



RESEARCH PAPER

Exploring the Role of Historic Building Information Modeling for Heritage Conservation in Pakistan: Case of Chauburji Lahore

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ABSTRACT

The research involves application of modern technologies for digital documentation, management and monitoring of built heritage in Pakistan for sustainable developments, giving respect to the authenticity and integrity to the cultural landscapes. The purpose of paper is to evaluate impacts of virtual methods to traditional and conventional styles of conservation techniques. The core objective is to setup an innovative approach to generate a platform to be shared across the country to safeguard the built heritage. Chauburji, a monumental gateway to a large Mughal garden, built in 1646 C.E. during the reign of Emperor Shah Jahan, has been selected as a case study, being one of the initial monuments digitally documented and characterizes the implementation of integrated building design processes and virtual 3D Models in conservation practices. In short, digital methods of assessment, documentation, data recording, management and monitoring can provide more realistic visualization for the future fabric of the cities.

Introduction

Conservation and preservation of historic monuments and urban areas is a great challenge for the Conservator and historians. The core objectives of the department of archaeology as well as educational institutes are sustainable development, legitimacy of the built heritage, integrity of heritage sites and preservation of cultural landscape. Techniques of architectural conservation are digitizing with the passage of time to get the best outcomes. New methods of assessment and documentation of historic buildings have been introduced to step forward for the sustainable development of the historic cities. With these developments, digital technologies support in the process of presentations, assessment of the damages and preparation of digital archival (Cheng, Yang, & Yen, 2015).

Data collection is the most important phase-in the process of conservation and it is necessary to collect data in a cost effective and trustworthy manner, within the recognized accuracy, tolerance and program. 3D Interactive Model could provide a more realistic visualization for stake holders so that they can swiftly and accurately understand unique character of built heritage (Banfi, Brumana, & Stanga, 2019). To understand sustainable development, we must place it in the territory of material, culture, history and architecture, while acknowledging the future fabric of the cities; we have to consider the historical evidences and architectural remains of that area. Built Heritage describes the social, religious, traditional and sometimes legal values of the civilizations. The conservation of built heritage and urban fabric of the city entails integrated representation of multi-layered information before the completion of the conservation plan. Historic Building Information Modeling is a scientific tool to convert the electronic data providing key opportunity to study the historic buildings and sites. Digital documentation provides 3D data to analyze the materials and multiple layers of information with reference to the significance, archaeological analysis, conservation plans and long term maintenance.

Pakistan is one of those countries which have been subjective to different cultures and civilizations. There are effects of different intruder who attacked on the sub-continent in different time periods and they left the traces of their cultures and architectural styles. The buildings constructed during the Hindus, Indo-Greek, Persian, Mughals and British periods are the index of those societies. The area comprising Pakistan has been ruled by different Dynasties leaving behind the stories of their splendor. Four Provinces, Tribal Areas and Capital city of Islamabad reflect a blend of cultures developed through ages. Territories of Azad Kashmir and Gilgit-Baltistan are examples of natural beauty. (Hashmi, 2016)

It is also mandatory for the future fabric of the cities to preserve these historic assets maintaining their authenticity, minimizing the threat of lost and saving the time and money and it is only possible with the help of innovative methods of conservation. The aim of this research is develop a strategic framework which could be followed across the country. The core objective of the research is to create awareness among the conservation community to assess the attitudes towards the placement of BIM as a tool for the identification of historic buildings and urban cores to assess their significance level, to document the built heritage and functions of the digital archives. The study will help to develop conservation standards for the preparation of master plan. All these methods and techniques of preservation, conservation and restoration will help to maintain the built heritage in terms of materials application and esthetic values. BIM has the potential to prepare 3D models to analyze and preserve the built heritage. (Banfi et al., 2019)

Literature Review

The role of HBIM in the documentation and data recording in the conservation projects is rapidly growing, specific technologies such as Digital Cameras, Total Station and 3D laser scanners are taking place to traditional methods

and practices of management and operations. Internationally a number of projects has been completed to assess the implementation of HBIM tools in the field of conservation (Baik, Boehm, & Robson, 2013). Pakistan is a developing country and has very limited resources for the conservation of built heritage. To safeguard its wealth of heritage, it is also trying to use latest equipment and integrated conservation techniques. Traditional and conventional methods of preservation need to be replaced by digital method to achieve the high levels of integrity and authenticity. It is only possible with the help of a strategic framework involving the use of digital documentation to achieve maximum details and 3D Modeling to synchronize interior and exterior spaces (Hull & Ewart, 2020).

