TECHNICAL PAPER

3D scanning, 3D virtual reality, and 3D printing for Najaf Holy City's cultural heritage and identity

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Abstract
Recently, great development in 3D technologies facilitates digital preservation of cultural heritage. Najaf holy city in Iraq has a rich ancient cultural history, which includes historic groups of buildings, monuments, sites, natural heritage, and energy and sustainability systems in the heritage's buildings. The Center of Preserving of the Cities Heritage and Identity (CPCHI) at International Energy and Environment Foundation (IEEF) founded a first roadmap in preserving Iraqi cultural heritage and identity with 3D scanning, 3D virtual reality, and 3D printing technologies. Part of this project was dedicated to the holy city of Najaf because of its rich cultural heritage. In this part, we intend to share how these three dimensional technologies can be the first step of intervention to save Najaf history. Furthermore, this work highlights the accelerating risks threatening Najaf cultural treasures. We also aim to get our local peoples to think about what we as a community can do to save heritage within our reach, before it is lost to us forever. Not knowing about Najaf heritage is of course a key risk. Moreover, this work is intended to raise awareness of heritage issues in Najaf city by identifying those heritage places, monuments, sites, and the important objects.
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Keywords: Iraq; Najaf; Cultural heritage; Preservation; 3D printing; 3D scanning; 3D virtual reality.

1. The importance of cultural heritage
Cultural heritage is an expression of the ways of living developed by a community and passed on from generation to generation, including customs, practices, places, objects, artistic expressions and values. Cultural heritage is often expressed as either intangible or tangible cultural heritage (ICOMOS [1]). As part of human activity, cultural heritage produces tangible representations of the value systems, beliefs, traditions and lifestyles. As an essential part of culture as a whole, cultural heritage, contains these visible and tangible traces form antiquity to the recent past.
Cultural heritage provide an automatic sense of unity and belonging within a group and allows us to better understand previous generations and the history of where we come from. Understanding our cultural heritage can give a sense of personal identity. It has the enormous power to join people of different backgrounds. Together people can discuss the shared symbols of their collective memory and consequently work together to rebuild their own identities. Our heritage and culture is what gives us faith, will and hope.

Cultural heritage has a deep importance to who we are and shapes us into what we are. Najaf cultural heritage is very important in understanding the story of Najaf; its history, identity and its people [2]. The preservation of Najaf cultural heritage begins with understanding this heritage. Only then may we begin to value it. From there, we can learn to care for a culture and eventually enjoy it. With more enjoyment, we will want to learn and understand more (Heritage Cycle [3]).

2. Najaf Holy City's cultural heritage and identity

Cultural heritage sites are becoming collateral victims with the increasing frequency and intensity of disasters, both natural and human induced. There are many different risk factors that threaten our cultural heritage. These include direct and indirect factors, natural risks that could be catastrophic, sporadic or constant, neglect, decay and inappropriate development, wars and conflicts, bad restorations and reconstructions, looting and illicit excavations of sites, and urban planning policies and their consequences; all of which have a heavy impact on cultural heritage [4].

Iraqi cities have a world's oldest cultural histories [5]. Najaf city is one of the sacred cities of Iraq. The Najaf area is located 30 km south of the ancient city of Babylon and 400 km north of the ancient Biblical city of Ur. It is located on the edge of western plateau of Iraq, at southwest of Baghdad the capital city of Iraq, with 160 km far from the capital. The urban civilization triangle: the area bounded between Kufa, Al-Hira, and Najaf, called termed as urban civilization triangle, is one of the important spots of the era before Islam, has been deeply talked about by historians; because it is located within the area of world civilization accumulation that goes back thousands of years before been settled migrants. It is raised upon sea level with almost 70 meters, and is situated on the longitude of 19 degree and 44 minutes, as well as on the latitude of 31 degree and 59 minutes [6].

Najaf city changed and became a big city, its range was expanded and its inhabitants became crowded, this is because of existence of Imam Ali's holy shrine (peace be upon him) which gave the city a mark of holiness and respect. The Imam Ali Mosque is housed in a grand structure with a gold gilded dome and many precious objects in the walls. Nearby is the Wadi Al-Salam Cemetery, it is the largest in the world. It contains the tombs of several prophets, scientists, and many of the devout from around the world. Over the centuries, schools, research and education centers, and libraries were built around the shrine to make the city the center of learning for many sciences and theology. The city then became a center of religious leadership along with a resort of scientific figures [7, 8].

3. 3D digital cultural heritage

3D technologies are increasingly used in archeology and in cultural preservation. It provides museum curators, researchers and archeologists with new tools to capture in 3D ancient objects, artifacts or art pieces. They can then study, restore or simply archive them with much more details than traditional 2D pictures. It is even possible to 3D scan entire archeological sites to get a full 3D mapping. It is possible to use 3D scanning to keep accurate 3D mappings of those historical locations. Professional 3D scanners with a large scanning area allow archaeologists to capture a full site in 3D and obtain a 3D model of the excavation site. It is thus easier to visualize locations of archaeological remains and optimize the excavation site searches [9].

