreck putting a strain on the ship, resulting in sustained damage to the site. All these factors as well as the immersion of the wreck in salt waters for more than 75 years puts SS Thistlegorm at risk. A joint project of the University of Nottingham, Ain Shams, and Alexandria University is collaborating on 3D and virtual reality to bring the submerged wreck to the surface enabling everyone to experience an unforgettable dry-dive experience. (Middleton, 2009; Kean, 2009; Brown et *al*., 2020).
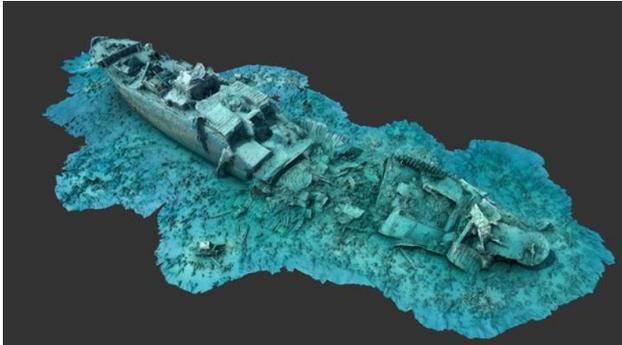

3D reconstruction of SS Thistlegorm shipwreck
After, Brown et *al*., 2020


Mooring ropes for dive boats attached to the deck of the wreck.
After, Brown et *al*., 2020

## 3. Methodology:

A qualitative methodology was used to explore the viability and extent of using virtual diving technology to promote UCH and diving tourism in Egypt, particularly in the Red Sea. The practical study was divided into three phases. First, a spatial geo-database for study sites was designed. Secondly, managers in organizations responsible for tourism, maritime, and UCH were interviewed. Thirdly, based on the theoretical part and the interviews' results, researchers proposed a promotion plan for maritime and UCH in the study sites at the red sea.

### 3.1. Methods

### 3.1.1. Spatial geo-database for study's sites

In this study, five of the most important maritime and UCH sites in the Red Sea were chosen for some consideration. These sites are: 1) the SS Thistlegorm, a popular destination for tourists yearly due to its value as a must-see landmark in the Red Sea. It generates 5 million euros annually and draws large numbers of tourists annually (Johnson & Heritage, 2021). Despite that, the SS Thistlegorm's reputation in the Red Sea and its appeal as a dive tourism destination that contains UCH are not adequately promoted. In addition, the site's current activity is unsustainable, and the presence of a promotional tool that simultaneously raises user awareness for continued tourism is required. 2) Saadana Island is a remarkable site; one of the most important artefacts is a shipwreck with a unique, undocumented construction style. The findings of the wreck include more than 600 porcelain artefacts from the Chinese Qing Dynasty's Kangxi. Three ancient harbors: 3) Wadi el-Jarf is the most ancient harbor installation and the provenance of the most ancient papyrus archive from the reign of King Khufu in Egypt (Tallet, 2015). 4) Ain Sokhna is also one of the earliest ports in ancient Egypt. The site includes essential rock inscriptions that reveal important information about ancient expeditions. 5) Marsa Gawasis is considered the earliest discovered harbor for the ancient Egyptian seafaring expeditions to the land of Punt, especially during the reign of the famous queen Hatshepsut.

Despite the archaeological, cultural, and historical importance of the three ancient harbors and the valuable artefacts discovered there, these sites are hardly known. They have been grossly underappreciated by the public. This might be due to the remote location of the sites from

archaeological attractions and the lack of adequate tourist promotion of the sites. In addition, some of these spots need to be better recognized among cultural and diving tourists; hence, it is necessary to promote these sites on a large scale through virtual technologies. Others, such as Saadana Island, are challenging to navigate due to the shallow sea and the abundance of corals in the area; thus, virtual diving is the best way to locate, explore, and promote this location. Overall, VR and VD are great methods to market both accessible and inaccessible maritime and underwater cultural heritage destinations in the Red Sea. Therefore, researchers designed a Google map to determine the geographical location of the study sites. This map was developed based on the images of the American satellite "Ikonos," and the digitizing process was done in the "Arc GIS program," version 10.5 (Cova et *al*., 2008). Based on previous scholars' literature (Schetselaar, E. M., Tiainen, M., & Woldai, 2008; Pandey, 2014; Bello & Aisabokhale, 2014; Zurmotai, 2020), a spatial geo-database for study sites was created through GIS (Geographic Information System) applications, with determining sites' names, coordinates, longitudes, and latitudes. For doing that, satellite images from the American satellite "ikonos" were used, and their coordinates were geometrically corrected through the Arc-GIS program, one of the most crucial GIS programs. The coordinates of the research points were then uploaded to the spatial database using the GPS device, and their data was entered.