The initiative was taken by the LUMS university with the help of U.S. Ambassador's Fund program with a project "Digital Preservation of Pakistan's Heritage" followed by a training session with 10 universities to create awareness among the students and conservation community about the functions of 3D laser scanner. AKCSP promoted these techniques by introducing digital tools in the conservation works being done in the Lahore Fort. Conservation of Picture wall is one of the projects digitally documented by the AKCSP. Walled City Authority has also been involved in use of digital documentation of the historic monuments. Chauburji Lahore is one of the examples (Taj, 2016).

These are the few projects which has been completed by different organizations and institutes to ensure the quality of conservation works, cost analysis, maintenance and life cycle cost analysis maintaining the authenticity of the heritage (Hashmi, 2016).

HBIM and Conservation

Historic Building Information Modeling is not only a latest version of AutoCAD, rather is a digital technique to provide multi-layer information regarding the heritage monuments and Historic Urban Cores. There are too many obstructions in the conventional methods of conservation related with documentation and presentation of 2D and 3D drawings being used for the preparation of conservation plans. On the other hand, HBIM strategies can provide virtual method based on digital documentation through the use of Total Station, digital cameras, digital photogrammetric and 3D laser scanner. These digital tools require different software to present technical details in 3D views such as TheoLT, cyclones, Revit, 3D Max, Naviswork etc. (Rocha, Mateus, Fernández, & Ferreira, 2020)

These 3D models ensure the maximum accuracy of the documentation process. The accurate documentation helps to develop a framework based on the digital tools ensuring the real time maintenance, life-cycle cost and energy efficiency. Historic Building Information Modeling (HBIM) is an integrated, reliable and accessible database which stores all of the relevant information of the buildings and historical sites. It reduces accidental user mistakes due to multiple data errors. Time saving and error reduction are the key benefits of HBIM. The conventional methods

are not sufficient to safeguard the values of Historic Urban Cores. We have to follow the International standards to save our urban fabric of the Historic Cities. The work done without a framework, neglecting the accuracy and authenticity of the heritage can't produce the desired results(Hull & Ewart, 2020).

Architects and conservation experts are now applying Building Information Modeling tool to conserve and document the built heritage. Digital documentation is part of this process. These methods have far greater range of characteristics than conventional methods. For the renovation and conservation purposes, these tools can provide more authentic data about characteristics, styles, materials, ventilation and site analysis. Due to the unique approach of these methods and techniques, this industry is growing more and more. BIM can also help to reduce environmental impacts to the heritage.(Fai, Graham, Duckworth, Wood, & Attar, 2011).

Application of BIM in the conservation process can provide a lot of information regarding scheduling of building components, can determine about the materials reuse and recycling , can determine structure and its performance in real-time. BIM can be used with other related software for energy analysis, lighting studies while 3D visualization and walk through allows the team members to improve interior comfort and energy use as well as renovating the exterior appearance. With the use of BIM tool, we can have multiple folds of information about the historical structures and sites. These information are invaluable with reference to archaeological analysis, conservation planning and long term maintenance.BIM has the ability to integrate this 3D data to visualize chronological sequence. The use of 3D imaging, mapping, modeling and CAD with the help of 3D laser scanner, photogrammetric and traditional and digital surveying tools and techniques will be useful for the conservation, preservation and renovation of the heritage monuments and archaeological sites(Brusaporci, Maiezza, & Tata, 2018)

Digital Preservation of Pakistan's Heritage

The project "Digital Preservation of Pakistan's heritage" has been done by Lahore University of Management Sciences (LUMS) under the umbrella of U.S. Agency for International Developments (USAID) .It has funded LUMS for the project started in February 2015. Under this project, six sites in the province of Punjab, Sind and KPK has been documented with 3D Laser Scanner during the period from February 2015 to January 2016. The project introduced an innovative approach towards the use of digital tools such as 3D laser scanner to create virtual tours and 3D models in the conservation practices. The process remains unfamiliar till June 2015. The built heritage of the Pakistan is critically endangered and needs intervention due to the ever increasing population, severe weather conditions and Govt. policies. Identifying the dilapidated condition of the built heritage, Terrestrial 3D Scanning technology has been introduced in Pakistan.(Taj, 2016.)