With 3D scanning, archaeologists or museum curators can improve the conservation of their collections. They can even repair or duplicate the most damaged items, by using 3D printing and 3D scanning. It only takes a few minutes to 3D scan a human-size statue. The 3D model obtained (a simple file) can then be saved, archived, and 3D printed.

3D models generated with a 3D scanner are often used by researchers, who can zoom-in on the 3D model of the item captured in 3D. The high level of details of the 3D scan can be very useful for research purposes, since almost invisible details can be revealed with this technology. Working on 3D models instead of original pieces also enables researchers to protect sensitive artifacts. With 3D printing, it is possible to replicate an entire object or specific parts. Researchers can then work on the 3D printed replica and manipulate it while preserving the original objects [9].

Researchers worldwide can share 3D models obtained by 3D scanning and collaborate remotely. 3D scanners allow scientists to capture 3D models of artifacts. The 3D files obtained can then easily be shared via internet with the global scientific community [10].

Having an exact copy of an historical item will allow the museum to give more access to his collection to the public. For example, allowing students to touch and manipulate 3D printed art pieces or artifacts is a more recreational way of teaching than just showing the object. A 3D printed replica, based on a 3D scan

of the original object, can also be used and manipulated by archeologists or researchers, without fear of damaging the original piece [10].

3D technologies open the doors to virtual visits of museums and learning more. With these visits, persons begin with understanding the cultural heritage. Then they will begin to value it. From there, they will learn to care for a culture and eventually enjoy it. With more enjoyment, they will want to learn and understand more.

4. Preserving Najaf holy city's cultural heritage and identity

Najaf holy city has a rich cultural history, which includes historic groups of buildings, monuments, sites, natural heritage, and energy and sustainability systems in the heritage's buildings. Preservation of sites like these is a top priority for many local historians, who will do anything in their power to ensure that the remarkable buildings and monuments at these heritage sites live on for future generations to appreciate.

The Center of Preserving of the Cities Heritage and Identity (CPCHI) at International Energy and Environment Foundation (IEEF) founded a first roadmap in preserving Iraqi cultural heritage and identity with 3D scanning, 3D virtual reality, and 3D printing technologies [11]. Part of this project was dedicated to the holy city of Najaf because of its rich cultural heritage. In this part, we intend to share how these three dimensional technologies can be the first step of intervention to save Najaf history. This work is very important for the conservation at the details and decorative works level as sculptures, or decorations which form an integral part of the monument. The 3D models of this project will be very important in all works of preservation, restoration or excavation. Furthermore, this work highlights the accelerating risks threatening Najaf cultural treasures. We also aim to get our local peoples to think about what we as a community can do to save heritage within our reach, before it is lost to us forever. Not knowing about Najaf heritage is of course a key risk. Moreover, this work is intended to raise awareness of heritage issues in Najaf city by identifying those heritage places, monuments, sites, and the important objects [12].

Interesting results have obtained from this project. Some examples covering different types of Najaf city cultural heritage like monuments, manuscripts, archaeological sites, buildings, works of art, artifacts, and so on, have created and presented in the following figures (1-12).
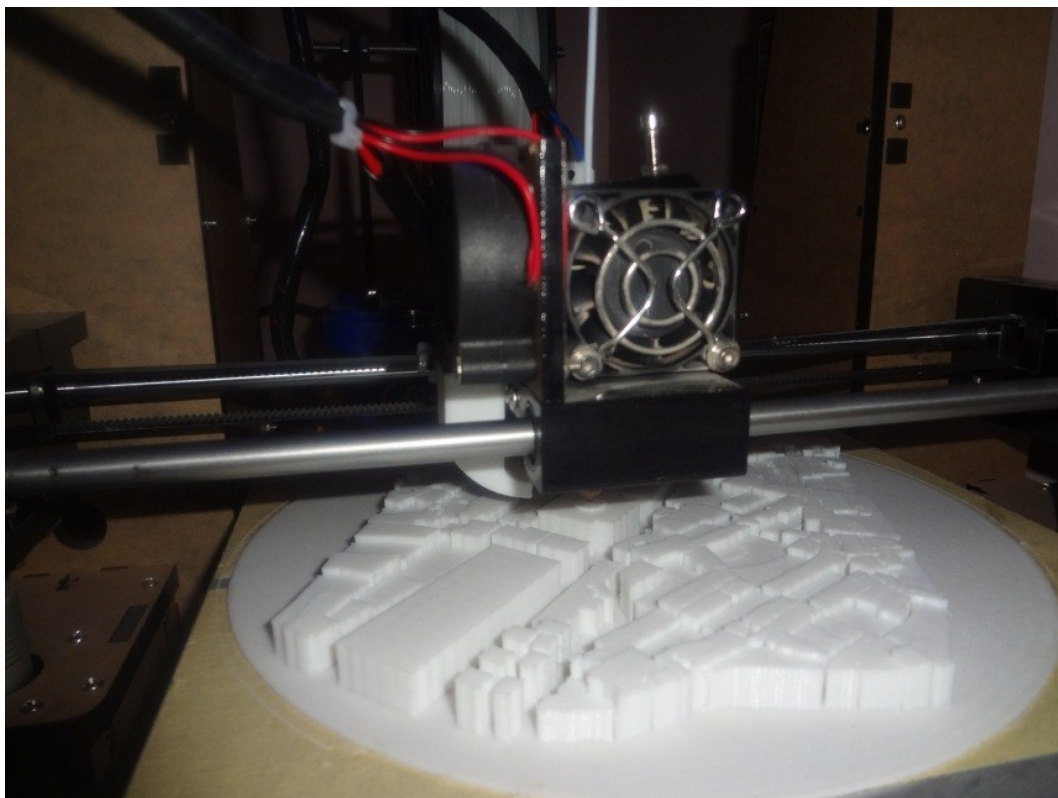