Building a spatial database in geographic information systems for the study sites would provide accurate data that could help academics and exploratory excavations with their scientific research. It would also help people from different fields interested in maritime and UCH, like archaeologists, marine science experts, and geographers, get accurate access to these sites. Furthermore, the GIS* system's compatibility with web-based navigation tools like Google Maps will make it easier for visitors to find and visit these locations. Unlike other historical sites and structures, which can be described and accessed using Google Maps, UCH sites are not visible. They require coordinates, latitudes, and longitudes to discover their precise locations. This also improves tourists' access to those locations through coordinates and GIS integration with web-roaming tools like Google Maps. Since UCH sites are not available on Google Maps, tourists need coordinates, latitudes, and longitudes to find them.

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* GIS (Geographical information systems) is a science concerned with collecting, entering, processing, storing, analyzing ,modeling and outputting data (spatial and descriptive) in the form of maps and reports (Marble, 1990).

**Figure (1) Spatial Geo-database for study sites**
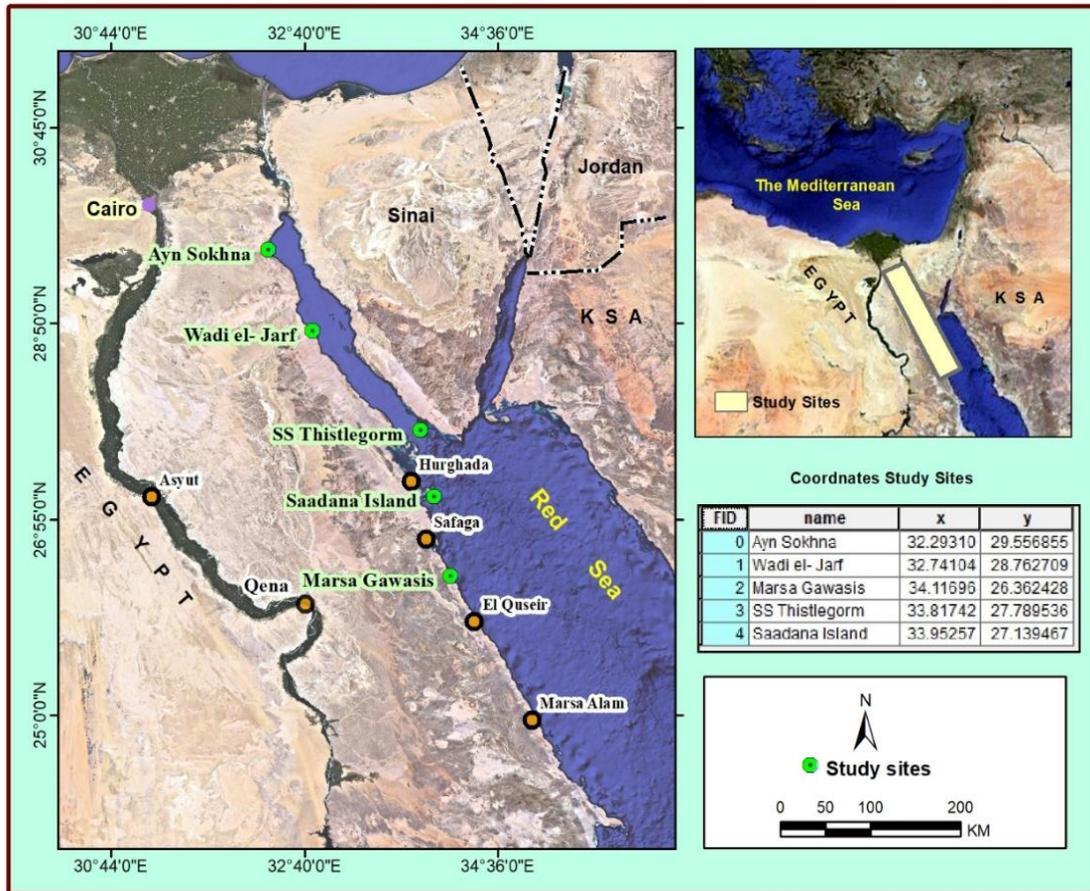


**Source:** *Researchers based on the images of the American Satellite "Ikonos", and the digitizing process was done in the "Arc GIS program", 10.5*

### 3.1.2.   Interviews

### 3.1.2.1.Methods

Semi-structured interviews were used for data collection in this study. Predetermined open-ended questions were designed to explore the experiences of those who know the phenomena. Lune and Berg (2017) stated that interviewing participants is the most common way to collect qualitative data, answer research questions, and discover meaningful insights. Interviews yield abundant data, engage interviewees well, are inexpensive, and do not require the formulation of a hypothesis before getting started (Knox & Burkard, 2009). They encourage participants to share their thoughts and opinions on a variety of issues related to the study's topic and provide researchers with valuable information and suggestions (Brinkmann, Jacobsen & Kristiansen, 2014)

### 3.1.2.2.Interviewees:

The study targeted managers, representatives, and members of six official organizations that are mainly responsible for UCH and diving tourism in Egypt. These organizations include **a** (the Egyptian Ministry of Tourism ,**b** (the General Administration of Diving and Maritime Activities ,**c** ( Alexandria Center for Maritime Archeology and Underwater Cultural Heritage ,**d** (the Chamber of