These sites were selected for the diversity in styles and presenting different cultures and architectural characteristics within three provinces of Pakistan. These sites includes

- Masjid Wazir Khan and Derawar Fort in Punjab,
- Masjid Khudabad and Shiva Temple in Sind,
- Takht-i-Bahi and Stupa at Jaulian in KPK.

These sites have been developed during the Mughal period around 1200 A.D and Hindu period around 7000 B.C in the sun-continent. Different institutions helped in the field work to complete this project. WCLA and AKCSP collaborated in Punjab based part of the project, MUET in Sind and Directorate of Archaeology and Museum, Govt. of KPK to complete the documentation in the province of KPK. (Taj & Hashmi 2016).

Terrestrial Laser Scanning Technology in Pakistan

Physical preservation involves a lot of stages to complete the process. It involves the identification and documentation of the built heritage to complete the conservation of the built heritage. Digital documentation is one of the phases to preserve the heritage monuments and sites. There are four stages to complete the process of digital documentation with the help of 3D terrestrial laser scanners. This technique has been introduced in Pakistan by the LUMS University under the project of "Digital Preservation of Pakistan's Heritage". Under this project USAID funded 3D Laser Scanner of the Model Leica Scan Station P20, Range: Up to 120 m, Scan rate: Up to 1'000'000 points/s and Field-of-view: H 360°, V 270° (Taj 2016) as shown in (Figure 1)



Figure 1 Leica Scan Station P20

Source: Digital Preservation of Pakistan's Heritage (Dr. MurtazaTaj)

Field work / Scanning

The process involves Field Work to scan the object needs to be documented. The data received by the scanner is in the form of 3D point clouds. 3D laser scanning systems which emits a huge amount of laser beams per second and generate thousands of data points. This data is termed as point cloud as it is not in the form of picture but actual digital representation of the monument with accurate details. We need the appropriate softwares such as cyclones to transfer the raw data to 3D point cloud as shown in Figure 2.



Figure 2. 3D Point Cloud Masjid Khudabad

Source: Digital Preservation of Pakistan's Heritage

Point Cloud Registration

The data taken by the Laser Scanner needs registration with the help of specific software like cyclone. The data was in the form of cloud of points and the expert have to draw the images out of these clouds. This can also be done with the help of different software such as ArchiCAD, Cyclones etc.

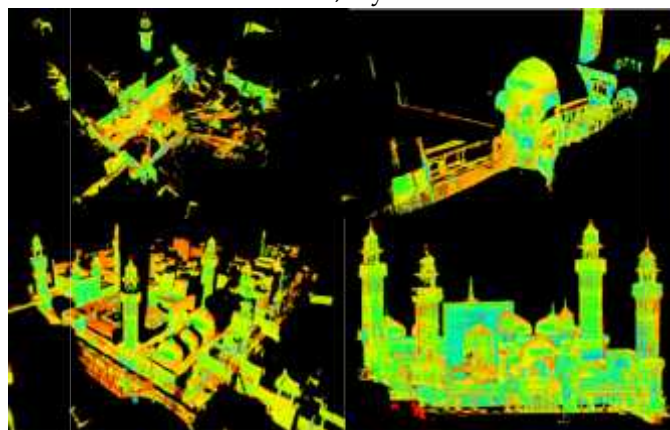


Figure 3 Point cloud Data Registration Source: (Dr. Murtaza taj LUMS Lahore)

Panoramas and Texturing of point cloud model

After the registration of the point cloud data. We can have virtual tour of the site to visualize the whole site and we can move around the monument avoiding any mistake while preparing the Conservation Plans of any project. Autodesk Revit ,3D Studio Max , Sketch up and Rhino etc may be used to render the 3D image prepared from the point cloud data. (Figure4)



Figure 4Panoramic view Source: Dr. MurtazaTaj

These virtual tours give the chance to the experts towards the integrated approach rather than linear approach .In the traditional methods one has to rely on the other and the work have tube done by the individuals. On the other hand, in the integrated approach, all the team members got involve towards the project completion.