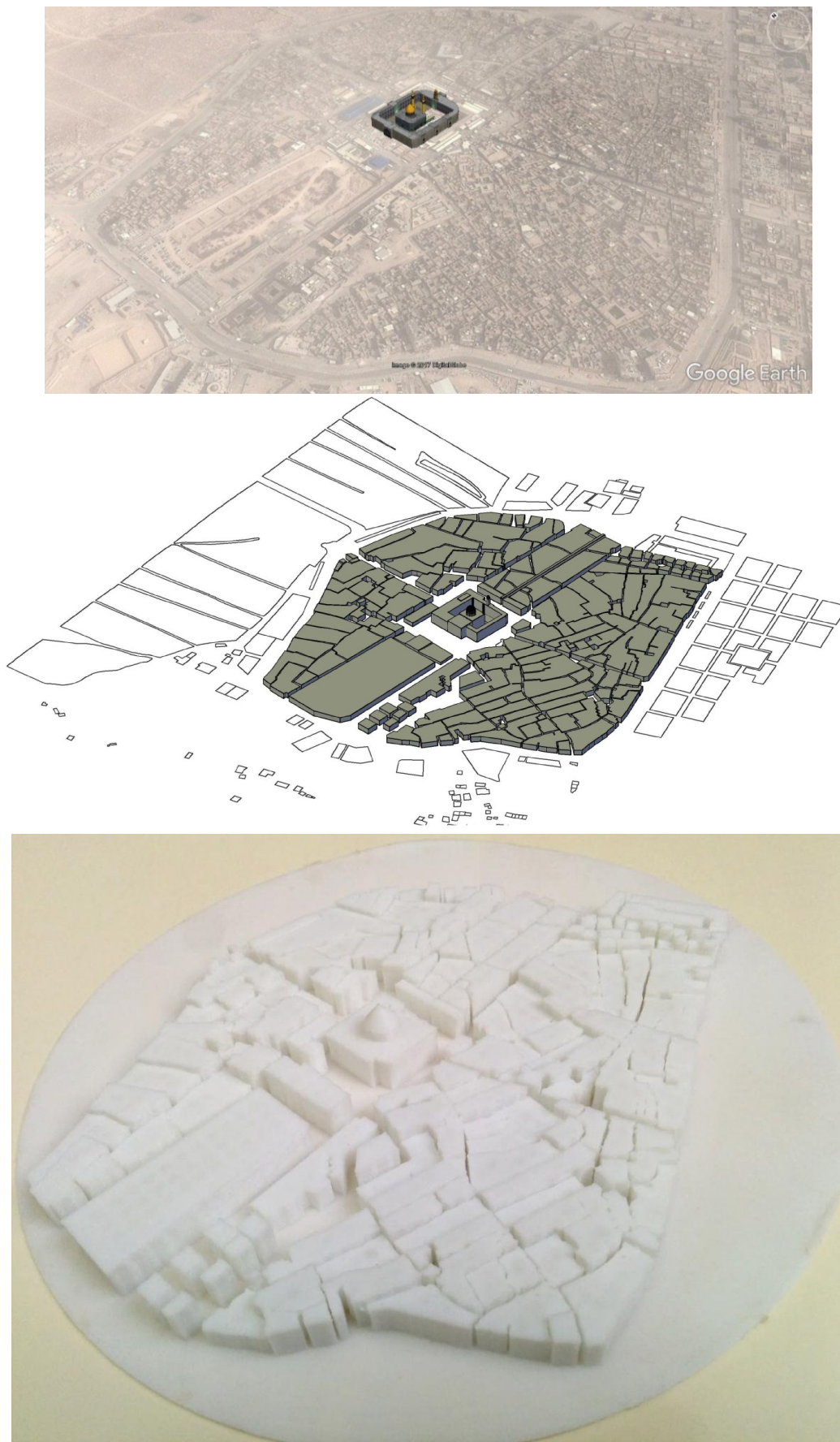Figure 1. 3D printed replica of a full 3D mapping of old Najaf Holy City during printed it in our 3D printer.