Diving and Water Sports (CDWS), e) Egyptian Tourism Promotional Authority, f) UNESCO Scientific Committee on Underwater Cultural Heritage*.

Qualitative research seeks to comprehend a phenomenon rather than establish causal relationships (Priporas, Vassiliadis & Stylos, 2012). Unlike quantitative research, which requires a large sample to reach statistically accurate and generalizable quantitative results, qualitative research does not require a large sample size because it seeks detailed information about the research questions (Stephen et *al*., 2015). A *Purposive or Judgmental sampling technique* was adopted based on selecting a specific sample of community members who had unique qualities and prior experiences. This helped the study meet its goals (Gay & Diehl, 1992).

### 3.1.2.3.Research Design and Data Collection:

Initially, emails and phone requests were conducted with 16 managers and representatives representing the management bodies in the selected organizations to explain the study's purpose and politely request their participation in the study by asking them to schedule an appointment to collect the necessary information. Among them, three managers were unable to take part. Thirteen respondents in total participated in the interview, representing an appropriate sample size for conducting qualitative research (Christy & Wood, 1999; Harding & Whitehead, 2013). All interviews took place in September and October 2022, with an average duration of 30 to 45 minutes per interview. There were six interviews held in Alexandria. Two interviews were audio-recorded at the respondents' request, and three were accomplished over the phone. The other two interviews were conducted using an online Zoom meeting.

Interview questions were developed using Castillo-Montoya's (2016) method. The interviews were structured around three main thematic areas of discussion. The *first theme* focused on the possibility of using virtual technology to **create an opportunity to** promote UCH and diving tourism in the Red Sea region. The *second one* discussed the initiatives and procedures taken by the relevant authorities in this regard. The third area contains the challenges that could arise when trying to reap the promotional benefits of virtual diving technology and how to overcome them. The *third theme* included the anticipated advantages of utilizing virtual diving technology to promote the Egyptian UCH in the Red Sea. *In the end,* interviewees were asked whether they had any suggestions regarding the research topic.