Architectural Drawings& 3D CAD Modeling

Architectural Drawings such as plans, elevations etc. can be prepared from the data. These drawings will be helpful for the area calculation, to preserve the historic fabric of the city. From the Point cloud data, 3D CAD models with the help of different softwares. These 3D models can present complete picture of the project and the environment surrounding the site.

Laser Scanning Time Cost

As well as time consumption to complete the project, Dr. Murtaza Taj describes the fact that the scanning is lesser time consuming as compared to the preparing of Architectural drawings and 3D Models. He explains that scanning consume almost 35% of the total time consumed for the completion of the project. On the other hand, the most laborious job is to extract views from the point cloud data and it is more time consuming. Almost 65% of the time has been consumed to prepare the Architectural Drawings and CAD model.

Material and Methods

The current policies, procedures and practices to preserve the built heritage in Pakistan has been transforming from traditional methods to virtual methods. An initiative has been taken by the Lahore University of Management Sciences and Agha Khan Cultural Service Pakistan with the funding by USAID in terms of application of digital tools in the process of preservation saving time and money. It has been observed that traditional methods don't ensure the authenticity in terms of multi-layered information which is mandatory for the appropriate conservation. The historic monuments documented with 3D terrestrial laser scanner under the project "Digital Preservation of Pakistan's Heritage" has been analyzed through desk-based studies about , how historic Building Information Modeling can help to digitize conservation procedures and practices, how digital tools can save time and money.

- Data has been collected from literature, online and libraries.
- Data has been collected from Dr. Murtaza Taj from LUMS about the project done under the Umbrella of USAID and different phases from field scanning to 3D modeling has been studied and analyzed.
- Chauburji Gateway has been selected as a Case study which has been digitally documented with 3D lase scanner by "Trojon" on behalf of Walled City Lahore Authority.
- Data has been collected about the on-going projects with the increasing trends of digital tools in the process of conservation.
- Conclusions and Recommendations has been proposed to apply Historic Building Information Modeling techniques to identify, document, and store multilayer information with the help of modern digital tools and softwares to develop digital achieve of built heritage in Pakistan.

Chauburji, Lahore : Case Study

Lahore was famous due to its gardens built during the Mughal period and was named as City of Gardens. The entrance to the garden was termed as Gateway and Chauburji is the gateway to a Mughal Garden which was built during the period of Shah Jahan in 1056 A.H. (1646 A.D.). Department of archaeology, Government of Punjab is taking care of the monument following the Antiquity Act 1975 and Punjab Special Premises Ordinance 1985 and it has been listed in the protected documents as category-I with the total area of 0.16 acres.

Location

Chauburji is located in the south of the walled city of Lahore on the road leading southwards to Multan. At times, when river Ravi was flowing near the Lahore Fort, Chauburji was located on the west side of the Multan road, Lahore and

perhaps this diminished garden was located on the eastern banks of river Ravi while Shahdara was located on the western bank of the river Ravi. After shifting of the course due to the human activities in the area of the river 4.8 kilometers towards India, the area came under the floods and the garden vanished due to the river water activities in the area (LDA 2016). The only remaining part of the garden is its gateway which is now in the list of heritage due to its embellished decorations of glazed mosaics on all its facades and its octagonal corner minarets. This monument with its splendid architectural styles stands alone in the center of roundabout on Multan Road, Lahore.

Historical Importance

Mughals constructed number of gardens in Lahore during their reign and these gardens were of two categories, one is Royal garden and other is Tomb garden. Chauburji is a gateway of a royal Garden which was built in the vicinity of the river Ravi which was also known as River of Lahore.

Its name chauburji was owed to its four minarets (chau means four and burj means towers) built on four corners of the gateway as shown in figure 5