Figure 2. Satellite image of Najaf historic city centre (upper), 3D virtual model (middle), and 3D print model (lower). In the center of old Najaf city lies the Holy Shrine of Imam Ali bin abi Talib (peace be upon him), which is the prominent building in the city.
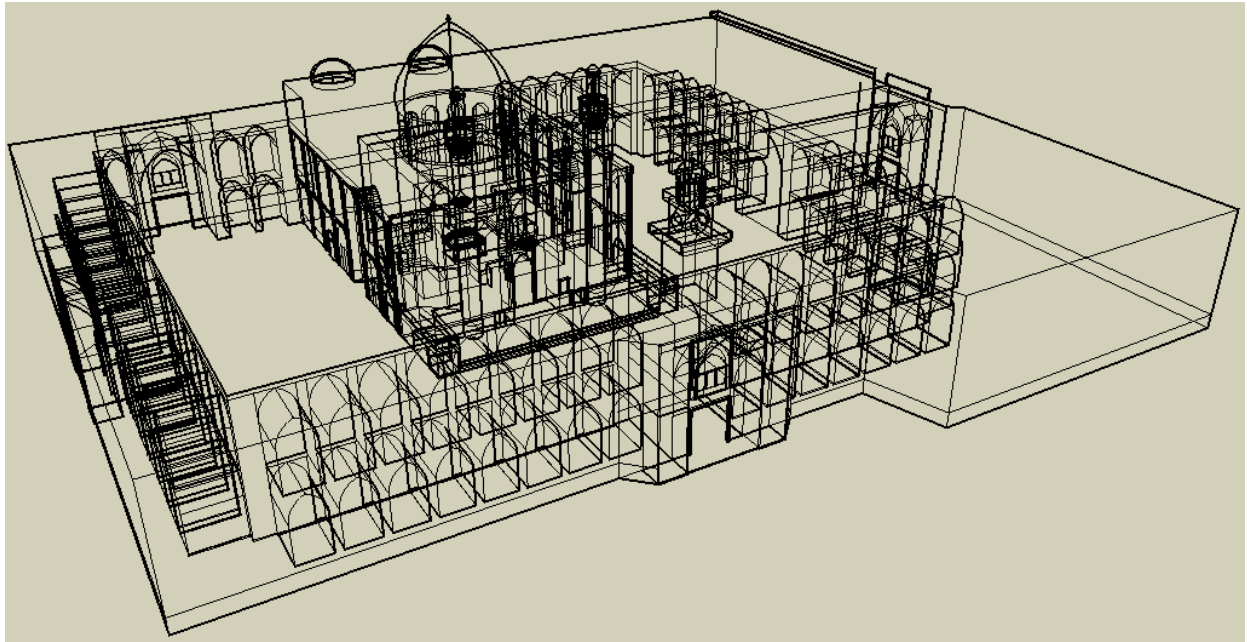
Figure 3. 3D virtual reality model of the Holy Shrine of Imam Ali bin abi Talib (peace be upon him), which is the prominent building in the city. The current architecture of Imam Ali Holy Shrine dates is back to the seventh century A.H. (eleventh century A.D.).