## 4. Results and Discussion

### 4.1. Interviews results

The findings of the conducted interviews are illustrated as follows:

**Regarding Theme 1.** *The current situation regarding the promotional effort for the maritime and UCH for Wadi El Jarf, Marsa Gawasis, Saadana Island, and Thistlegorm shipwreck in the Red Sea*

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*Prof. Dr Emad Khalil, Professor of Marine Archeology at the Faculty of Arts, a member of the UNESCO Scientific Committee on Underwater Cultural Heritage

All participants from the surveyed organizations agreed that technology has become widely used to promote and preserve archaeological sites. However, there was a strong emphasis on the 3D modeling and the limited virtual tours for only on-land heritage sites, whether for well-known sites such as the pyramids, tombs in the Valley of the Kings, and private tombs, or less well-known locations such as private tombs at Giza, such as the tomb of Queen Meresankh III, and the tomb of Menna TT 69 at Luxor. Interviewees in the Ministry of Tourism and Antiquities stated that such virtual tours were indeed necessary to preserve these small tombs with limited capacity and to safeguard their wall decorations. Nevertheless, 87.5% of the participants revealed that marine and UCH, notably in the Red Sea, didn't get enough promotion compared to terrestrial sites.

Furthermore, 68.8% of interviewees indicated that visualization of on-land sites could not replace the experience in-situ, except in extraordinary cases such as the COVID-19 epidemic. For example, the Ministry of Tourism, in collaboration with its partners from scientific and archaeological institutes and institutions, has launched virtual visits for some heritage sites via the official pages of the Ministry on the Internet and social media.

Due to the fact that many UCH sites are difficult to reach for many reasons, including the nature of deep water, the fear of UCH destruction, the distance of some UCH sites from tourist attractions, and the inability of some tourists to dive, it is necessary to use modern technology to display the historical and cultural value of submerged sites. Despite this, less thought has been given to utilizing technology to promote these submerged regions. In addition, over 62.5% of the sample claimed that most promotional materials distributed by Egyptian tourism promotion authorities focus primarily on archaeological sites in Alexandria. In sum, most participants agreed that UCH in the Red Sea needs more attention in general.

According to most interviewees (81.25%), marketing campaigns have yet to focus mainly on promoting underwater cultural heritage and diving tourism in Wadi El Jarf, Marsa Gawasis, Saadana Island, and the SS Thistlegorm shipwreck in the Red Sea. Some interviewees revealed that the "SS Thistlegorm Shipwreck" had been digitally captured by producing accurate photo-realistic 3D renderings as part of a project based on existing relationships between the universities of Nottingham, Ain Shams, and Alexandria (https://thethistlegormproject.com/). They added that Thistlegorm's VR tour was only published via the project's website.

According to them, tourism activity related to maritime and UCH sites should be promoted as part of an inclusive tourism program. They noted that diving tourism at underwater cultural heritage sites is practiced either by tourists interested in UCH who already know the archaeological areas in the Red Sea where diving is permitted or by chance without including it in their original itinerary.

*AS for Theme 2. The key factors influencing the adoption intention of VR and VD technologies by concerned authorities*

Even though tourism and heritage are two sides of the same coin, interviews showed no coordination between official parties in the field of underwater cultural heritage and tourism. They said they usually work separately. This confirms what was said by AbdelNaby's research (2017), in which she noted that each authority or institution in heritage and tourism works independently in its own field.

All interviewees agreed that putting VD technology into practice may be hampered by several obstacles such as lack of adequate funding: the high financial cost is likely the biggest and most significant barrier to the effective use of VR and VD technologies. Insufficient technological infrastructure, as well as the lack of skilled personnel: The application of VR and VD technologies is a challenging task, which requires a variety of expertise and an interdisciplinary team committed to the use and development of such applications. This perspective was further supported by the research conducted by Shehade and Stylianou-Lambert about virtual museums (2020). Besides, the difficulty in coordinating with external organizations and the lack of collaboration between the relevant authorities, and the top management's refusal of virtual diving technology's implementation and disbelief in its significance.

The interviewees stated that a profound study should be conducted to allocate specific halls in museums for displaying VR and VD technology considering that the space is compatible with each site, its history, and its scenario. This should include a study of the exhibition space and interaction design to create an executed virtual reality environment and engage the visitors with the material and bring history to life.

Interviewees have also highlighted the necessity of exploring other nations' achievements in implementing and utilizing VR and VD technologies and attempting to benefit from their successful experiences and trying to avoid the challenges and obstacles they have encountered. According to interviewees, it is essential to identify the authorities that are responsible for promoting the application of VR and VD technologies as well as the promotional tools and strategies. To accomplish the goal, an exact and clear action plan should also be established.

