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Survey Research Papers on Materials and Techniques in the UNESCO Chair Programme

Material Science Analysis of Lacquer for Traditional Repair of Stones in Cambodia

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Abstract

Cambodia has been producing various crafts and functional materials using lacquers since ancient times. Compared to its neighboring countries of Myanmar and Vietnam, Cambodian traditional lacquers have received less attention despite their extensive use and long history. This study aims to evaluate the potential of lacquer as an important material for repairing cultural properties, and examines its various uses in making and repairing stone statues in Cambodia. To gather basic data, the composition and characteristics of lacquer utilized during the ancient times were analyzed scientifically. The study confirmed that Cambodian lacquer mortar was used as adhesives, fillers, and finishing materials in the repair of stone statues before the development of modern synthetic resins. Furthermore, the adhesive lacquer was made of almost pure lacquer without any inorganic additives, and the filling lacquer mortar was manufactured by adding a large amount of soil and bone fragments to the lacquer. The results obtained can provide valuable insights to help revive the traditional techniques that have been forgotten and to develop technologies that can be used in the repair of modern stone heritage statues in Cambodia.

Ⅰ. Introduction

1. Background and research aims

Heritage stone statues in Cambodia's Angkor ruins (9th to 14th centuries) have been worshiped and revered by locals as religious and cultural objects since their creation. They have been repaired and restored several times after being destroyed either by changes in social and religious ideology or after natural damage incurred due to prolonged usage and weathering. Hindu and Buddhist stone statues found in the ruins were extensively destroyed for religious reasons and were further damaged by the civil war. Lacquer was extensively used to restore the damaged stone statues, especially for binding the fallen heads or arms of the stone statues or for filling in the missing parts. Lacquer comes in various colors, lusters, and surface textures depending on the mixing ratio of various organic and inorganic substances which can be altered as per the usage requirements.

The use of lacquer is confirmed after analyzing the artifacts; however, no record or data exists on its manufacturing process or the time of its application. Furthermore, little research has been conducted on the Cambodian lacquer mortar—hence, it is quite difficult to find information on the traditional lacquer technology. This research aims to obtain the basic information needed to restore the traditional lacquer technology by scientifically analyzing the lacquer products used in the repair and restoration of the stone statues from the ruins of Angkor, Cambodia.

2. Object and method

Stone Buddha statues from the Thousand Buddha Gallery at Angkor Wat and the Pre Rup Temple within the Angkor Archaeological Park were selected as research subjects. Angkor Wat is located to the south of Angkor Thom and Pre Rup to the east (Figure 1). Reparation of stone Buddha statues using lacquer is undertaken at the Thousand Buddha Gallery in Angkor Wat. The Pre Rup Temple is a Hindu temple dedicated to Shiva. It dates to the 10th century and is still revered as a sacred place of worship by the residents nearby. There are two stone statues of Kor and Gor in the central sanctuary, many parts of which have been restored using the lacquer mortar. The Pre Rup stone statues particularly showcase various types of lacquer mortar. Preservation treatment performed in 2019 allowed for samples to be collected for further analysis.

The types of lacquer materials identified by naked–eye observation were classified into adhesives, surface finishing, bonding filling, and molding restoration. Their macroscopic characteristics were differentiated by type in

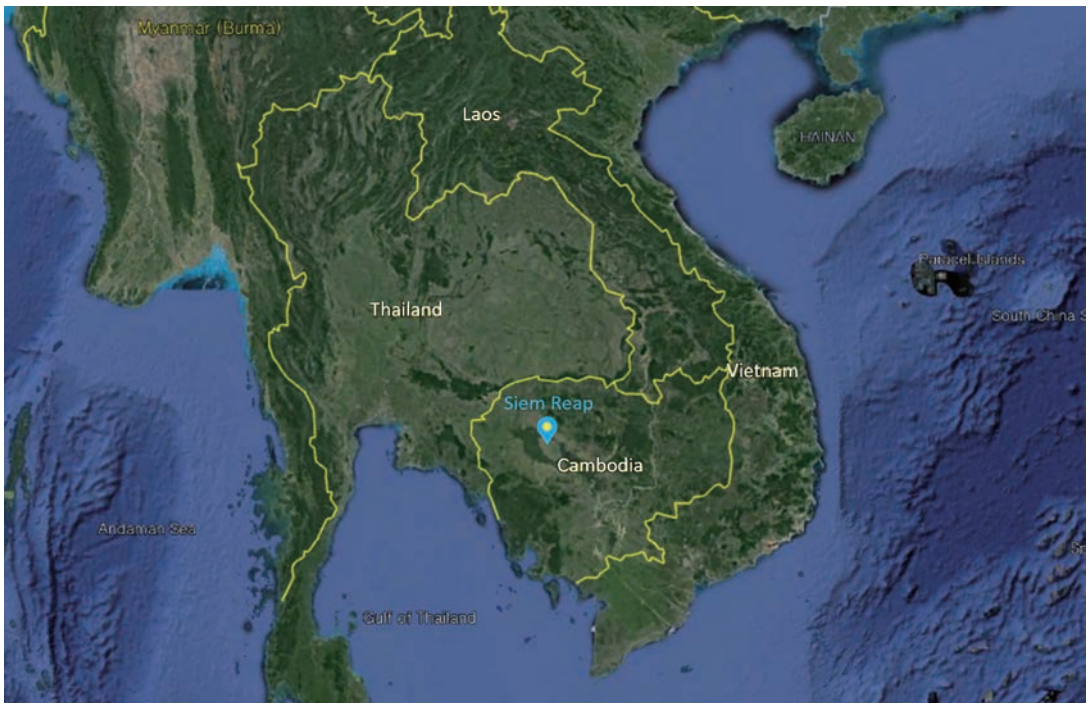


Figure 1. Location of Siem Reap, Cambodia

Figure 2. Location of Angkor Wat and Pre Rup temples

detail so that the microstructural characterization and qualitative analytical methods could be conducted. To determine the additive materials while manufacturing the lacquer mortar, characteristics such as color, luster, and hardness were investigated through visual observation, whereas microscopic observation was performed to identify microstructures and components that could not be confirmed macroscopically.

Polarized microscopic, stereoscopic microscopic, and scanning electron microscopic analyses were performed on the lacquer mortar samples collected

from two stone statues in the Pre Rup Temple sanctuary which permitted sample collection. Additionally, X–ray diffraction analysis and SEM–EDS analysis were conducted to identify its mineral and chemical composition respectively. Pyro–GC and FT–IR analyses were performed to analyze the organic matter.

Table 1. Analytical methods

Category	Content
Macroscopy	Color, luster, hardness
Microscopy	Polarizing, stereoscopic, and electronic microscopic analysis
Qualitative analysis	XRD, SEM–EDS, FT–IR, Py–GC/MS

Ⅱ. Current status and previous studies

1. Current status

Cambodians have used lacquer to create small objects. Lacquer was applied to the surface of base materials such as wood, bamboo, earthenware, ceramics, paper, metal, and leather and was used for finishing, waterproofing, and decoration purposes. Lacquer has been applied to stone statues from the pre–Angkor period and became a universal decorative technique during the Angkor period. Interestingly, lacquer has also been used to repair stone statues as evident in those found in the Thousand Buddhas Gallery, Angkor Wat. Lacquer was used to bind broken heads and arms of the stone statues. Iron rods and bands were also added to reinforce their mechanical strength—a practice perhaps adopted from the 19_{th} to the early 20_{th} century (Figure 3).

A similar case was observed at the Pre Rup temple. This temple is located south of East Baray, along with the East Mebon Temple on the north–south axis. Rajendravarman II (944–968 AD) is assumed to have built it as a Hindu temple devoted to Shiva either in 1961 or early 1962. The name of the temple means "turn the body," hence it is presumed that it might have served as a crematorium,

In the central sanctuary of the temple, there are two Buddhist–style stone statues called Gor and Kor, which are presumed to have been moved from the temple of Prasat Bat Chum which is only 1.8 km away from Pre Rup (Figure 4). These stone statues are considered sacred by the locals and are still handed down as objects of worship. There are several traces of reparations. The head has disappeared, and a red pigment covers its surface, and in the case of Kor, the gorgeous waist decoration remains intact. It appears to have been painted with a red pigment after lacquer was applied to the entire surface of the stone statue. It is presumed that lacquer was also used to attach the waist decoration.

Figure 3. Case of lacquered stone statues located in the Angkor Wat 1000 Buddhas Gallery at Angkok Wat

Figure 4. Stone statues located in the central sanctuary of Pre Rup (left: Gor, right: Kor)

Figure 5. A stone statue located around the library in Phnom Bakheng

Figure 6. Case of stone statues lacquered and painted in the National Museum of Cambodia. Buddha on Naga/Angkor period–Angkor wat style(left); Head of Divinity/Angkor period–Bayon style(center); Bas–relief/Post Angkor period(right)

Figure 7. Case of stone statue repair using lacquer

Estimated to have been built during the reign of Yasovarman at the end of the 9th century, Phnom Bakheng Temple was built two centuries earlier than Angkor Wat was. Two libraries are located on the east side of Phnom Bakheng, and stone statues are enshrined inside and around the library located in the south. Only one stone statue with lacquer, gold leaf, and red pigment remains. The remaining form suggests that the stone was lacquered, painted with red pigment, and then covered with gold leaf. The production form is similar to the stone statues of Pre Rup (Figure 5).

Apart from the stone statues located within the ruins, the National Museum of Cambodia also possesses a large collection of stone statues with lacquered remains. Upon searching for sandstone in the inventory of the museum's collection system, thirteen stone statues were identified with clear traces of pigments, gold leaf, and lacquer. The main production periods for these stone statues are the Angkor period (Angkor Wat style, Bayon style) and the post–Angkor period (Figure 6).

Lacquer can be used for bonding, filling, and surface finishing while repairing the stone statues as can be observed in the two stone statues located in the Pre Rup. Bonding and surface finishing lend a glossy and dense appearance and looks brown in color. The lacquer used for filling a lost part of the statue appears gray in color and contains small particles accounting for its high additive content (Figure 7).

2. Previous studies and cases

Research conducted in the last five years was reviewed to confirm the domestic research trends related to lacquers and the method for scientific analysis of the material of the statues. Research on lacquers can be classified into the scientific analysis of the material of the excavated artifacts (focused on lacquer layer), research on lacquer craft techniques (mainly lacquerware), and research on lacquer application for utilizing it as a coating material. The scientific analysis of the material of the excavated artifacts made of wood lacquer was conducted as follows: organic materials such as lacquer were analyzed using FT–IR (Fourier Transform Infrared Spectroscopy) and Py–GC/MS (Pyrolysis/GC/MS); and inorganic materials such as soil powder were analyzed using EDX (Energy Dispersive X–ray Spectroscopy) analysis after observation with an optical microscope and SEM (Scanning Electron Microscope).

Various analytical methods confirmed in previous studies were applied to Cambodian lacquer samples. The lacquer craft techniques were reviewed through the literature available on it which was then compared with the craft techniques for the currently handed down artifacts. A significant portion of the research on craft techniques was focused on the "mother–of–pearl" technique handed down to the current artisans. Research reflects that the application of lacquer to various objects depends on its waterproofing ability, the firmness of the coating film, and its excellent adhesion ability and that its intended use as a natural material.

The first Cambodian sculptures were produced in the Kingdom of Funan (2nd – 6th century) located in the Mekong Delta. Considered as the cradle of the Khmer civilization, the first sites with carvings and statues of Indian–style footprints were discovered here. From the 7th century onwards began the development of the unique style and craftsmanship of Khmer sculptures. Sculpture continued to develop in this area and later reached the climax of Angkor sculpture.

At the beginning of the 10th century, Yasovarman I moved the capital of the Kingdom from Hariharalaya to Angkor. Over a thousand temples and sanctuaries were built by succeeding kings of the capital between the 9th and 13th centuries owing to the region's abundant rocks and soil rich. Sculpture–making peaked in the 12th century, the splendid period of the Khmer Empire. With the fall of the Khmer Empire, stone carving work became less advanced, and over time the material was replaced by wood. This was a result of the large–scale conversions of the locals from Hindu to Theravada in the 15th century. Since then, lacquer or huge panels have been produced to decorate the wooden

sculptures, and the scenes depicting Cambodian culture and history have been mainly produced there.

Woodwork was centered in Battambang. Cambodian sculptural craft based on wood or stone almost disappeared during the Khmer Rouge period. During the period from 1975 to 1979, most of the artisans were persecuted or forced to farm or earthwork. Since 1992, with the efforts of the European Union and NGOs, the training and education of young Cambodians have begun to revive the ancient Cambodian arts and techniques.