Figure 4. 3D model and 3D print of the golden dome and the golden minaret of the Holy Shrine of Imam Ali bin abi Talib (peace be upon him).
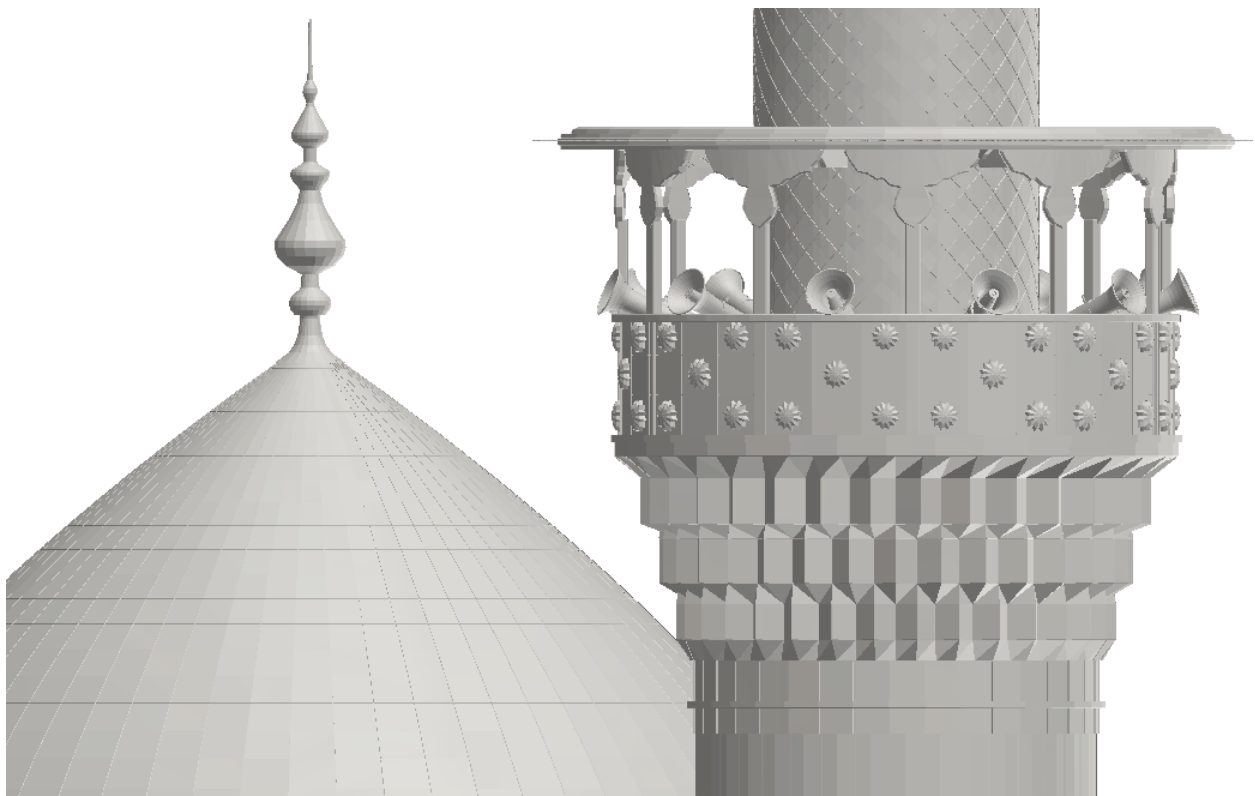
Figure 5. 3D model of the Holy Shrine of Imam Ali bin abi Talib (peace be upon him), lies in the center of old Najaf city, which is the prominent building in the city. The current architecture dates is back to the eleventh century A.D.
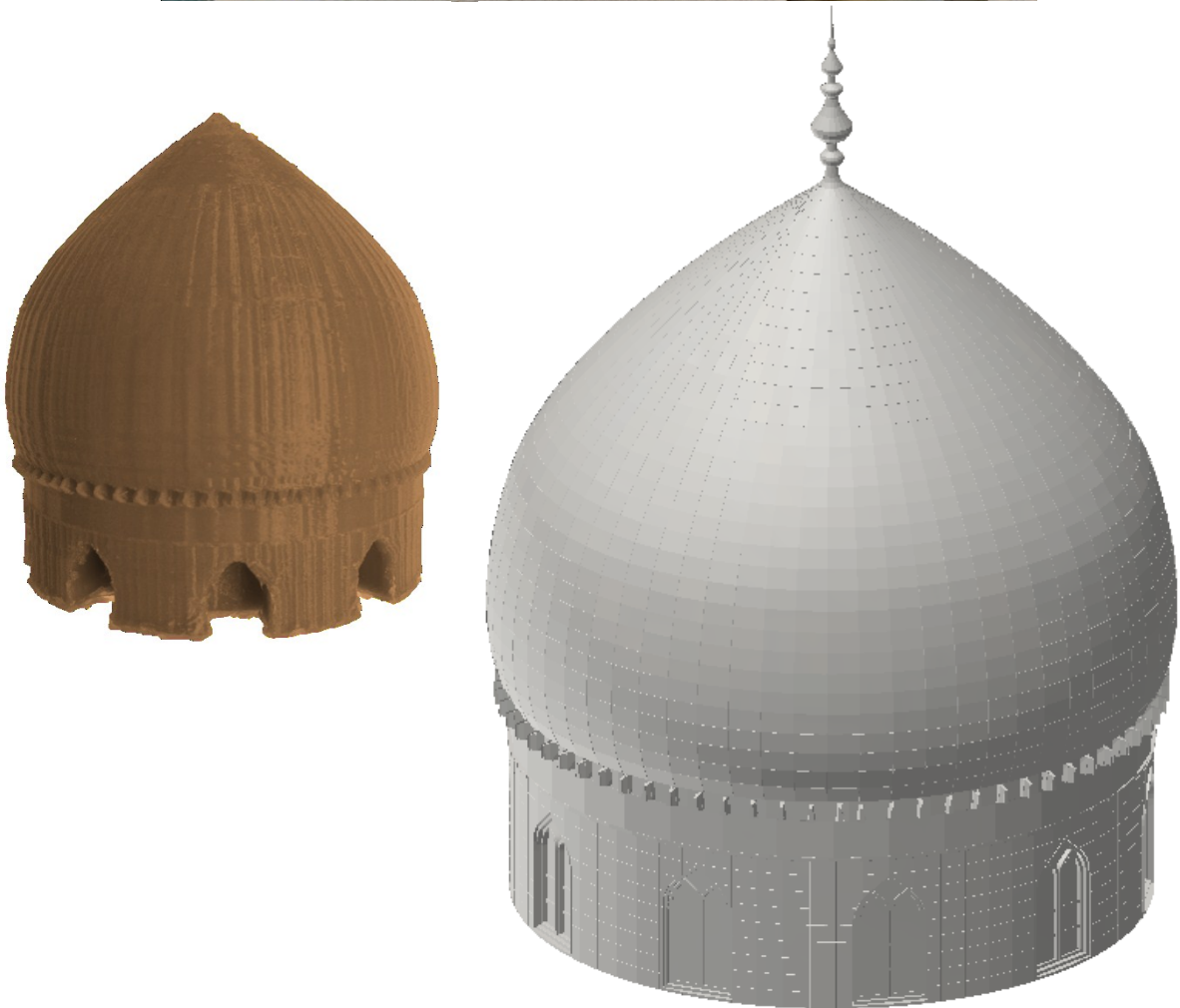
Figure 6. 3D model and 3D print of the golden dome of the Holy Shrine of Imam Ali bin abi Talib (peace be upon him).
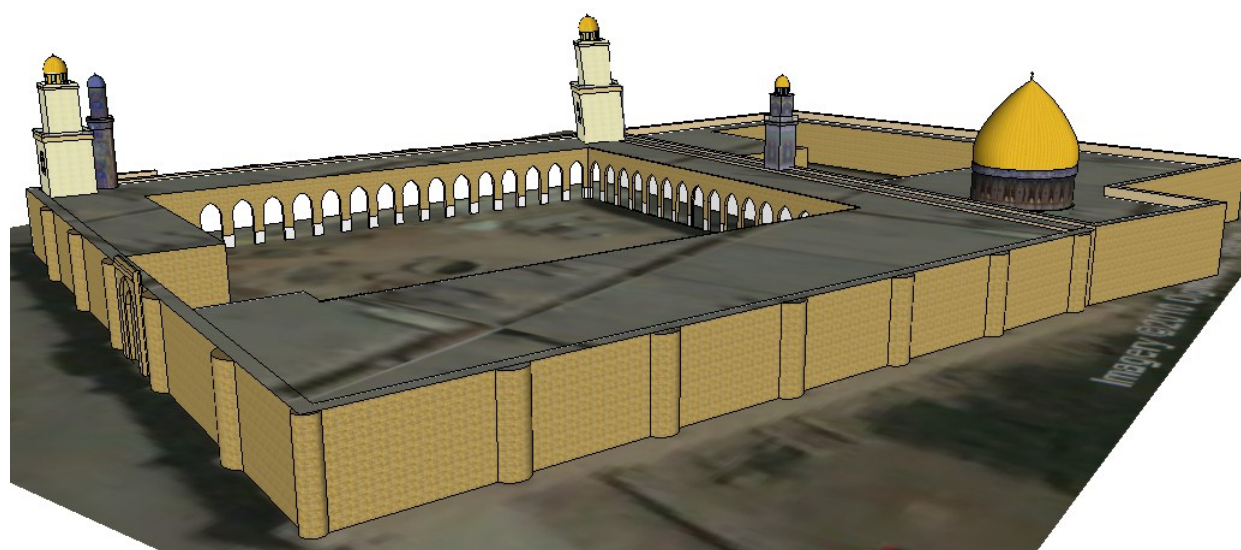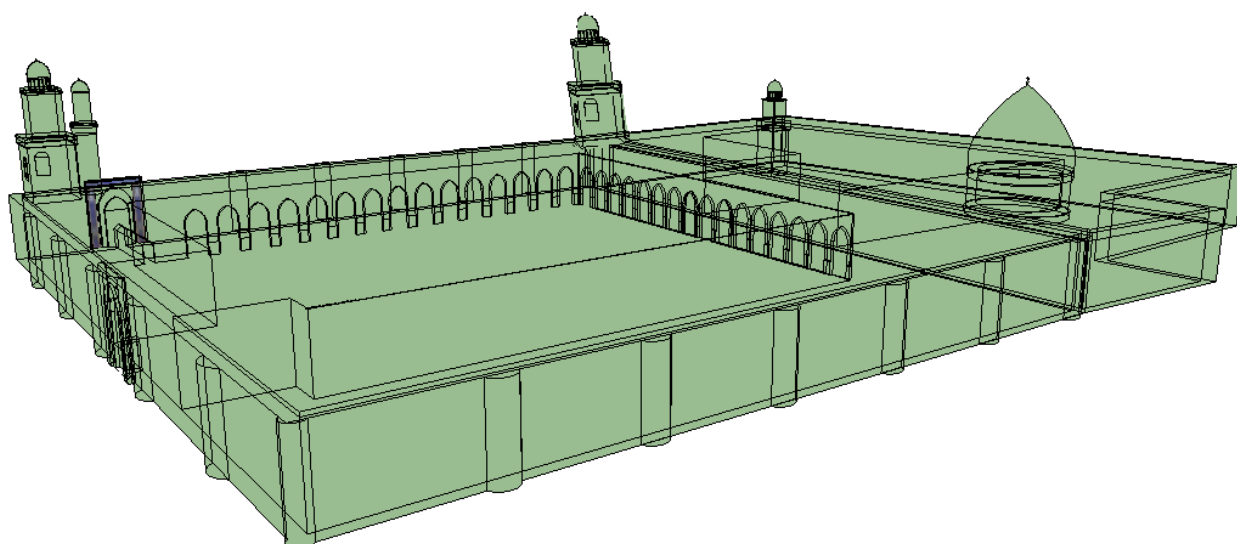
Figure 7. 3D virtual reality model of the Kufa Mosque and holy shrine of Muslim bin Akeel (peace be upon him). Kufa mosque is one of the holiest four mosques in the whole Islamic world.