**Concerning Theme 3.** *The anticipated advantages of VR and VD in the context of promoting the Egyptian UCH in the red sea*

All interviewees agreed that virtual reality and virtual diving could be beneficial in raising tourists' awareness regarding maritime and UCH preservation and sustainability by showing them how to deal with and protect maritime archaeology. Most interviewees (87.5%) confirmed that these modern technologies enable tourists to visit and experience inaccessible UCH sites, such as those located far from the most popular tourist attractions. These locations will not pique the interest of tourists, and there will be no opportunity to incorporate them into the tourism program. For example, ancient harbors like Wadi El-Jarf, Ayn Sokhna, and Marsa Gawasis, are deemed boring for visitors to explore independently since they are distant from tourist attractions (for instance, far from Luxor or Giza Governorate). Additionally, these ports include only some caves and archaeological remains, which may not appeal to tourists. Consequently, exploring these inaccessible places virtually could be better for many tourists. In this regard, managers in the General Administration of Diving and Maritime Activities, CDWS, and ministry of tourism noted that most on-land heritage sites such as ancient temples, tombs, and buildings can be easily included in a tourist's itinerary compared to marine and UCH sites.

The majority of participants stated that the three ancient harbors, as well as the Saadana Island shipwreck have a remarkable and fascinating history. Virtual reality, virtual diving, and a pleasant

digital storytelling scenario that may be created for these harbors will significantly enhance the experience. However, in the case of Saadana Island, many sunken artefacts were discovered by expeditions and are currently displayed in the Hurghada Museum. Interviewees assumed that tourists may be interested in a virtual diving experience if a hall is developed at the Hurgada Museum to display a VD tour of Saadana Island, backed by digital storytelling that narrates the island's history. This type of immersive experience would certainly perform better than the current "silent" exhibition of these artefacts.

These results are in line with what was found in studies conducted by Bruno et *al*. (2020) and Pérez-Reverte Mañas *et al*. (2021), in which they noted that VR and VD technologies could provide enjoyable dive experiences to exploit maritime and UCH sites in order to enrich cultural tourism and diving tourism in different destinations. They also noted that UCH's invisibility, vulnerability, and limited availability require adopting such modern technologies. Another study carried out by Navarrete (2019) proved the usefulness of virtual technologies in protecting cultural heritage, enhancing its value, and raising public cultural awareness.

In contrast to the sites mentioned above, the case of SS Thistlegorm is different. Since SS Thistlegorm is located in a region that attracts many tourists annually, it makes perfect sense to include it in a tourism program. Moreover, virtual diving could be used as a promotional tool for luring high-spending divers and cultural tourists to visit SS Thistlegorm. This result agrees with what was discussed by Salem et *al*. (2021) in which they proved that virtual tours could influence tourists' intention to visit the heritage site in the future.

Some respondents demonstrated that virtual diving could be helpful also in the case of sites containing artefacts that could be damaged by actual diving such as Saadana Island. This result confirms what was noted by Ch. Ward (2001) that cargo remains were stolen from Saadana Island. Managers at the General Directorate of Diving and Marine Activities said that, for instance, some tourists who dive into the Red Sea cut pieces of coral reefs and take them home as souvenirs.

Furthermore, all interviewees emphasized that virtual diving technology can be applied to specific regions compared to others. They attributed that to practical considerations such as the physical environment, water condition, accessibility, the possibility of monitoring the site, safety considerations, and the risk of heritage destruction.

*From what has been discussed, it seems that virtual reality and virtual diving technologies can be helpful in three situations:*

- *Firstly*, promoting and attracting many diving and cultural tourists to UCH sites where actual diving is possible and integrating this experience into a comprehensive tourism program like SS Thistlegorm.
- *Secondly*, promoting submerged cultural heritage places that are suited for actual diving, but the actual diving may cause heritage destruction due to theft or damage. Hence, the virtual experience is the optimum option in this situation, such as Sadana Island.
- *Thirdly*, promoting marine and UCH sites (whether actual diving is possible or not) that are far from popular tourist attractions and, as a result, may be difficult to incorporate into an inclusive tourism program such as Wadi el-Jarf, Ayn Sokhna, and Marsa Gawasis.