Two stone statues of Pre Rup have been analyzed for conservation from 2018. It was carried out at the SCU (Stone Conservation Unit) which has for long overseen the preservation and restoration of stone heritage in the Angkor site. The two stone statues are covered with faint traces of gold leaf and ornaments, lacquer, and pigments. Prior to conservation, an educational workshop on the material of the stone statue was held on July 5, 2018. Thirty experts in the field of stone conservation and archaeology from APSARA (Authority for the Protection of the Site and Management of the Region of Angkor) and ACO (Angkor Conservation Office) and GIZ (Deutsche Gesellschaft für Internationale Zusammenarbeit) held a workshop on traditional Cambodian lacquer and its application.

Figure 8. Lecture on Cambodian traditional lacquer (source: GIZ)

Participants visited the site of Pre Rup and discussed the lacquers on the Buddha statue. Lectures were then delivered on the history of lacquer, traditional methods of harvesting and processing, and methods of using materials in Southeast Asia. Finally, practicals was carried out and lacquer sampling methods were conducted based on the theoretical lecture delivered earlier (Figure 8). Under the leadership of GIZ and SCU, the conservation work of the two Pre Rup stone statues was completed, and the results were reported at the 35th Technical Session of the ICC–Angkor on January 26, 2021. The results reflected that lacquer was used to fill the cracks in the statue.

Ⅲ. Characteristics of the lacquer sap and mortar

1. General characteristics of lacquer

Lacquer is a natural resin/oil–based paint containing catechol compounds, water, polysaccharides, glycoproteins, and enzymes. The lacquer sap forms a coating layer (film) via self–polymerization. The lacquer layer is a polymer that is polymerized by laccase and does not dissolve in various organic solvents. As this enzymatic reaction is required, it is important to maintain a temperature and humidity of 25~28 ℃ and 70~80 % when drying the coating layer.

Lacquer is collected from the lacquer tree and used in the form of sap. There are three types of lacquer trees. *Toxicodendron vernicifluum* grown in Korea, Japan, and China has a major lipid component of urushiol (C15), and *Toxicodendron succedanea* grown in Vietnam and Taiwan has a major lipid component of laccol (C17). *Gluta usitata*, the main lipid component of which is thitsiol (C17), is grown in Myanmar, Thailand, Laos, and Cambodia. In the case of the Cambodian lacquer tree, Gluta laccifera is the main lipid component (Figure. 9).

Laccol (T. succedanea) and thitsiol (G. usitata, G. laccifera)–based lacquer sap contain catechol that, when combined with skin proteins, can trigger an immune system response (allergic reaction). Lacquer sap is a water–in–oil emulsion. Its aqueous phase consists of water (20–30%), polysaccharides (5–6%), and laccase enzyme (~1%), while the oil phase consists of catechol derivatives (60~70%) and glycoproteins (2–3%).

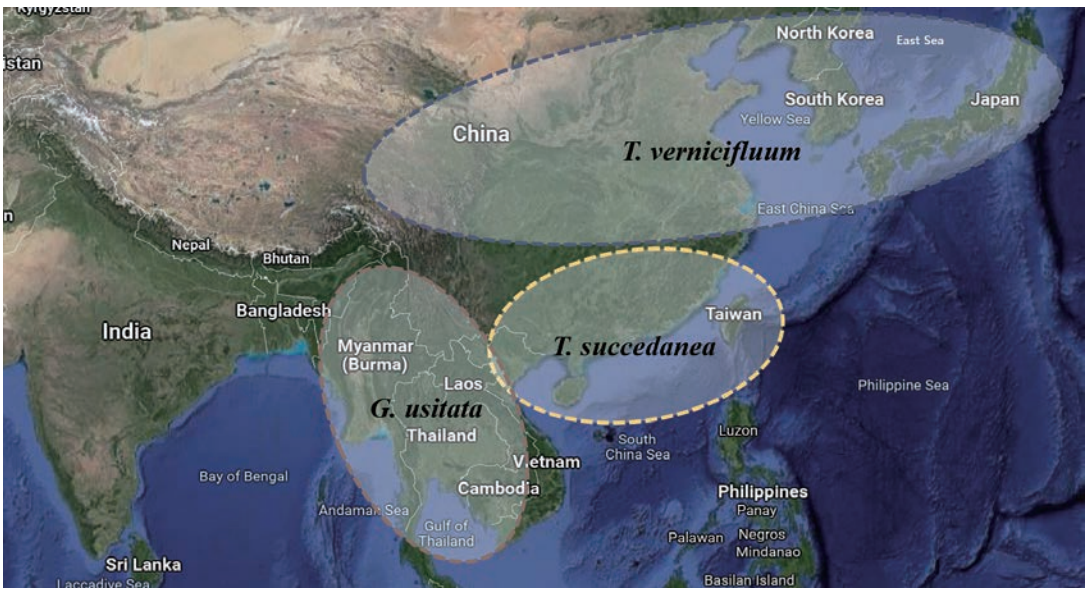


Figure 9. Dominant lacquer tree species by region in Asia

2. Characteristics of functional lacquer

The Cambodian lacquer mortar is a functional lacquer that has been given plasticity by adding various additives to the lacquer sap. This functional lacquer has also been traditionally manufactured and used in Northeast Asia, Korea, China, and Japan. It was called 'Golhoe' (bone ash or bone powder). Golhoe is sometimes called "Tohoe" (clay ash or clay powder), as bone powder was the main additive in the traditional era. It has been substituted by soil powder in the modern era. Golhoe was originally used as a filler to prevent deformation of core shape and to fill gaps in the base material. To make wood lacquerware, bulky material high in plasticity was needed to fill large gaps in the wooden core structure. Therefore, various organic and inorganic materials were added to the lacquer sap. Golhoe was not only widely used to produce wood lacquerware in Korea, China, and Japan, but also in Nakrang.

Today, golhoe is generally made by mixing soil powder and fresh lacquer sap in a 1:1 ratio. Other components added to it include bone powder, soil powder, roof tile powder, animal extracts (animal glue, fish glue, etc.), and vegetable materials (tree resin, etc.). Bone powder, soil powder, and roof tile powder give volume to the material, especially bone powder and roof tile powder (or pottery powder) as they are porous which allows lacquer sap to penetrate them. This makes golhoe dense and more concentrated.

The color of lacquer mortar varies slightly depending on the materials mixed. It is usually dark brown or dark black. However, when soil powder is added to it, the red color becomes deeper, and when wood powder or roof tile powder is added, it takes on a grayish color. Additionally, when the charcoal powder is mixed, it becomes dark black.[1]

Lacquer mortar has different workability and properties depending on the added material. Adding shellfish powder to lacquer decreases its strength, whereas adding animal bones increases it. For the lacquer mortar to have excellent adhesive strength, porous material is added to it. In modern lacquer crafts, it is difficult to supply bone powder or roof tile powder; therefore, coral is used sometimes.

The adhesion of lacquer mortar is not only determined by the added material but also by the quality of the lacquer sap itself. The quality of lacquer sap depends on whether the main components are urushiol, laccol, or thitsiol. Even for the trees of the same species grown in the same region, the quality varies greatly depending on the soil and in–situ environment. Therefore, it is necessary for a person to determine the quality after collecting lacquer sap.

1 Eunjeong Jang, Junghae Part, Soochul Kim, A Study on Conservation Materials of the Lacquer Wares : the Tohoe and Goksu, Journal of conservation science, 31(2), 2015.

Another important factor affecting adhesion is the curing process of lacquer. While bonding two materials, lacquer is first applied to the surface of one substrate after which hardening begins. The best adhesive effect can be obtained by attaching the rest of the pieces at the most appropriate time. This appropriate time in the curing process is mostly determined by the knowledge and expertise acquired by the craftsman. Additionally, the supply of water vapor plays an important role in the curing process of lacquer. If a thick layer of lacquer mortar is applied, the water vapor does not penetrate sufficiently into the sap; therefore, the curing process is incomplete, and the adhesive strength is weakened.

As an adhesive, lacquer is usually prepared by mixing starch glue with it. Lacquer adhesive prepared using barley glue is called Magpul which is used for bonding pottery.[2] The higher the mixing ratio of starch glue, the higher the viscosity of the lacquer adhesive. There are only a few instances of using lacquer as an adhesive for stones. Only Goguryeo murals feature a layer of raw lacquer applied to the stone surface followed by laying on the pigment. In this case, even when the raw lacquer was directly applied to the stone, a thin and homogeneous film was produced with good adhesion. The excellent adhesive properties of such lacquer were also confirmed during the reproduction experiment of lacquer paintings on granite stones.[3]

2 Sungyoon Jang, Lacquer as Adhesive : Its Historical Value and Modern Utilization, Mumhwajae, 49(4), 2016.

3 Jonghun Lee, Haeri Jo, Lacquer painting for basic art theory, Hexagonbook, 2018.

Ⅳ. Analytical results for lacquer mortar

1. Sample selection and macroscopic characteristics

Cambodian lacquer mortar is gray, dark brown, or black. The diversity in color is determined by the type and composition of the material mixed into it, such as bone ash in Korea. Black lacquer mortar has a homogeneous color and texture; therefore, it is presumed that it contains almost no additives or is mixed with pulverized additives in small quantities. Consequently, gray and dark brown lacquer mortars have various colored particles added to them in various sizes (Figure 10 and Figure 11).

Major parts of the body of the stone statue in the Sanctuary of the Pre Rup Temple were severely damaged. Though the exact time is unknown, the lost parts have been restored using a massive amount of lacquer mortar. The lacquer mortar was dark brown and very hard, lime mortar. Although it was not observed on the fractured surface of the mortar, the pore surface within the mortar exhibited a resinous luster. Additionally, traces of lacquer were found to attach the white ornaments in the decorative belt of the Kor statue.

Figure 10. Occurence of lacquer mortar in the Sanctuary of Pre Rup Temple

2. Stereoscopic analysis

The microstructural characteristics of the collected lacquer mortar samples were analyzed. The color of the lacquer was translucent, the thick part of the specimen was close to blackish brown while the thin part was close to golden or light yellowish brown (Figures 12a and 12b). The resin luster was also distinct (Figure 12d). The cross–section of the lacquer mortar attached to the pigment layer looked blackish brown. The fractured surface was irregular; consequently, the luster did not appear obvious and the texture looked loose (Figure 12e).

When the cross–section was enlarged, it was observed that there was a thin layer with a darker color and more pronounced luster than the mortar between the reddish–brown pigment layer and the lacquer mortar layer (Figure 12f). This thin layer was considered as a lacquer finish or a lacquer base layer for the succeeding layer of pigment. The pigment was applied with a uniform thickness (Figure 12f).

The cross–section of the specimen was polished and observed under a stereomicroscope. A reddish–brown pigment layer was clearly observed. Additionally, it was confirmed that various materials were added to the lacquer sap. The round particles under the microscope were presumed to be mineral particulates such as sand and clay, and other irregular angular substances were