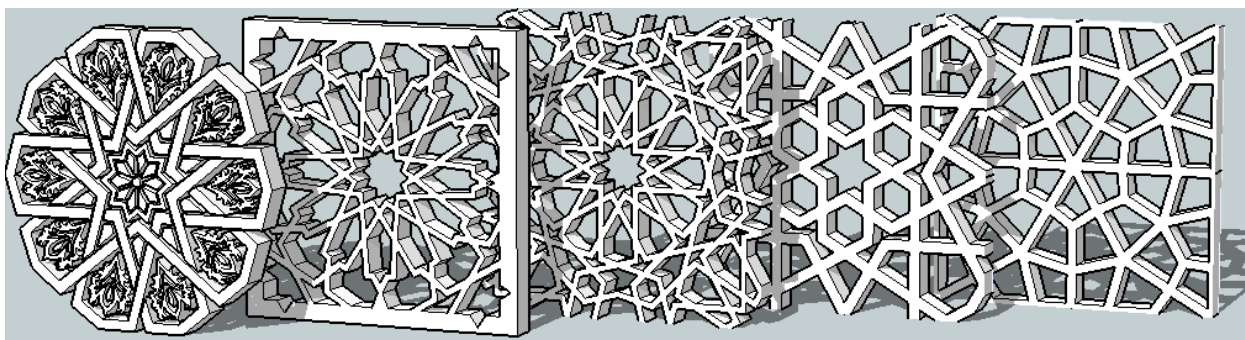Figure 8. 3D model of column in Najaf cultural buildings.