According to most participants, virtual reality and virtual diving would allow non-divers to live a realistic diving experience, especially those who desire to practice scuba diving but cannot due to health issues or a fear of the deep water.

*At the end, interviewees proposed some suggestions regarding the research topic which are:*

Local authorities, such as the Ministry of Tourism and Antiquities, must reconsider regulations requiring a 100-year period for a site to be considered a cultural heritage site, particularly in the case of significant archaeological sites such as shipwrecks (SS-THISTLEGORM), which can generate income for the Egyptian tourism destination.

Most of the interviewees pointed out that the Ministry of Tourism and Antiquity currently lacks an accurate record of all the maritime and UCH sites situated in the region of the Red Sea. Therefore, they further highlighted the significance of creating a Google map that accurately pinpoints the precise locations of all maritime and submerged heritage sites in the Red Sea.

Some interviewees proposed designing and creating various temporary or permanent exhibitions either in museums or heritage sites. Utilizing VR and VD technologies may provide a new level to these museum exhibitions and their collections by making exhibits interactive and placing things into context. These exhibits may be considered a primary attempt toward a larger-scale virtual technology application for maritime and UCH sites designed to be displayed in specific museum halls in the near future.

**Based on what was discussed above in the literature review and through interview results, researchers proposed a promotional plan for study sites, including required actions that should be previously implemented before the promotional step (see table 1).**

| Table (1) Proposed Promotional Plan | | | | |
|---|---|---|---|---|
| **Main goal** | **Required Actions** | **Proposed promotional tools** | **Target groups (the promotional efforts directed to…)** | **Concerned authorities that should be involved** |
| **Promote maritime and UCH for: Wadi El Jarf, Marsa-Gawasis, Saadana Island, Ayn Sokhna and SS Thistlegorm shipwreck in the Red Sea** | (1) Form a committee consisting of archeologists, historians, academics, and experts in technology, tourism, heritage, and engineering to determine the requirements for applying VR and VD technologies for sites under study. (2) Allocate halls in specific museums to display VR and VD tours, allowing interaction between the user and the experience. Researchers proposed the following museums for each site: - *Hurghada museum for **Saadana Island*** - *Grand Egyptian Museum in Cairo for **Wadi El Jarf*** - *Hurghada museum for **Thistlegorm*** - *Luxor museum for **Marsa-Gawasis*** - *Museum of Suez for **Ayn Sokhna*** (1)   Create story-telling scenarios about important characters and history and events related to each site. (2)   Design advertising Campaigns | (1) Print advertisements such as brochures, advertisements in magazines & banner Ads. (2) Websites (of official organizations and museums), considering design and creating innovative digital photos for web ads and Create video content). (3) Social media platforms (Facebook, Instagram, Twitter …etc.) (4) VR Goggle advertising (5) SEO (search engine optimization) tools (6) Arrange visits to educational institutions (7) One-day trip (arrange visits to VR & VD halls in the proposed museums to showcase to users some of the different aspects of the site's history). (8) Pay-per-click (PPC) (allows advertising agencies to buy website visitors. Advertisers pay for each click on advertising on Google and other search engines. These advertisements often are found at the top of search pages and are bid-based, while advertisements on websites have predefined costs. (9) Celebrity marketing campaigns | International and domestic tourists, Travel agencies, Hotels, airports, educational institutions, tour guides, Museums, and tourism information centers | *Authorities that are directly responsible for planning and implementing VR and VD technologies* **a**) Egyptian Ministry of Tourism and Antiquities **b**) General Administration of Diving and Maritime Activities **c**) Alexandria Center for Maritime Archeology and Underwater Cultural Heritage  **d**) Chamber of Diving and Water Sports (CDWS) e) Egyptian Tourism Federation f) Professionals in history, heritage, archaeology, and tourism from Higher educational institutions ── *Authorities that are indirectly responsible for planning and implementing VR and VD technologies* a)   Ministry of Environment b)   Ministry of Communications and Information Technology c)   Private sector ── *Authorities that are responsible for promotion* 1)   Egyptian Tourism Promotional Authority 2)   Travel agencies 3)   Museums 4)    Private sector |