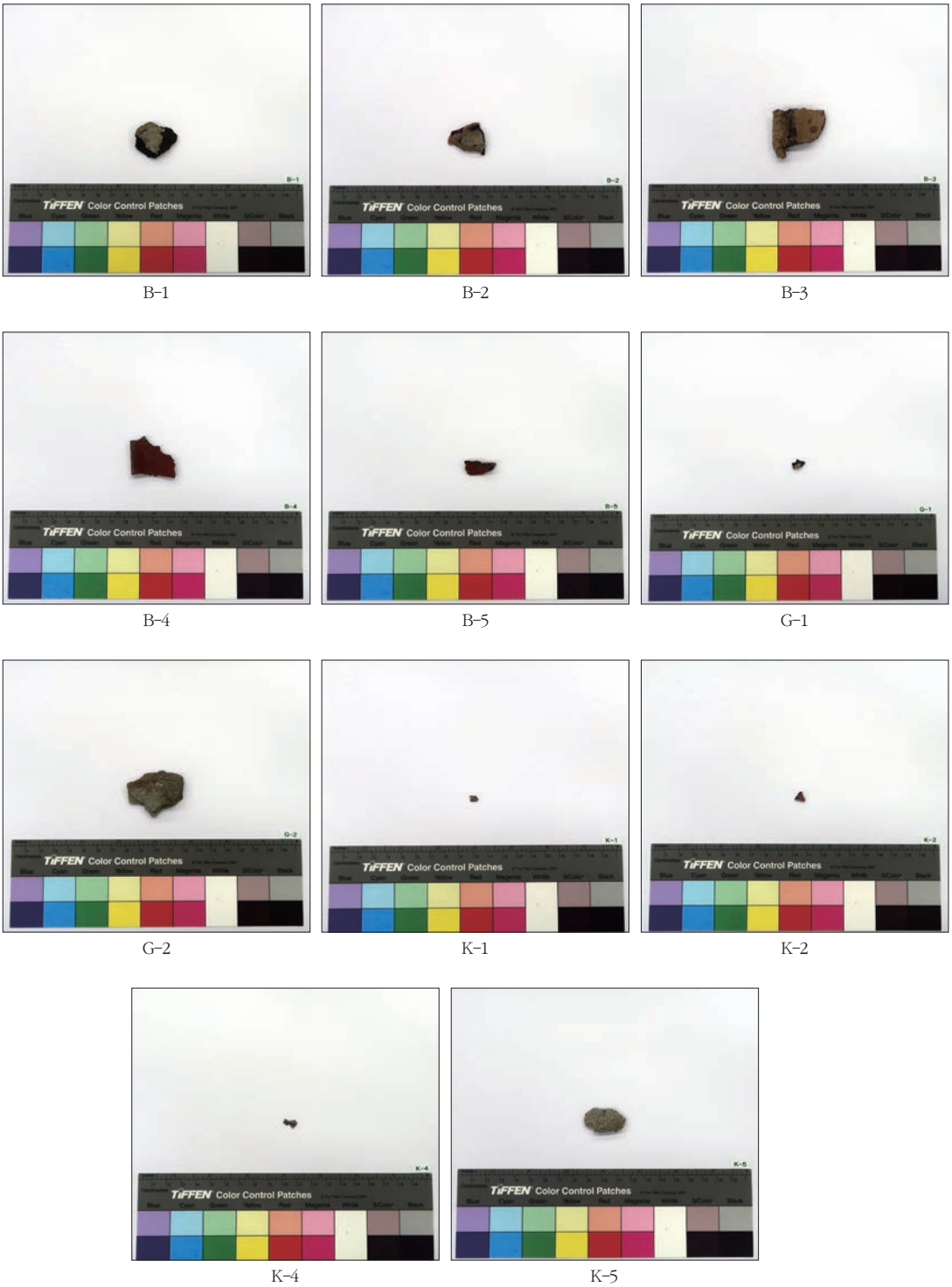


Figure 11. Lacquer mortar samples collected from the Pre Rup

presumed to be some sort of additives (Figure 12g).

When the polished cross–section was enlarged, it was observed that several layers had formed between the pigment layer and the mortar layer. The layer just below the red pigment layer did not contain a large amount of particulate matter, and the succeeding layer exhibited a layered structure with diverse thicknesses and colors. Moreover, it was observed that the pores were distributed throughout the layer of the lacquer mortar. The sizes and shapes of the pores were not constant (Figure 12h).

3. Polarizing microscopic observation

The thin–section observation of the sample under a polarizing microscope showed a large number of mineral particles such as quartz and feldspar. The varied size of the mineral particles corresponded to that of sand, silt, and clay according to the standard soil classification criteria. A brown aggregate with a diameter of about 1 mm was found. It was presumed to be an aggregate of clay. It is likely that silty sand and clay were added to it. Considering that the quartz and feldspar particles are highly rounded, it was presumed that aqueous clastic sediments were formed by natural weathering processes rather than being artificially crushed (Figure 13).

4. X-ray diffraction analysis

We conducted an X–ray diffraction (XRD) analysis for three lacquer mortar samples. Quartz (Qt) and feldspar (Ab, O) were detected the most in the analysis which meant that a large amount of soil was added to make the mortar. This was also confirmed by the previous polarized microscopic analysis. Additionally, hydroxyapatite (HA) was detected. It is an animal bone or tooth component comprising calcium and phosphorus. It suggested that animal bones or similar substances were added to manufacture the lacquer mortar (Figure 14).

5. FT-IR analysis

Among the samples collected from Pre Rup, those in which lacquer and pigment were well preserved were prepared as specimens for microscopic observation. After optical microscopy and SEM observations, the coated part was polished again and used for FT–IR analysis. An infrared spectrometer (FT–IR, Hyperion 2000, Vertex 70, Bruker, Germany) with a microscope and diamond ATR accessory was used. The following analytical conditions were set: a range of 4000 cm^{-1} to 650 cm^{-1} in the measurement area, the number of scans was set at

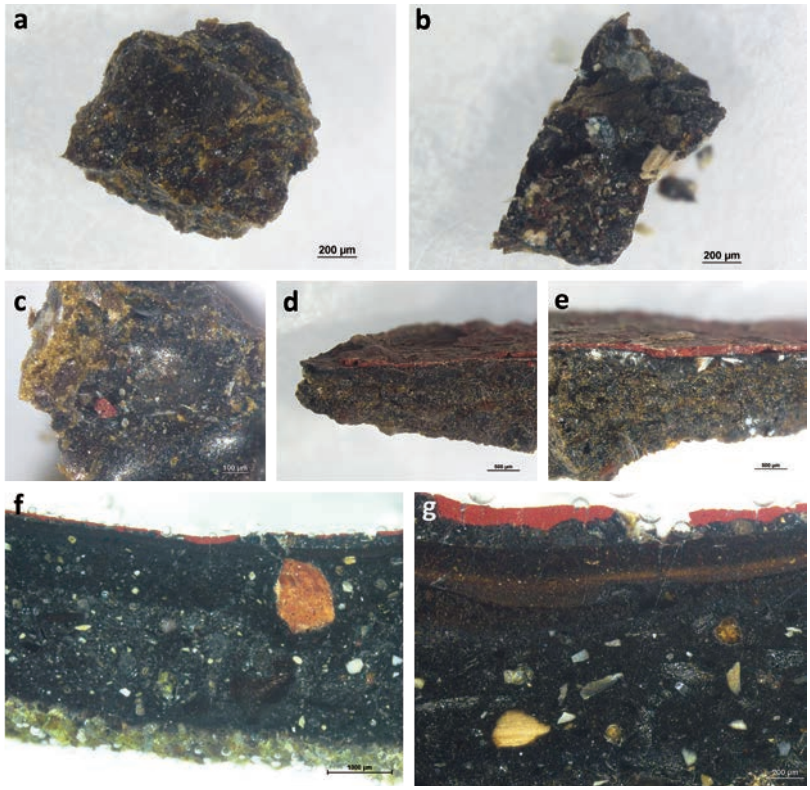


Figure 12. Stereoscopic observation of the lacquer mortar samples

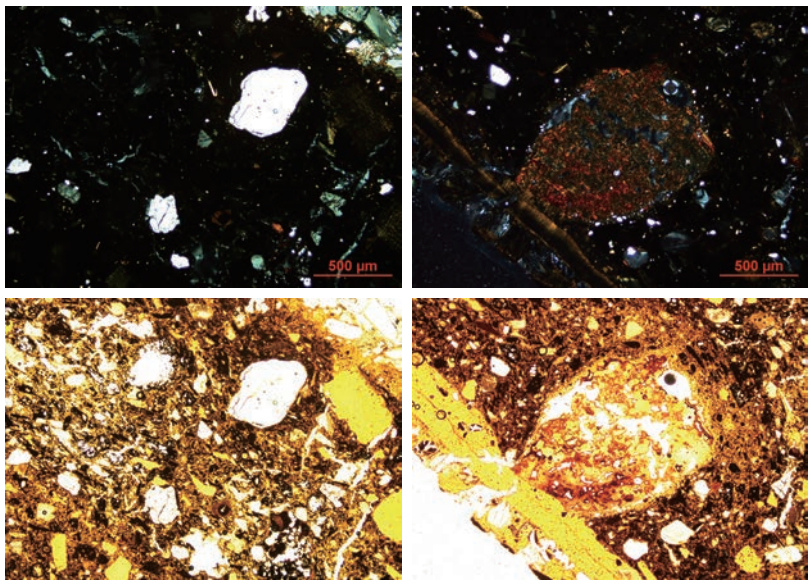


Figure 13. Polarizing microscopic images of lacquer mortar

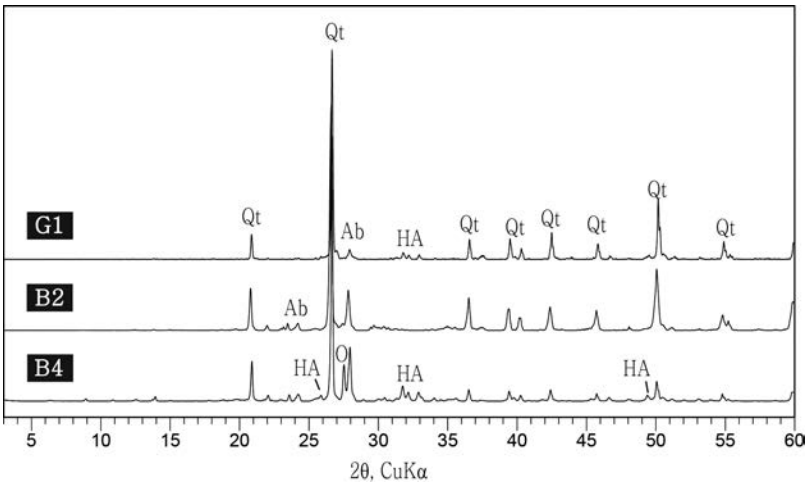


Figure 14. XRD patterns of the lacquer mortar

64 times, and a resolution of 4cm^{-1}.

An analysis of the red layer (A) and the black layer (B) of the B4 sample (Figure. 15) showed the presence of phenolic hydroxyl groups (–OH) near 3300 cm^{-1} in a wide range. Methylene groups (–CH_3, =CH_2), which can be identified characteristically in lacquer, were analyzed at 2928 cm^{-1} and 2858 cm^{-1} (Figure. 16). Previous studies of thitsiol analysis showed that the main characteristic absorption peaks were reported at 3500 cm^{-1} for the hydroxyl group, 2930 cm^{-1} for the methylene group, 1100 cm^{-1} for the phenolic hydroxyl group, and 1080 cm^{-1} for ether.[4]

After comparing it with the infrared absorption spectrum of the reference material (lacquer), both the A and B analysis positions of the Pre Rup samples were confirmed to be lacquer. Significant organic materials other than lacquer could not be identified.

4 Rong Lu and Tetsuo Miuakoshi, 2015, Lacquer Chemistry and Applications, Elsevier.

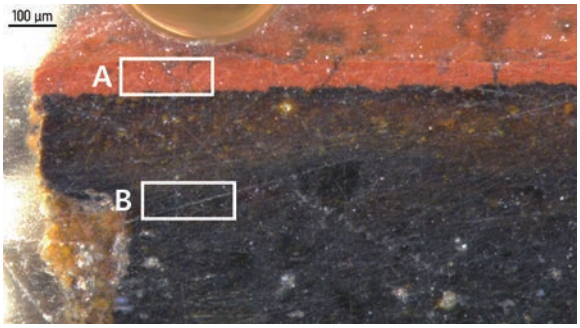


Figure 15. Analysis position by layer of lacquer mortar

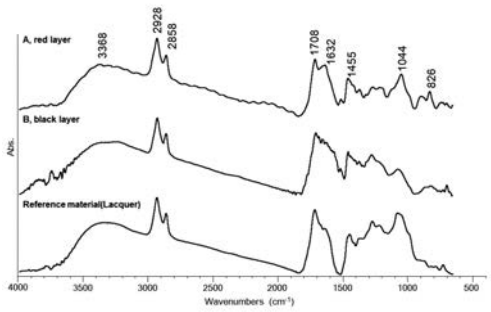


Figure 16. Infrared absorption spectrum of lacquer mortar (B4) sample

6. Py-GC/MS analysis

1) Samples and methods

Among the Pre Rup samples, the specimens were selected according to the purpose of the lacquer. G1 is a lacquer sample with a clear resin luster taken from the Gor, and K1 is the adhesive used to decorate the waist of the Kor. K2 is the pigment layer on the left arm of the stone statue of Kor, and K4 is the thin black and gray film sample (Table 2). Py–GC/MS analysis was performed on G1, K1, K2, and K4, and the analysis conditions are listed in Table 3.