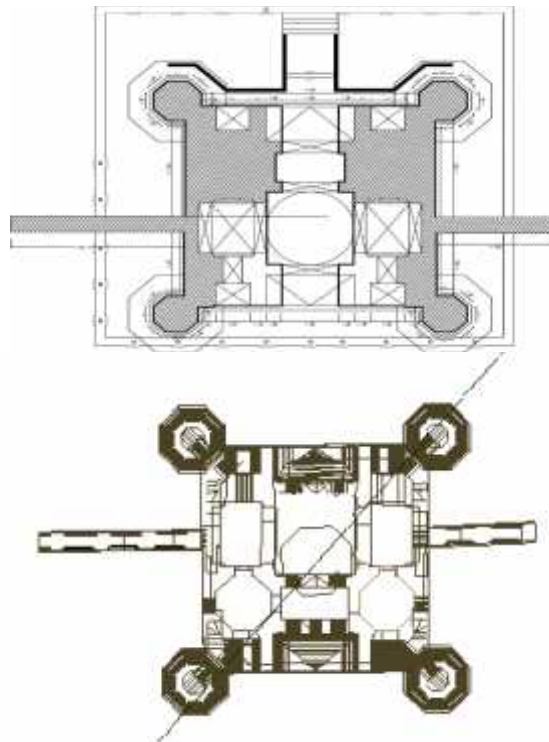


Figure 5(a, b) Plan of Chauburji Lahore, Source: LDA Lahore

There is a sitting space on both sides of the entrance and interiors walls are decorated with kasha kari filled with floral patterns. The gateway to the royal garden is rich in mosaic decorations on all its façade including its minarets. Calligraphy has been done on the main vault. Department of Archaeology is trying to protect the monument since the time, taken over the custody of this archaeological site by using all of resources.

Architectural Characteristics

Chauburji gateway is unique in its architectural characteristics. The salient features of the monument are rich mosaic decorations embellished on the entire façade including four minarets. Calligraphy in the form of Ayat-al-Kursi has been done on the panel over the main vault with the inscription, the year A. H. 1056 (1646 A.D.) Chauburji was a gateway to Mughal garden reflecting Persian styles and influenced by Charbagh concept of Mughal gardens. Cut Brick work with rich faience mosaic, which currently has been lost. Cut Bricks have been ornamented with Kashi Kari in variety of colors such as blue, green, orange, white , yellow and turquoise. The gateway has been designed on the Mughal architectural styles.

Conservation and Restoration of Chauburji

The monument was damaged due to the human neglect and weather conditions after the mughal empire and lost its various parts. The worst damage caused to the gateway due to the earthquake of 1843 and one of the four minarets situated in the north western side collapsed and structural cracks appeared in the central arch of the west elevation. The conservation and restoration of the monument was carried out by the Department of Archaeology in the late 60's maintaining the authenticity and integrity of the gateway as much as equitably possible following the mughal patroness.

Department of Archaeology, Government of Punjab put all the efforts to save the heritage site time to time but all the efforts were in vain. On the other hand, the work done to save the gateway was also done neglecting the ethics of conservation. The condition of the monument becomes worst during 2017 and it was at risk due to the construction of orange train as a part of City development Program. Due to the railway track passing nearby, this heritage site which was already in dilapidated condition was in danger. There were cracks in the walls, minarets and arches, bricks were in deteriorated, kankar lime was missing, delicate works of mosaic tiles were missing and loose at some places, the dampness destroyed the lower part of the internal and external walls due to large sewerage drain in the premises of the monument. At the same time, upper part was also in dilapidated condition due to the rain water. The monument was in danger due to its miserable condition and the new mode of transport could damage the monument resulting in collapse.

Digital Documentation of Chauburji

Considering the historical importance of the mughal gateway, Department of Archaeology planned to protect the monument on priority basis. Then Government of Punjab awarded the project of digital documentation of Chauburji, under the umbrella of Walled City of Lahore Authority to TROJAN, a private company engaged in 3D MODELING of different projects in the variety of fields.. They used 3D Laser Scanner, Total Station and manual drafting to develop 3D virtual models of the heritage site. After scanning cloud data registered to get CAD 2D & 3D files as shown in figure 6 & 7