*Source: Researchers based on the theoretical part and interviews*

**Conclusion and recommendations:**

The current study has examined virtual reality and virtual diving as cutting-edge methods of showcasing and promoting Egypt's marine and underwater cultural assets in the Red Sea. The results of the interviews indicate that the Red Sea's valuable underwater cultural legacy has yet to receive much attention despite marketing initiatives directed toward recreational tourism. Respondents also expressed enthusiasm for VD technology, arguing that creative promotion is essential for shedding light on maritime and UCH in the Red Sea, attracting cultural and diving tourists.

They noted that using VD might present a chance to gain an edge in the market by creating exciting and engaging tourist sites that draw in both virtual and in-person visitors and shine a light on Egypt's buried treasures beneath the sea. This virtual experience could entertain users, allowing them to explore the archaeological site and have an enjoyable experience. Considering the preceding, the study makes the following recommendations:

- Virtual diving tours need to be supported by interactive digital storytelling to allow virtual tourists to feel associated with and immersed within the archaeological site, increasing their relatedness, and richening their virtual experience. This may be useful in the digital age, where users do not have time to read or watch lengthy content.
- A detailed evaluation is needed by the General Administration of Diving and Maritime Activities, the Alexandria Center for Maritime Archeology, CDWS, in collaboration with the Ministry of Tourism and Antiquities and Archeology Excavations, to classify archaeological sites in the Red Sea into two groups: first, sites suitable for both virtual and actual diving; and second, areas where actual diving is not possible and therefore virtual diving would be the most appropriate method to explore these attractions and engage tourists in an enjoyable experience. This could make the Egyptian destination more accessible to many tourists.
- Tourism and diving officials and private sector institutions should examine various ways to raise public awareness of the underwater cultural heritage, such as designing awareness campaigns in educational institutions such as schools and universities. These campaigns should be carried out under the supervision of the Ministry of Tourism and Antiquities, academics, and experts specialized in maritime archaeology.
- It is also necessary to celebrate Egyptian underwater cultural heritage by planning and to organize "UCH Day" and effectively promoting it. This event aims to raise internal and external tourists' awareness of the sunken cultural heritage value and how to preserve it, given the insufficient efforts to revive and protect it.
- The Egyptian Tourism Promotion Authority should design advertising materials describing the underwater cultural heritage sites in the Red Sea, encouraging travel agencies to incorporate museums that include virtual diving technologies as a part of the itineraries they offer in the tourism programs.
- Since virtual diving provides archaeological sites as realistic tourism attractions in a way that attracts potential online and real-world tourists, a sufficient budget should be allocated to implement VD technologies.
- A professional committee consisting of members from the Ministry of Tourism and Antiquities, the Alexandria Center for Maritime Archeology, and CDWS, in collaboration with experts in ICTs, should be formed to investigate and determine the essential technology resources and requirements needed to apply VD technology.

- Egyptian tourism and diving authorities should consult experts in virtual diving technology in collaboration with the Ministry of Communications and Information Technology to determine the technological infrastructure and resources needed to prepare and present successful virtual diving experiences in submerged heritage sites. They should also learn from other countries' successes.
- Incorporating the concept of submerged cultural heritage into the curricula of the different educational stages will educate students about the importance of preserving cultural heritage.

## Limitations and implications for future research

Future research in this field may draw inspiration from this study in various ways. In particular, five maritime and underwater archaeological sites in the Red Sea have been chosen as testbeds; however, other maritime and underwater cultural heritage sites in the Red Sea should be investigated to draw attention to the importance of these sites and to promote tourism. Further studies should also examine the behavioral intentions of domestic and international tourists to experience VR and VD tours in the context of maritime and underwater cultural heritage. Barriers to VR and VD technology adoption in maritime and UCH sites in the Red Sea are also significant issues for future research. Also, academic institutions and exploratory excavations would benefit from the spatial geo-database of the study sites for their scientific studies. Lastly, more study is needed to examine the required resources to implement these modern technologies.

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