Table 2. Sample status

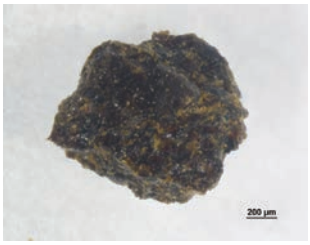
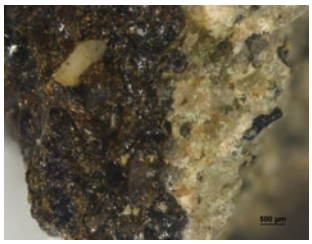
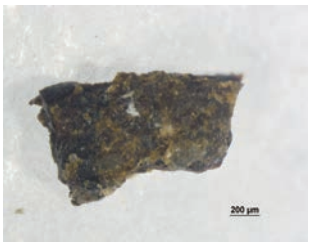
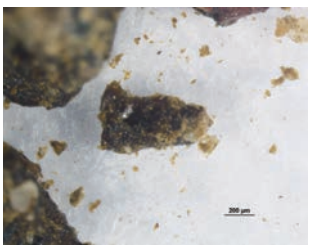
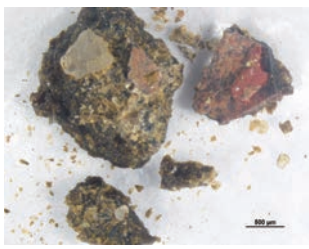
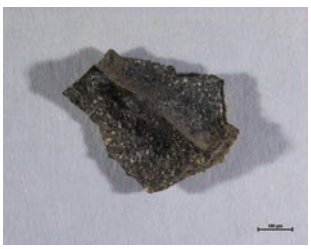
Name	Collection location	Stereomicrograph (magnification, ×20~60)	
G1			
K1			
K2			
K4			

Table 3. Instrument and analysis conditions

Pyrolyzer (PY–3030D, Frontier Lab, JPN)	Furnace	500℃, 1min
Gas Chromatography (7890A, Ahilent, USA)	Inlet	250℃, 20:1
	Oven	50℃ (3min.) to 300℃ (5min); 10℃/min
	Column	DB–1HT (30m×0.25mm id×0.10㎛)
	Gas	He 0.5ml/min.
Mass spectrometry (5975C, Agilent, USA)	Mass range	m/z 33–600
	Transfer temp.	280℃
	Ion source temp.	230℃
	Quadrupole temp.	150℃

2) Analysis result

(1) G1

Alkyl benzene and phenyl catechol compounds were detected in thitsiol, which is the main component of lacquer sap found in lacquer trees in Cambodia. Ursonic acid methyl ester, nor–alpha–amyrone, and hexakisnor–dammaran–3,20dione identified in dammar resin were detected as additives. However, dammar resin has a characteristic that is difficult to identify when it has deteriorated (requires confirmation with m/z 143). Olean–12en–28–oic acid, 3–oxo–, methyl ester was analyzed, and it may be a mastic resin. However, other characteristic peaks were not identified. Other additives such as oil and protein were not analyzed. Several fatty acids were identified, but glycerol was not analyzed; therefore, it is presumed that oil was not used (Figures 17 and 18).

(2) K1

A graph of the typical titsi was identified. It was assumed that gum benzoin was used as an additive (2–propenoic acid, 3–phenyl–, methyl ester/benzoic acid, 4–methoxy–, methyl ester/benzoic acid, methyl ester/methyl p–methoxycinnamate, cis). A compound (diketodipyrrole) analyzed in glue was identified. Other pyrrole compounds were not analyzed, and glycine, alanine, and pyridine were detected (Figure 19, 20).

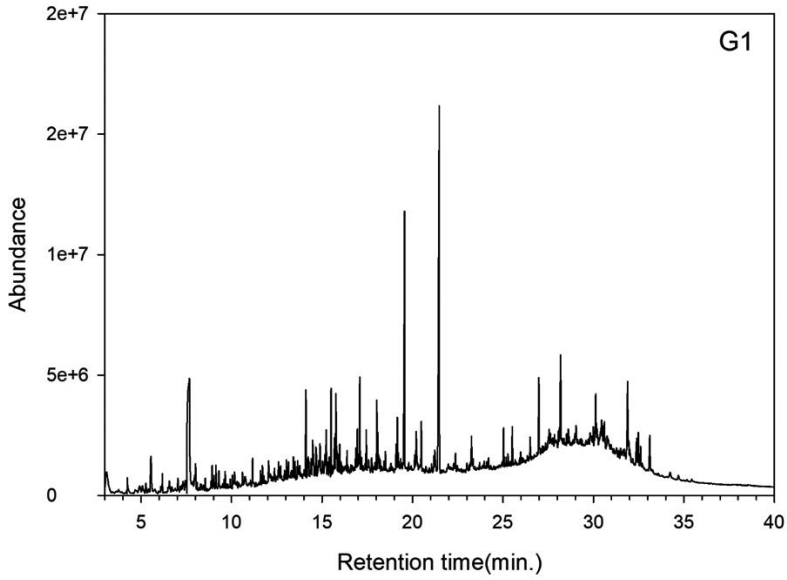


Figure 17. Pyrogram of G1 sample

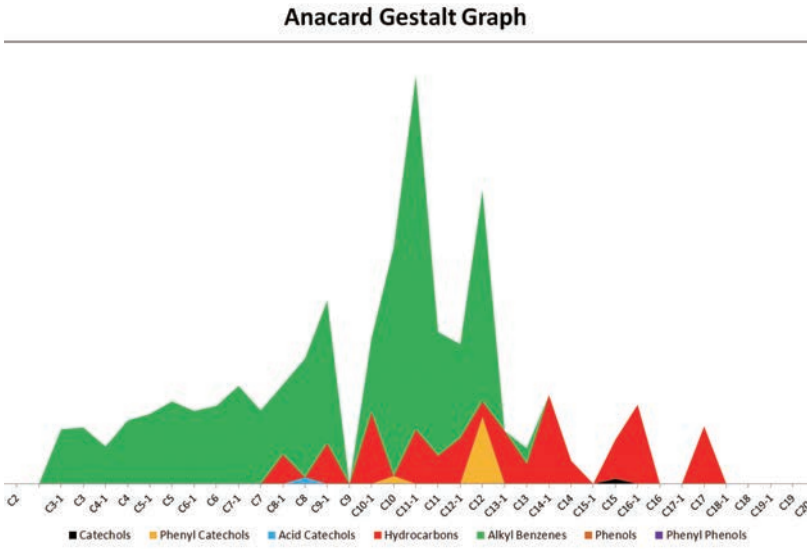


Figure 18. Gestalt graph for G1 sample

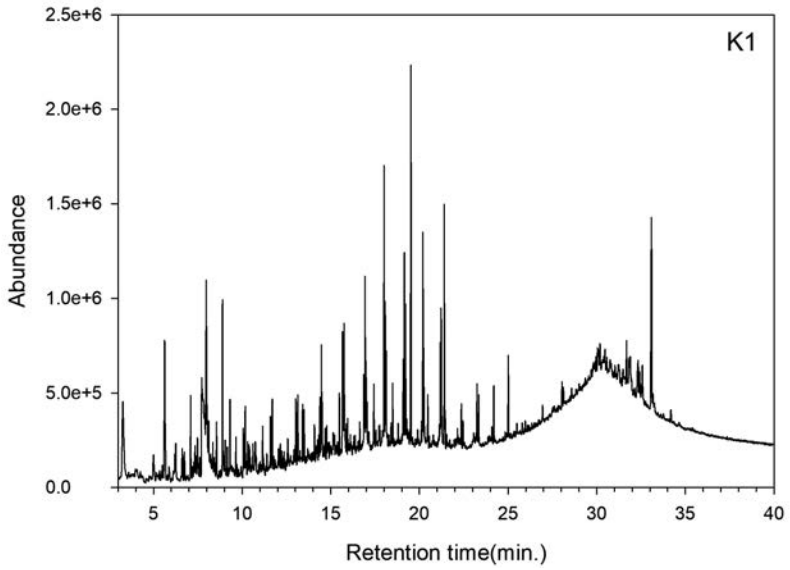


Figure 19. Pyrogram of K1 sample

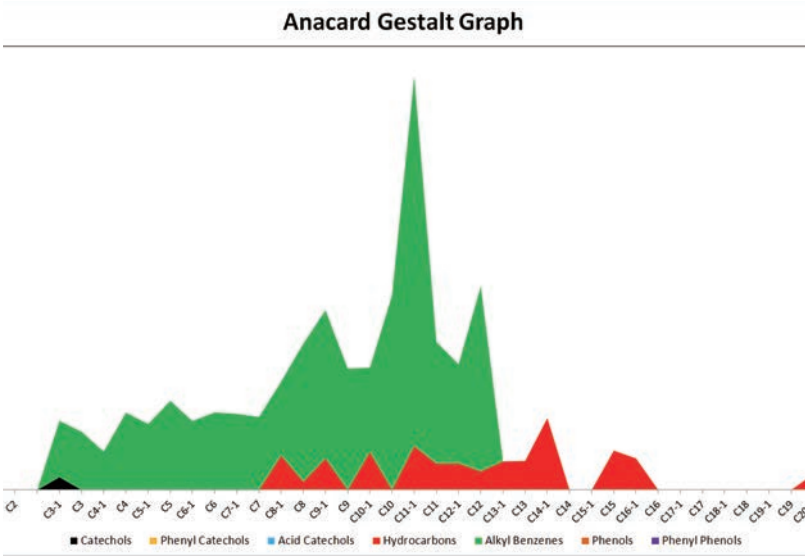


Figure 20. Gestalt graph for K1 sample

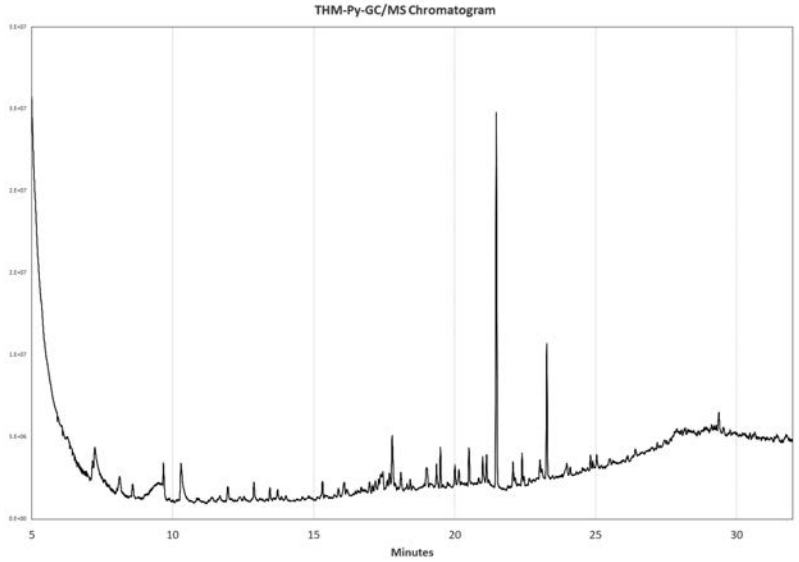


Figure 21. Pyrogram of K2 sample

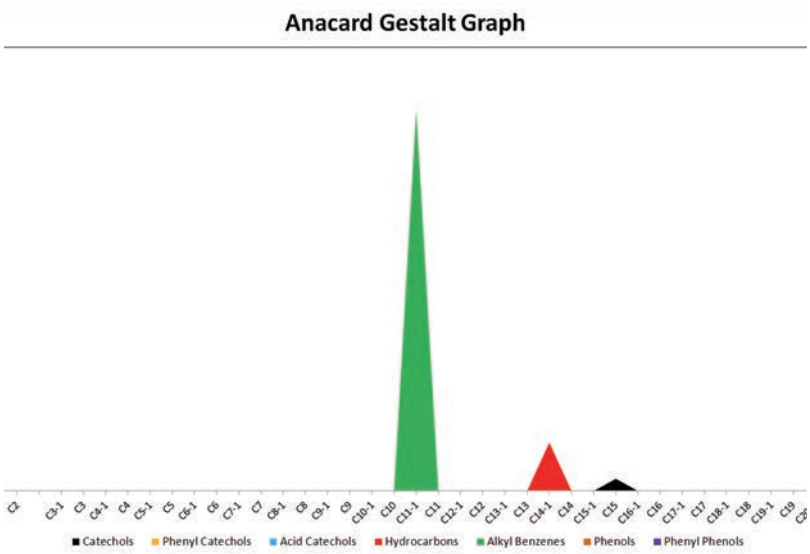


Figure 22. Gestalt graph for K2 sample

(3) K2

An analysis of the lacquer finish layer under the red layer of the sample confirmed compounds derived from thitsiol. Additionally, traces of using oil as an additive (monocarboxylic fatty acids) were found but were not analyzed with certainty (Figures 21 and 22).