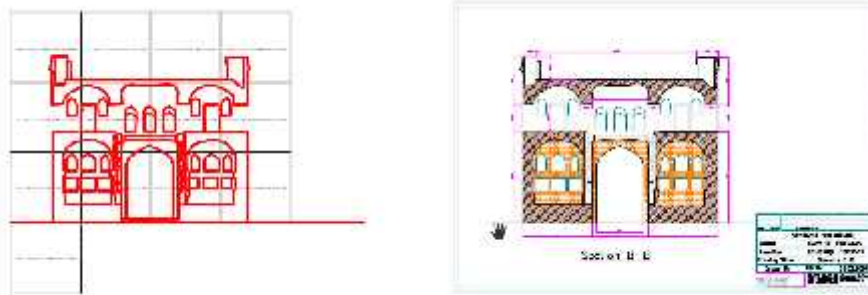


Figure 6 Sectional detail of Chauburji Lahore

Source: Ar. Najam us Saqib LDA Lahore

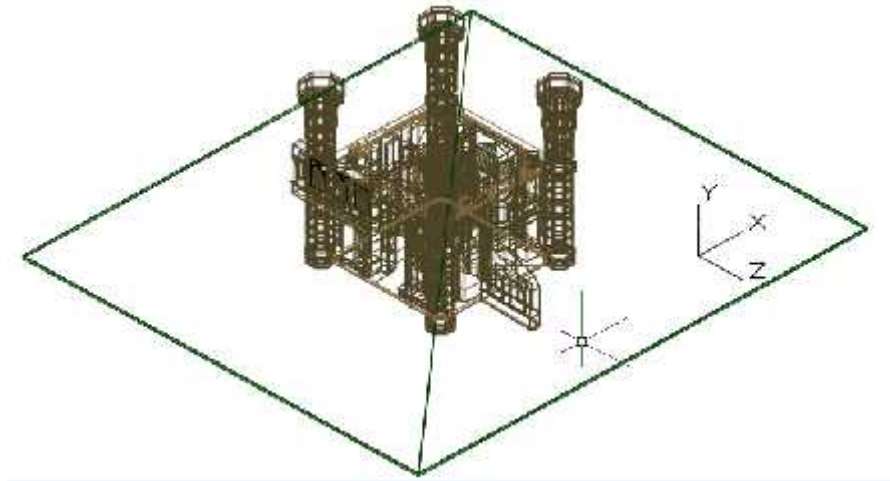


Figure 7 Virtual 3D Model of Chauburji Source: Source: Ar. Najam us Saqib LDA Lahore

On-going Projects

After the successful completion of the Project initiated by the LUMS University, the other conservator and their institutes also showed interest for the digital documentation of the heritage sites. Agha Khan Trust for Culture (AKTC) has started to document Heritage monuments of the Lahore Fort. One of these projects is Conservation of Picture Wall of Lahore Fort. The other project was Shish Mehal of Lahore Fort. The Walled City of Lahore has started Wall Prototype Project (PWP) in partnership with AKTC. Under this project they have started to conserve a part of the wall. According to an article published in "The Express Tribune", June 9th, 2017, this project was started in November 2016 with the documentation of the 350' x 50' western section of that Wall. The architectural documentation of the façade has been done with the help of Electronic Distance Measurement Devices. This project will be helpful to save the fading colors of the Wall. This wall is the world's largest mural wall of the area 1450' x 50' decorated with glazed tile and faience mosaic and frescos of the Mughal period. This picture wall gives an insight into the royal life.

Walled City Lahore Authority (WCLA) taken the initiative towards application of historic building information modeling in the case of Chauburji and started to apply the same practice in the conservation practices within the walled city of Lahore.

Conclusions and Recommendations

The above discussed concepts are envisioned as a starting point for implementation of digital technologies in documentation, data recording, management and monitoring of built heritage in Pakistan. The research will be helpful

- To develop an innovative approach to generate a digital frame-work for the Preservation, Conservation and Renovation based on building information modeling leading towards the sustainable operation management including identification of critical information, management between real-time operation and monitoring systems and the handling of uncertainty due to the unavailability of the resources and skills.
- To assess of the historic zones within Historic Core of Lahore with reference to the significant value of the architectural heritage and urban spaces. In order to assess the historic value of the Heritage, the particular focus can be placed on the type of building, age of the building, architectural works, decorative works, historic value of the each buildings comprising that Historic Zone and historic setting of that area.
- To evaluate the impacts of Building Information Modeling Tool to the traditional and conventional styles of documentation and conservation techniques. In order to evaluate the impacts of virtual methods to the

conventional methods, main focus will be the methods to document the historic buildings. Time, cost and available technology will also be taken into consideration in order to understand what have already been achieved, what has not been done and what could be expanded on in the research presented here.

- To analyze the probability of the implementation of integrated building design processes with the help of virtual 3D Models for the Conservation practices and to cope operations, maintenance and conservation of built heritage in Pakistan.
- To setup an innovative approach to generate a platform for the conservation community to place BIM as an encompassing tool, bringing together data collection, developing 3D models, analysis of these models to be shared across the country.

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