Figure 9. 3D models of some patterns in Najaf cultural buildings.

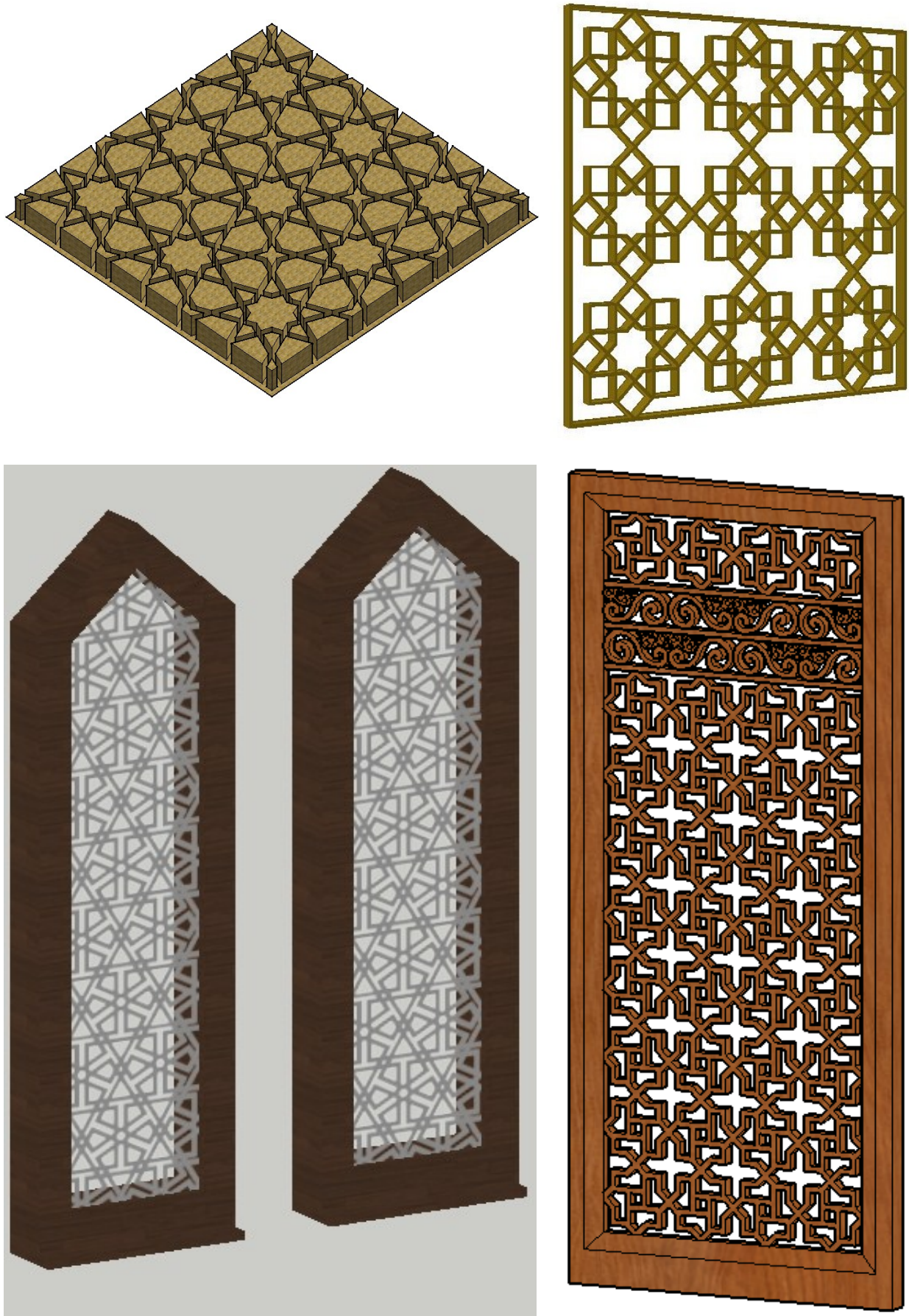Figure 10. 3D model of the stained glass in Najaf cultural buildings.