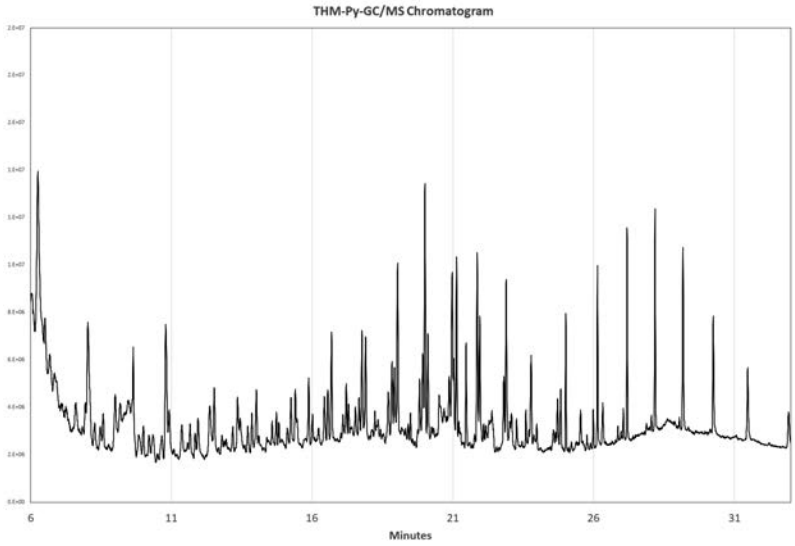


Figure 23. Pyrogram of K4 sample

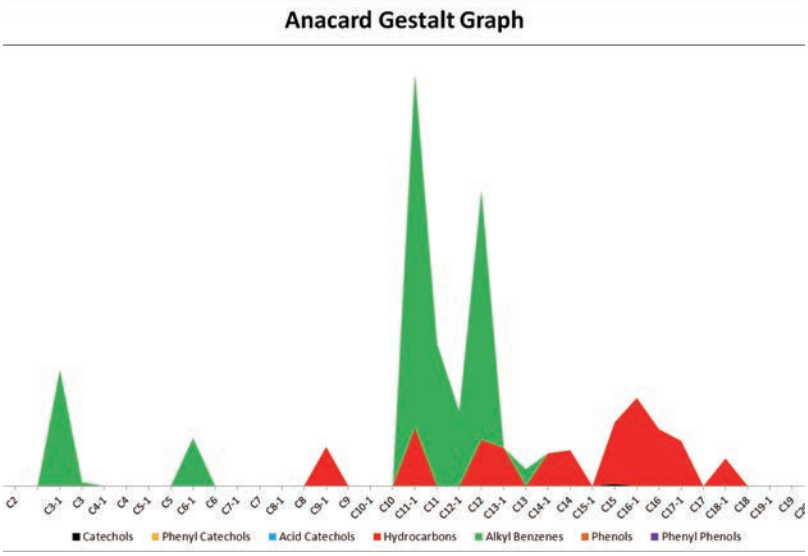


Figure 24. Gestalt graph for K4 sample

(4) K4

Lacquer was identified as typical thitsi, and no other additives such as resin or oil were detected (Figure 23 and 24).

7. Scanning electron microscopic analysis

Scanning electron microscopy (SEM) was performed. A homogeneous distribution of small pores was observed at low magnification (Figure 25). The size of the pores was approximately 10 ㎛. The dense particulates that appeared to be mineral additives and the smooth texture of solidified lacquer were mixed. It showed a mixture of sand particles with high roundness and angular to subangular particulates of smaller sizes. These small angular to subangular particulates were presumed to be bone powder as they appeared loosely structured owing to several pores and microcracks. This distinguished them from sand particles. A tubular and scale–like substance was presumed to be animal hair.

EDS (Energy dispersive spectroscopy) analysis was performed on the polished specimens. The dense, smooth, and relatively large particulates were identified as quartz sand based on the remarkably high Si (silicone) content. Particulates smaller than quartz were presumed to be clay or feldspar sand as Al (aluminum) is detected in addition to Si (silicone). An area was found where

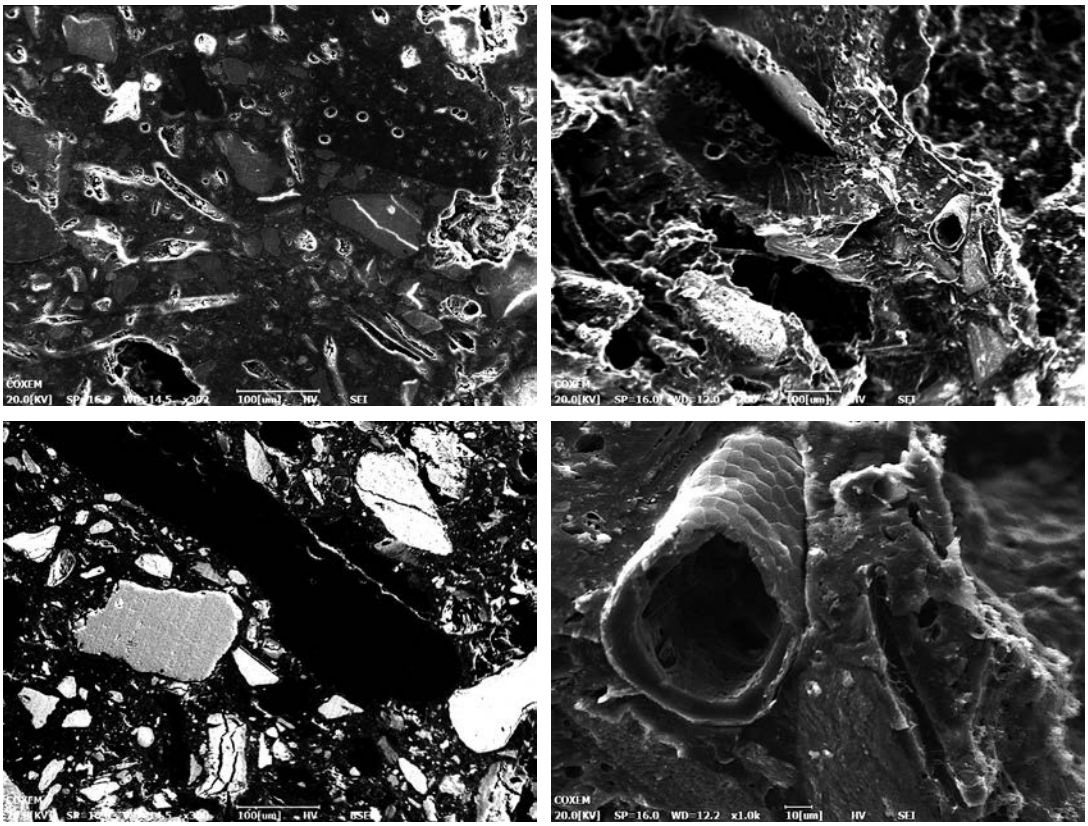


Figure 25. SEM images of the lacquer mortar

Ca (calcium) concentration was predominantly high in angular particles. These particulates were of the bone powder with a high P (phosphorus) content. The thin pigment layer was identified as a red pigment composed of iron oxide with a predominantly high Fe (iron) content (Figure 26).

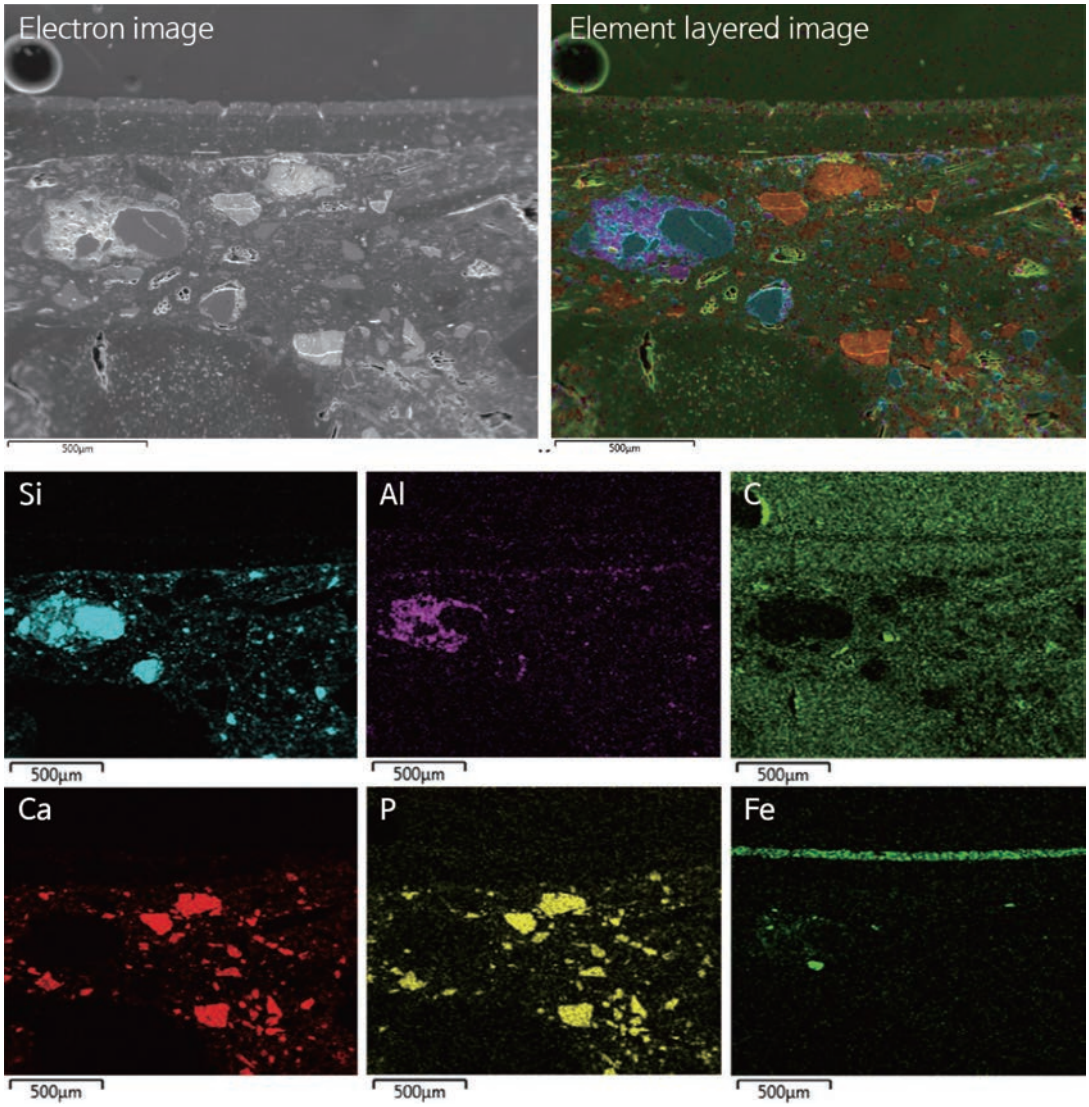


Figure 26. SEM–EDS mapping result

V. Discussion and conclusion

A basic scientific investigation was conducted on lacquer mortar used for the reparation and restoration of stone statues found in Cambodia. Lacquer mortar is prepared by mixing various additives in lacquer sap. It was used earlier to bind broken parts of the stone statues and was often used to shape or fill in the missing parts. Several such cases have been found in the Gallery of Thousand Buddhas, Angkor Wat, and the stone statues in the Sanctuary of the Pre Rup Temple.

Various scientific analytical methods were applied to the lacquer mortar samples collected from the stone statues of the Pre Rup sanctuary. As confirmed by microscopic observation, XRD analysis, and SEM–EDS analysis, the lacquer mortar samples contained a large number of additives. Commonly added materials were sand and bone. Quartz and feldspar sand, and bone powder with calcium and phosphorus were identified. FT–IR and Py–GC/MS analyses determined the lacquer as containing thitsiol, which is the main component of lacquer tree sap grown in Myanmar, Cambodia, and Thailand. In addition to thitsiol, resin–based substances collected from trees and barks, such as dammar and mastic, were also identified. Thitsiol and gum benzoin was also detected in the lacquer adhesive used in the decoration of the Pre Rup statue. Only lacquer thitsiol was identified in some lacquer specimens without any other substances.

Cambodian lacquer mortar is very similar in material to Golhoe from Korea, China, and Japan. According to the research data on Golhoe from Korea, the additives were soil, charcoal, and bone powder , although the component and ratio altered slightly with time. It is believed that wood powder,[5] wheat flour, coal powder, and horse incense were also used,[6] although obvious analytical data or literature data to prove it were insufficient. The inorganic materials added to the lacquer in Cambodia, Korea, China, and Japan are presumed to be almost the same. Organic additives such as dammar, mastic, and gum benzoin were found in Cambodian lacquer mortar. It was reported in previous research that rice husk ash, fatty acids, and tannins were also identified in Cambodian lacquer.[7] However, this was not clearly confirmed in this study. Several materials added to lacquer to make it functional vary greatly depending on region and era. Accordingly, the components to be detected also vary depending on the type of object analyzed. Additionally, it is possible that the deterioration of old lacquer also affected the analysis results.

Only a few studies on Cambodian lacquer exist as scientific analyses on it are rare in comparison to those on lacquers found in Myanmar or Vietnam.

5 Seulyoung Lim, The Modern Transformation of Bone Ashes and Its Cause, Korean journal of art history, 305, 2020.

6 Eunjeong Jang, Junghae Part, Soochul Kim, A Study on Conservation Materials of the Lacquer Wares: the Tohoe and Goksu, Journal of conservation science, 31(2), 2015.

7 Haana Szczepanowska and Rebecca Ploeger, 2019, The chemical analysis of Southeast Asian lacquers collected from Forests and workshops in Vietnam, Cambodia, and Myanmar, Journal of Cultural Heritage.

Therefore, based on the results of this basic research, it is necessary to conduct additional analysis and in–depth studies in the future to determine the characteristics of lacquer from different Cambodian regions and periods. The results obtained from this study will be used as basic data for the same and to revive the traditional lacquer techniques of Cambodia.

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Development of Photogrammetry Education Program for 3D Digital Scan of Cultural Heritage

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Abstract

Various interdisciplinary studies are needed in the field of heritage, and the fourth Industrial Revolution has established projects utilizing digital technology related to the excavation, conservation, and utilization of heritage. However, owing to the characteristics of digital technology, it is not easy for laypeople to access cultural heritage through it, which is an aspect field of heritage that requires to be worked upon in the future.

This study thus developed a photogrammetry education program—a digital technology for workers engaged in the field of heritage. The concepts and definition of digital heritage were first examined. Digital heritage is a digital approach to heritage that involves the transformation of physical heritage into a digital form. Additionally, the concept of born–digital heritage is also defined as digital heritage in accordance with the Charter on the Preservation of Digital Heritage.

The importance of digital education in the field of heritage is recognized by several countries such as the United States, the United Kingdom, and South Korea. The necessity for the education and application of digital technology is emerging with the complex changes in the functioning of museums. Hence, we intend to encourage the use of digital technology in the field of heritage by developing educational programs for people working in this field in the Asia–Pacific region.

In conclusion, photogrammetry, aiding in acquiring and generating 3D data, was selected, and its basic principles, preparations, and practical methods were studied. Consequently, the goal is to acquire photogrammetry skills easily through an educational handbook, irrespective of the location of the workers, by creating an educational program that can educate workers engaged in the field of heritage in the Asia–Pacific region.

Ⅰ. Digital Heritage

1. Cultural Heritage

The United Nations Educational, Scientific and Cultural Organization (UNESCO) defines heritage as the living heritage inherited from our ancestors to be passed on to future generations (UNESCO, n.d.). Currently, South Korea uses the term cultural property (문화재; *Munwahjae*) as a legal term for cultural heritage. The Cultural Heritage Protection Act, enacted to promote the cultural improvement of the people and to contribute to the development of human culture, defines cultural heritage as follows.

> The term "cultural heritage" in this Act means artificially or naturally formed national, racial, or world heritage of outstanding historic, artistic, academic, or scenic value.
>
> (Cultural Heritage Protection Act, Article 2 (definition), 2020)

As defined above, cultural heritage lives with us in the present, and it is important to pass on its value intact to the next generation (Venice Charter 1964). This means that cultural heritage must be properly excavated, conserved, managed, and utilized in the communities in which it exists. John Ruskin (1849, 179) argued that cultural heritage should be utilized by all generations and that the present generation has no right to alter or destroy it.

However, it is important to utilize cultural heritage sustainably, because the conservation of cultural heritage is to respect not only the present generations but also the future generations. Various methods have been suggested to utilize cultural heritage sustainably and to maintain its integrity. This study recognizes the digital formats of the resources and information related to cultural heritage as the concept of digital heritage. We will suggest ways to maintain the authenticity and integrity of cultural heritage.

2. Digital Heritage

Since the 1990s, with the advent of the Information Age, the digitization of information on heritage has been undertaken. It has brought about changes in the museum and cultural heritage management systems (Ahn and Kim 2016, 5). In accordance with these changes, UNESCO and several other international organizations have begun to pay attention to the concept of digital heritage. In 2001, the UNESCO Council discussed the preservation of digital heritage, paying special attention to the issues of digital preservation faced by the European Commission on Preservation and Access (ECPA) (Ahn and Kim 2016, 5).

Accordingly, UNESCO drafted the Charter on the Preservation of Digital Heritage in 2003, which outlined the definition of digital heritage, approach towards it, threats from loss of cultural heritage, the need for action, and digital continuity. The Charter defines digital heritage and its scope as follows.

> The digital heritage consists of unique resources of human knowledge and expression. It embraces cultural, educational, scientific and administrative resources, as well as technical, legal, medical and other kinds of information created digitally, or converted into digital form from existing analogue resources.
>
> (UNESCO, 2003)

As mentioned above, digital heritage not only includes the cultural heritage expressed and reproduced in digital form but also the concept of born–digital originally created by digital technology. In particular, Mckenzie and Poole extended the concept of digital heritage to a 'digital approach to heritage' (Mckenzie and Poole 2010 cited in Ahn and Kim 2016, 6–7). Several relevant international charters can confirm the importance and scope of digital heritage.

3. Charters on Digital Heritage

International charters on digital heritage include the Universal Declaration on Cultural Diversity (2001), Charter on the Preservation of Digital Heritage (2003), UNESCO Recommendation concerning the Promotion and Use of Multilingualism and Universal Access to Cyberspace (2003), The London Charter for the Use of 3–Dimensional Visualisation in the Research and Communication of Cultural Heritage (2006), and Recommendation Concerning the Preservation of, and Access to, Documentary Heritage Including in Digital form (2015). These charters deal with the relationship between culture and the digital world and display the following characteristics.

Ⅱ. Education on Digital Heritage

1. Professionals in the Field of Heritage

Various types of workers are employed in the heritage field based on their qualifications. There are museum and art gallery curators, culture and arts educators, cultural tourism docents, cultural heritage repair technicians (Kim 2012), amog others. For this study, a museum curator, who practices cultural heritage, was selected to take an educational program on digital heritage. The International Council of Museums (ICOM) Korean Committee defines museum workers as follows.

Table 1. Charters on Digital Heritage

Year	Charters	Contents
2001	Universal Declaration on Cultural Diversity	Article 6 declares cultural diversity for all and codifies measures to ensure the free flow of ideas in text and images, while at the same time allowing all cultures to express and promote themselves.
2003	Charter on the Preservation of Digital Heritage	Establishment of a concept for the conservation and management of UNESCO digital heritage, guaranteeing access to digital heritage including born–digital heritage.
2003	UNESCO Recommendation concerning the Promotion and Use of Multilingualism and Universal Access to Cyberspace	Recognizing that the restriction of the use of multiple languages in the global information network hinders the securing of universal access to the digital environment. The purpose is to promote a solution through international cooperation.
2006	The London Charter for the Use of 3–Dimensional Visualisation in the Research and Communication of Cultural Heritage	It covers a wide range of applications such as the arts, humanities, and cultural heritage that use 3D visualization for research and dissemination and includes measures to clarify the 3D visualization of digital models.
2015	Recommendation Concerning the Preservation of, and Access to, Documentary Heritage Including in digital form	In relation to the Memory of the World, UNESCO members should lead exchanges and cooperation related to preservation and accessibility enhancement of documentary heritage, emphasizing the establishment of a continuous network with the private sector and internal and external expert groups and related institutions, as well as international organizations.

> "Museum workers" includes all people engaged in the museums recognized by ICOM and institutions that conduct educational and research activities useful for museum activities, and they have received training in a field appropriate to museum activity and operation or have had practical experience equivalent to that.
>
> (ICOM Korea 2013).

In the past, museums and art galleries focused on the role of collection, research, and exhibition of relics; however, due to recent development and the diversity of relics, their functions have been expanded to serve as complex cultural facilities (Choe et al 2019). Choe (2019, 97) emphasized the strengthening of the educational functions in museums and argued that the roles of curators should be diversified. It can thus be confirmed that digital education for museum workers is considered as one of the requirements necessary to enhance the sustainable development of museums and art galleries.

2. The Necessity of Digital Education

Digital education is crucial for future generations. Attempts to combine the ICT technology of the fourth Industrial Revolution with existing educational methods are emphasized. They are based on competency–oriented education and creative convergence education.

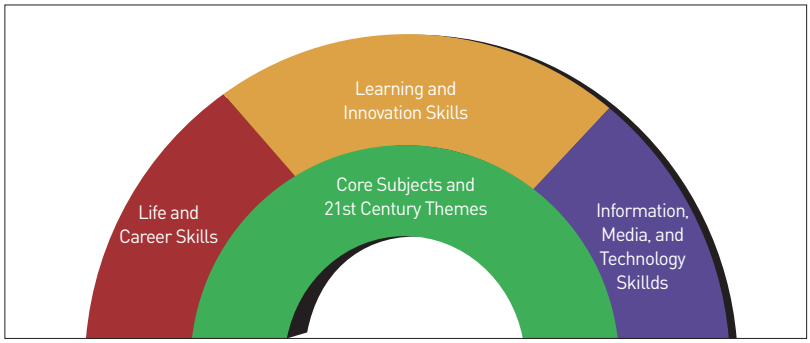


Figure 1. 21st Century student competency framework (partially restructured by the author) (Source: Partnership for 21st Century Skills 2009, 1)

Competency–oriented education refers to the cultivation of competencies necessary for future generations. It cultivates the learners' ability to utilize and apply knowledge rather than simply acquiring it (Lim 2019, 260). Major international organizations such as the OECD and EU have suggested future core competencies (Jung & Kim 2019, 337). Among them, the Partnership for 21st Century Skills project recommends the following core competencies.

As shown in Figure 1, the Partnership for 21st Century Skills mentions competencies such as life and career skills, learning and innovation skills, and information, media, and technology skills (P21 2009). It emphasizes computational thinking along with creativity, critical thinking, communication, and collaboration under information, media, and technology skills that were previously suggested (Lim 2019, 259).

In the case of the UK, computational thinking was applied to the regular curriculum (CAS & Naace 2014, 4). South Korea also emphasizes the significance of computational thinking in the Software Education Operation Guidelines of 2015 (Ministry of Education 2015).

Creative convergence education refers to the ability to creatively use and approach the knowledge and technology of the fourth Industrial Revolution. Jung and Kim (2019) also suggested an art education plan that strengthens competencies by converging technological capabilities in artistic creation and cultural enjoyment. Convergence education started with STEAM (Science, Technology, Engineering, Arts, and Mathematics) in the United States, which teaches art with STEM (Science, Technology, Engineering, and Mathematics). It helps reinforce strengths that provide a wide range of convergence education such as creativity and imagination (Kang 2015, 7).

In the educational field, emphasis is laid on creative convergence education

that encourages creative use by applying competency–oriented computer thinking and the fourth Industrial Revolution technology to the field of culture and art. Therefore, this study suggests a digital heritage education program suitable for the present era by adopting an educational method that applies digital technology to the field of heritage education. The subject for digital heritage education is the staff working in institutions related to cultural heritage. We aim to provide a digital heritage education program that can be applied in the Asia–Pacific region. Consequently, instances of active studies being conducted abroad, where digital technology is applied to heritage education, were analyzed.

3. Heritage Education Programs Using Digital Technology

1) CIPA Heritage Documentation Summer School

CIPA Heritage Documentation organized an annual summer school to educate archaeologists, architects, historians, and surveyors on the correct way to document, survey, and model cultural heritage. In this program, participants gained firsthand experience in 3D surveying, photogrammetry, and laser scanning conducted in the laboratory and on the field.