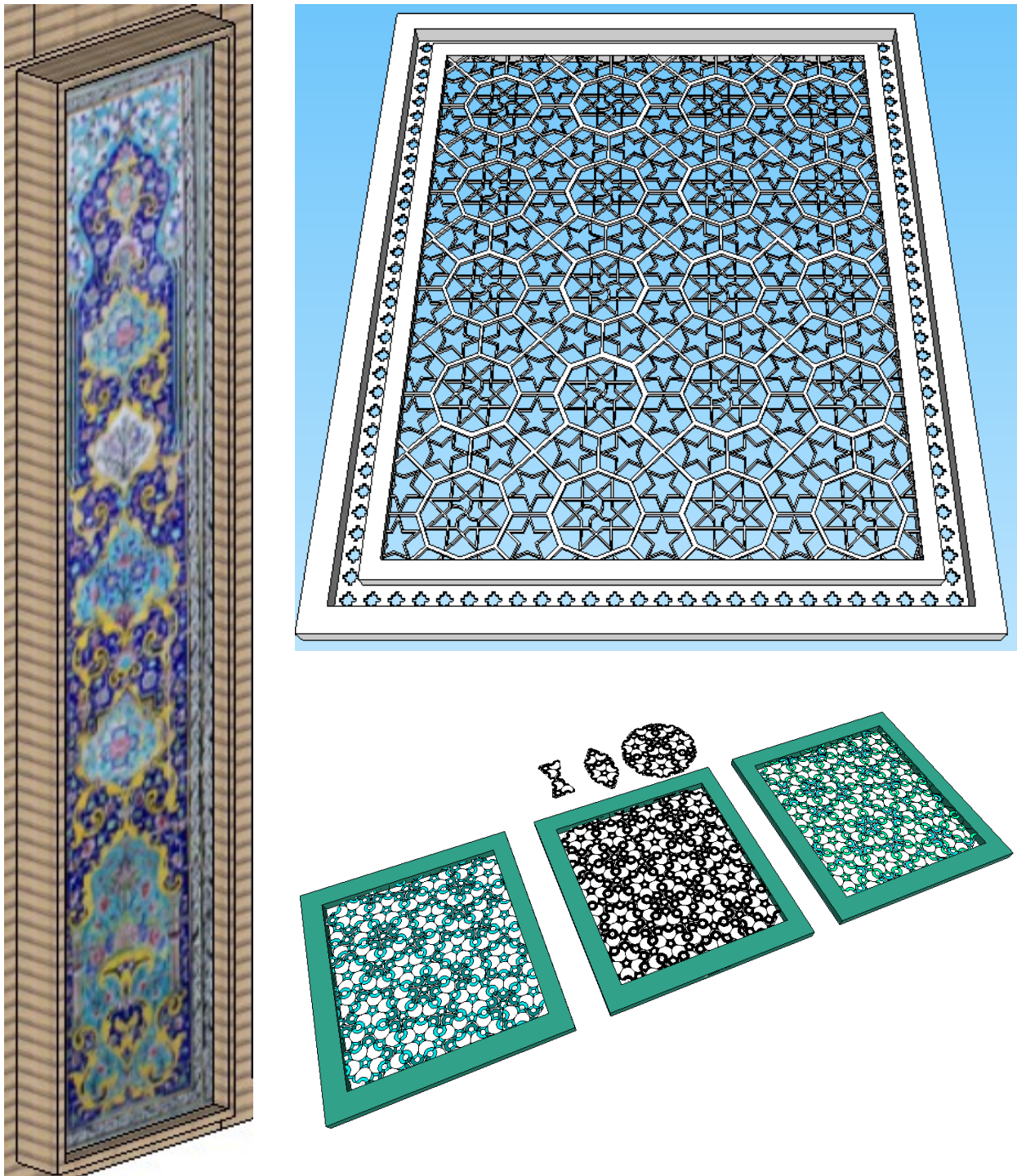Figure 11. 3D model of wood pattern in Najaf cultural buildings.

Figure 12. 3D model of glazed brick (left) and metallic pattern (right) in Najaf cultural buildings.

5. Conclusions

Najaf holy city in Iraq has a rich cultural history, which includes historic groups of buildings, monuments, sites, natural heritage, and energy and sustainability systems in the heritage's buildings. The Center of Preserving of the Cities Heritage and Identity (CPCHI) at International Energy and Environment Foundation (IEEF) founded a first roadmap in preserving Iraqi cultural heritage and identity with 3D scanning, 3D virtual reality, and 3D printing technologies. Interesting results have obtained for Najaf holy city in preserving its heritage. Some examples covering different types of Najaf city cultural heritage like monuments, manuscripts, archaeological sites, buildings, works of art, artifacts, and so on, have created and presented.

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