Table 2. The Schedule of CIPA Heritage Documentation Summer School

No.	Date	City
1	July 5–12, 2014	Paestum, Italy
2	July 12–19, 2015	Paestum, Italy
3	August 30 – September 3, 2016	Valencia, Spain
4	July 12–18, 2017	Paphos, Cyprus
5	July 15–21, 2018	Zadar, Croatia
6	September 2019	Manila, Philippines
7	July 14–20, 2019	Gyeongju, Republic of Korea

Figure 2. CIPA SUMMER SCHOOL 2019 in Gyeongju (Source: CIPA Heritage Documentation)

Time Schedule

Schedule

	July 14	July 15	July 16	July 17	July 18	July 19	July 20
09:00 ~ 12:00	Arrival to Gyeongju	Lectures	Data Acquisition		Data Processing		Seminar I (National Museum of Korea, Seoul)
Lunch				Lunch			
13:30 ~ 18:00		Lectures	Data Acquisition		Data Processing	Final presentation	Seminar II (National Museum of Korea, Seoul)
Dinner	Pre-activity: Welcome Dinner & Cultural Visit (UNESCO World Heritage)	Dinner		Social Dinner (networking)	Dinner + Museum visit	Farewell Dinner	

Meals

	July 14	July 15	July 16	July 17	July 18	July 19	July 20
Breakfast	Arrival to Gyeongju	Breakfast is included in the Accommodation					Seminar I
Lunch		Sandwiches or Lunch box					Lunch
Dinner	Welcome Dinner	Ordinary Dinner		Social Dinner	Ordinary Dinner	Farewell Dinner	Seminar II

Figure 3. CIPA Gyeongju training program schedule (Source: CIPA Lecture Notes)

Lists of Lectures

01	Andreas GEORGOPOULOS	Photogrammetry
02	Fabio REMONDINO	Laser scanning
03	Efstratios STYLIANIDIS	Topography
04	Abhijit DHANDA	Photography
05	Isabella TOSCHI	Demo CloudCompare
06	Elisa FARELLA	Demo Metashape

Figure 4. CIPA Gyeonju lecture content (Source: CIPA Lecture Notes)

2) Cultural Heritage Imaging

Cultural Heritage Imaging (CHI) is a non-profit organization that develops practical digital imaging and conservation solutions. It leads the adoption of these technologies by cultural heritage stakeholders to preserve cultural heritage before it is lost. Its goal is to universalize technology so that people worldwide can document their cultural heritage and preserve and protect it for future generations. CHI technologies comprise new and easily learnable imaging techniques (photogrammetry and reflectance transformation imaging (RTI)) along with various tools, skills, and training.

Table 3. Cultural Heritage Imaging Programs

	Programs	Content
1	4-Day photogrammetry training	See how to acquire photogrammetric image sets and create scientific 3D documentation. Experience how to build 3D content using equipment, image capture setup, and software.
2	4-Day RTI training	Learn how to use Highlight RTI to create digital representations of various objects. Develop the ability to implement digital imaging workflows, including capturing, processing, and viewing RTI digital representations.
3	CHI training with an expert	4-day training classes on RTI and photogrammetry with direct visits from CHI experts.
4	Half-day workshop	Learning digital imaging skills in the field of conservation and education. Held for archaeologists, photographers, or staff of museums or libraries.

Figure 5. Educational environment at Cultural Heritage Imaging (Source: CHI)

3) CyArk

CyArk is a non-profit organization established in 2003 with the goal of archiving, storing, and sharing digital heritage. Currently, over 200 sites have been documented, and 3D documentation training programs are provided for students through workshops. In June 2021, CyArk and Capturing Reality collaborated to provide a joint educational workshop on the topic of 3D

Figure 6. Preserving Slovakian Heritage Workshop at CyArk (Source: Cyark nd)

documentation for students at the Academy of Arts in Banská Bystrica and the Technical University of Košice. The two–week course provided students with training to record historical sites using photogrammetry techniques and to create virtual reality scenes and 3D models

Ⅲ. Digital Recording Technology

1. Digital Records in the Field of Heritage

The International Council on Monuments and Sites (ICOMOS) adopted the 'Principles for the Recording of Monuments, Groups of Building and Sites (1996)' in 1996, stating that records are an important part of the preservation process (ICOMOS 1996, 49). Recording has become an indispensable process in the conservation of cultural heritage, and digital technology has helped to improve the speed, accuracy, and data quality of cultural heritage documentation. Digital technology enables the recording and analysis of high–quality cultural heritage data at a high speed, and the results of the analysis facilitate the establishment and implementation of cultural heritage conservation plans. These results were shared by experts and related parties and used in the conservation, management, and utilization of cultural heritage.

2. Digital Recording Technology

Several technologies can be used to record cultural heritage, and the application of these technologies depends on the type and properties of the cultural heritage being documented. The format of digital recording includes 2D images, 3D shapes, sounds, and motions. Figure 7 shows how 3D data of cultural heritage is acquired through contact and non–contact methods depending on

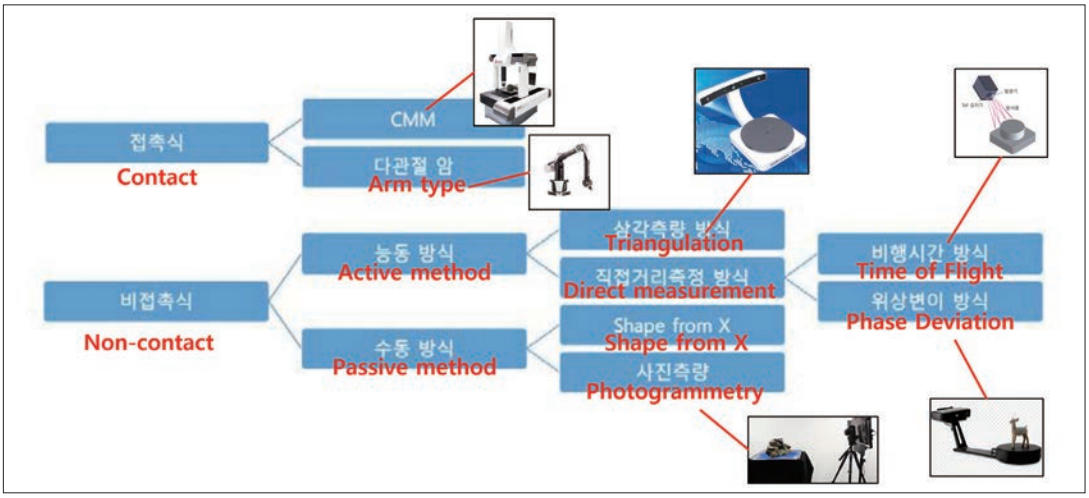


Figure 7. Classification of 3D scanners by scanning method (edited by the author) (Source: Cultural Heritage Administration 2018, 12)

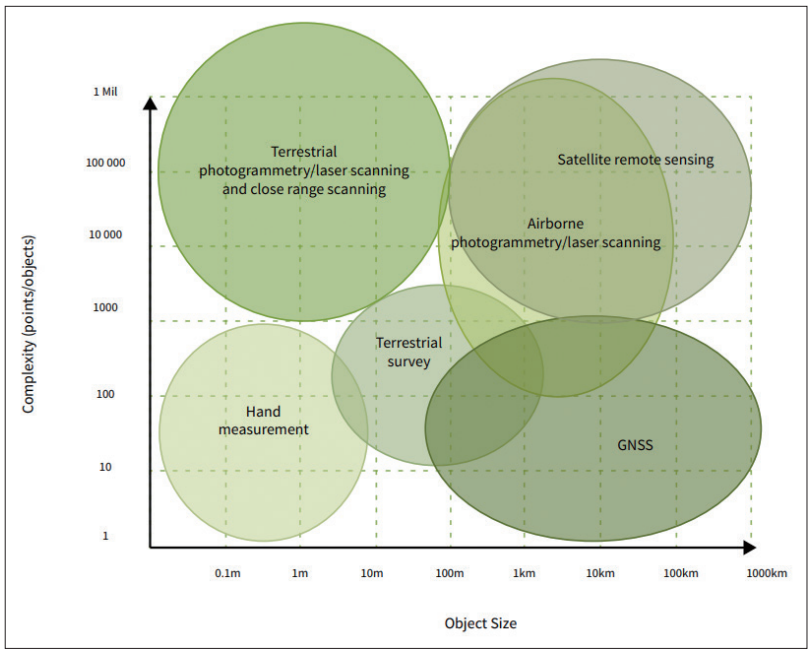


Figure 8. Investigation technology according to the characteristics and size of the object (Source: Historic England 2018, 2)

whether the scanner is in contact with the surface of a relic or not. The non–contact method is further bifurcated into an active method, which is a distance–based method obtained by firing a laser or light, and a passive method, which is an image–based method that calculates 3D data by recognizing an object using an image sensor. The use of the non–contact method for data acquisition is suitable for cultural heritage sites to maintain their integrity.

1) 3D scanning

3D scanners record the 3D coordinates of numerous points on the surface of an object within a relatively short time period. In this process, a laser beam is projected onto the surface of the object (Boehelr et al 2001, 1). The 3D scanner operates through the time–of–flight method, the phase shift method, and the triangulation method. The precision scanner uses the triangulation method (Cultural Heritage Administration 2018, 13).

2) Photogrammetry

Photogrammetry is a technology that extracts 3D form information by acquiring images of stationary objects from various angles and positions. This is an image–based modeling technique included in SfM (Structure from Motion) technology that interprets the structure of an object from motion.

In this study, educational content on 3D data generation of cultural heritage was developed, focusing on photogrammetry technology, so that workers in the field of cultural heritage can acquire data in a short time at a relatively low price and with easy access. The technical characteristics of 3D scanning and photogrammetry are compared in Table 4.

Table 4. Comparison of technical characteristics of 3D scanning and photogrammetry

Categories	3D Laser Scanning	Photogrammetry
Technology base	Distance	Image
Price	Expensive	Cheap
Operability	Low	High
Date Acquisition Time	Long	Short
Modeling of Complex Shape	Difficult	Easy
3D information	Direct Acquisition	Extraction
Distance Dependence	High	Low
Space Dependence	High	Low
Material Dependence	High	Low
Light Dependence	Varies by Machines	High
Date Size	Large	Depends on Resolution
Texture	Low resolution	Including
Open Software	Few	Several

IV. Photogrammetry

1. Basic Principles

1) What is photogrammetry?

Photogrammetry is a method of measuring an object by taking its image. Qualitative data, such as the color of the object and the degree of wear, and quantitative data, such as the height and size of the building, can be obtained from the survey by measuring the acquired photos.

Photographers must follow certain rules and procedures to obtain correct data through photogrammetry. Photogrammetry proceeds in the following order: 1) image capture, 2) image matching, and 3) point cloud generation. The preparations differ depending on the size, characteristics, and condition of the object. This photogrammetry course focused on the method of photographing artifacts of 20cm×20cm or less so that relatively small artifacts can be photographed.

2) Needs

Photogrammetry supplies for small artifacts include a DSLR camera, tripod, lighting, white background paper, release, color reference card, turntable, and software (3DF Zephyr, Reality Capture, etc.).

2. Photography

Photography refers to recording the shape of an object by adjusting the light sensitivity, aperture, and exposure time. To use photogrammetry technology correctly, an understanding of photography and the art of handling cameras is essential. It is necessary to check the basic parameters of sensor sensitivity (ISO), aperture, and shutter speed among the main operating elements of the camera to properly record the shape of the artifact.

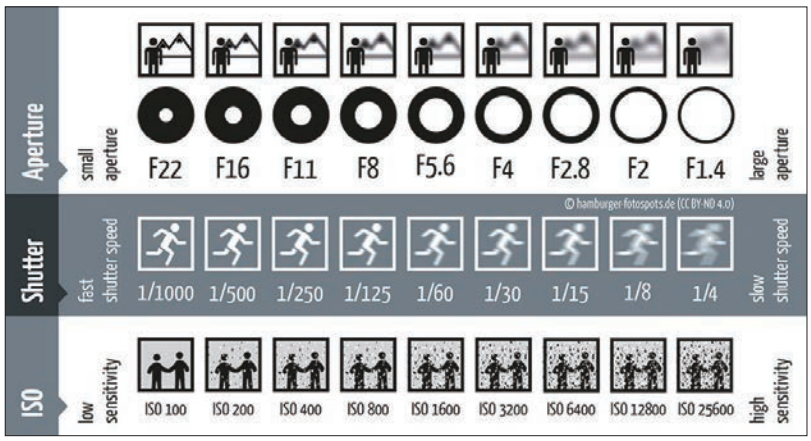


Figure 9. The three factors of photography (Source: Hamberger Fotospots, n.d.)

1) Sensor sensitivity (ISO)

ISO is a measure of the sensitivity of a camera's image sensor. Until the 1980s, each country had a non–uniform standard for sensitivity, but the International Organization for Standardization set a film sensitivity standard that can be used worldwide. The sensitivity of the sensor is often called ISO sensitivity. In general, the lower the sensitivity of the camera, the less light it receives, and the higher the detail and saturation of the picture, the clearer is the picture.

Figure 10. Comparison of quality degradation according to ISO manipulation (ISO 100 versus ISO 12800) (Source: Kim 2019)

2) Aperture

Aperture is defined as the degree to which the lens opens. The light hits the sensor through the lens, and the amount of light is limited by the degree to which the lens is opened. When the aperture is opened, the amount of light increases, and the image becomes brighter. Consequently, the depth of focus becomes shallow and the front and rear parts except for the focused part blur the image. Conversely, if the aperture is closed owing to the high number of apertures, the amount of light is reduced. Consequently, the depth of focus is deep and clear images can be obtained.

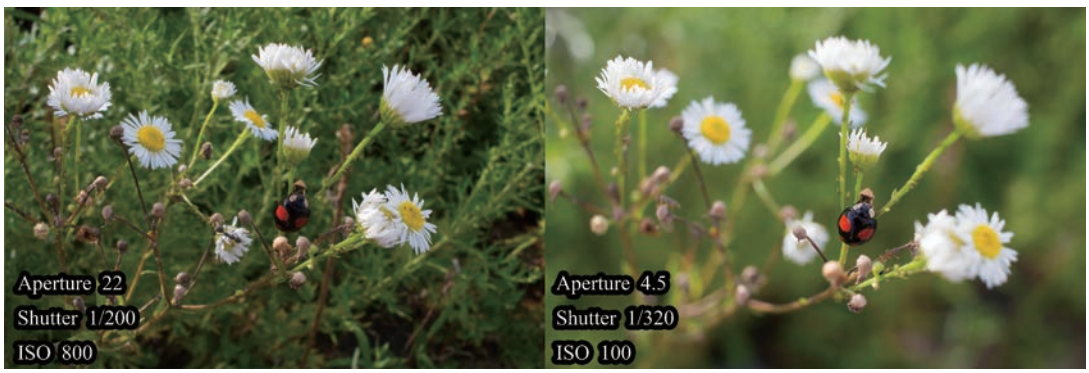


Figure 11. Comparison of changes in the focus of photos according to the manipulation of the aperture value (aperture 22 versus aperture 4.5) (Source: Kim 2019)

3) Shutter Speed

The shutter speed or exposure time refers to the amount of time the image sensor inside the camera is exposed to light. The faster the shutter speed, the clearer the dynamic picture can be obtained, but the lesser the light entering the sensor, the darker the picture can be obtained. Furthermore, the slower the shutter speed, the harder it is to capture dynamic photos, but the longer the sensor is exposed to the light, the brighter the photos can be obtained at times in places with low light, such as at night or indoors.

Figure 12. Comparison of photos according to shutter speed manipulation (shutter speed 1/3200 sec. versus 1/15 sec.) (Source: Kim 2019)

3.Application to Small Objects

Photogrammetry requires the application of different surveying techniques depending on the size, shape, and condition of the object. It is necessary to pay attention to the focal length of the lens, the control of the light, and the location of the artifacts while conducting it. In the case of small artifacts displayed in museums and art galleries, it may be advantageous to use a macro lens that can take pictures at a short distance from the subject. It is recommended to set up the lighting and tents in a manner that can disperse the light evenly and control it. Additionally, high–quality data can be obtained by improving the shooting environment using turntables, scale bars, and color reference cards.

1) Macro lenses

A macro lens is a lens that is optically designed to focus closer to a subject. Regardless of the focal length of the lens, it can be used if it has a macro function; however, as it gets closer to the subject, it is easier to use a wide–angle lens to capture the entire range of the artifact. However, sometimes a telephoto lens is needed to photograph artifacts such as coins. A 40–60 mm lens is called a standard lens, a lens with a shorter focal length than that of the standard lens

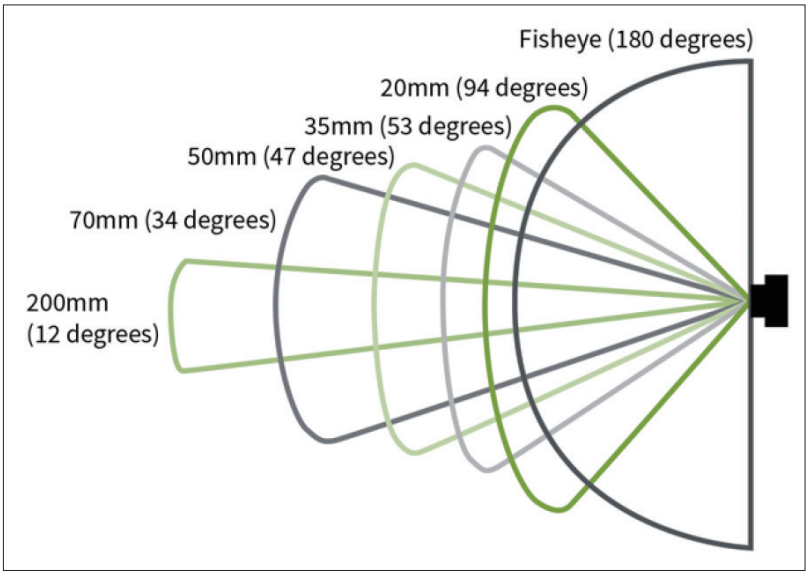


Figure 13. Shooting range according to the focal length of the lens
(Source: Historic England 2017, 29)

is called a wide–angle lens, and a lens longer than the standard lens is called a telephoto lens.

2) Lighting tent

In the case of small artifacts, shadows may occur depending on the location of the lighting in the studio, which may prove to be problematic in acquiring data. Accordingly, shadows on the relic should be minimized, and the material of the relic that does not reflect light is ideal to obtain photos for photogrammetry. Moreover, the light should be evenly dispersed. There is a technique to use the tent to disperse the light. After installing the tent, if LED lights are installed outside it, the light is evenly dispersed inside the tent. The tent is easy to set up so that the light can be dispersed evenly.

3) Turntables

Turntables are used while photographing small artifacts. The turntable is used to rotate the artifact while the camera is fixed at a particular spot. The advantage is that 360–degree recording is possible with the camera, lighting, and tent fixed, so the intensity of light can be uniformed. Additionally, it reduces the acquisition time of image data by reducing the time required to set up the camera and lighting.

Figure 14. Dispersion of light and shadow removal using a tent (Source: Historic England 2017, 107)

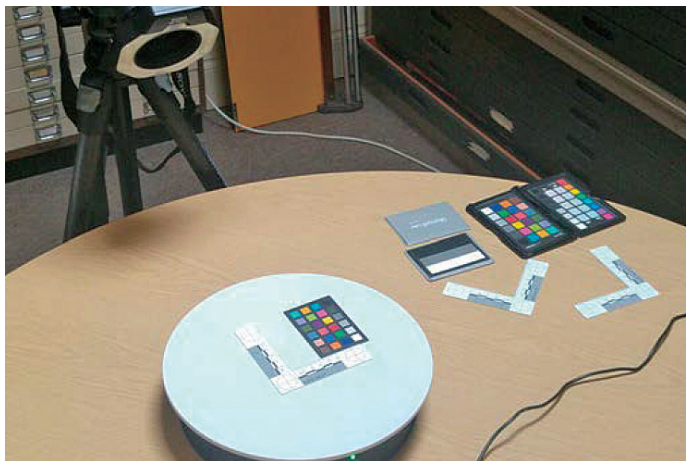


Figure 15. Tools used to photograph small artifacts (Turntable, scale bar, and color checker) (Source: Historic England 2017, 76)

Figure 16. The scale bars produced by Cultural Heritage Imaging (Source: Cultural Heritage Imaging, n.d.)

4) Scale bars

The scale bar acts as a measure to check the distortion that occurs during the shooting. When shooting an artifact, the actual size of the artifact can be checked, which is necessary to create an accurate 3D model of the artifact.

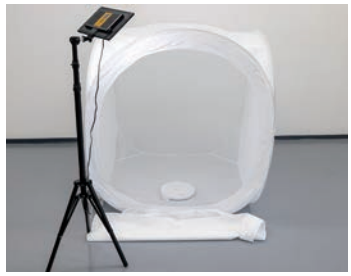
5) Color reference card

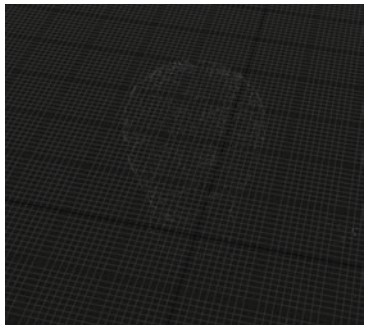
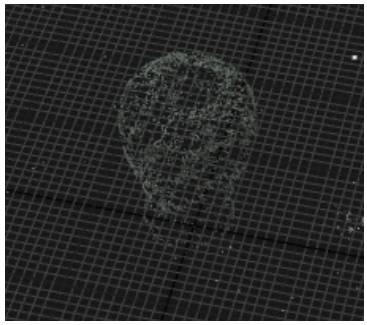
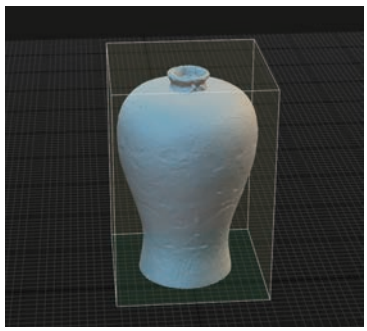
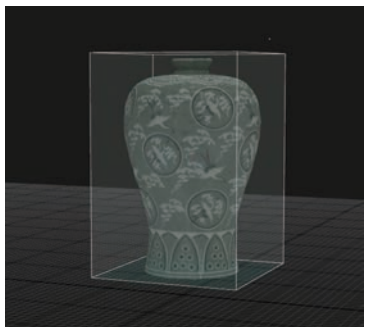
The color checker helps photographers adjust the white balance by checking the color of the image on the computer. White balance refers to adjusting the color balance of the color to match it to the original one by neutralizing the color of the photographed light.

4. Practice

In this photogrammetry handbook, Reality Capture and 3DF Zephyr were the programs used for aligning the photos of a relic. Reality Capture especially provides the advantages of good performance, fast processing speed, and easy operation. This handbook dealt with a replica of Goryeo celadon, one of Korea's representative artifacts, applied with the inlay technique as a target artifact. The procedure for generating a 3D model of the artifact utilizing photogrammetry is as follows (see Appendix 1).

Table 5. Practice creating 3D models of small artifacts using photogrammetry

1. Selection of an artifact	2. Setting up the environment
	
Select the artifact you want to create a 3D model of from the museum or art gallery. Since the difficulty of acquiring image data varies depending on the size and shape of the artifact, a simple artifact is recommended in the beginning.	Set up the environment by installing tents, lighting, turntables, color checkers, and scale bars. Rather than direct light, it is better to have an environment where the lighting light passes through the tent and the light is dispersed evenly.
3. Taking an Artifact	**4. Data Acquisition**
	
Rotate the turntable and take pictures of artifacts. It is recommended to rotate the turntable at an angle of about 15 degrees. When shooting, consider the focus and image shake.	Acquire image data using photography skills suitable for the artifact. When acquiring image data, the more the overlapping parts of the image, the better the image alignment. The height of the camera is adjusted based on the artifact, and several shots are taken.

5. Data Alignment	6. Generating High–Density Point Clouds
	
Use the application to match the artifact data. The initial data arrangement produces a low–density point cloud.	Based on the generated low–density point cloud data, more points are connected to create a high–density point cloud.
7. Generating Mesh Data	**8. Generating Textured Mesh and Export Object File**
	
Generate mesh data based on high–density point clouds.	If the generated data is processed into a textured mesh and exported as an object file (OBJ), the 3D model can be used in applications that support OBJ extension.

V. Conclusion

This study aimed to produce a photogrammetry education program for 3D digital scanning of cultural heritage for professionals working in the field of heritage. The concepts and definition of digital heritage were researched and charters related to it were examined. Digital heritage has been defined in various forms and can be summarized as computerized materials with lasting value that should be preserved and transmitted to future generations (Lee 2019). After the UNESCO Charter on the Preservation of Digital Heritage was published in 2003, the concept of digital heritage was expanded and discussions on digital heritage were actively conducted.

Chapter 2 examined the definitions of the types of professionals in the

heritage field and the museum workers discussed in ICOM to examine the importance of digital heritage education. The museum has particularly developed into a complex cultural facility due to the diversity of the artifacts on display. With the advent of the information age, museum curators must acquire knowledge about digital heritage. Additionally, as the ICT technology of the fourth Industrial Revolution is being applied to educational methods, the necessity of digital education for workers in the heritage field has been in demand. Currently, more cultural heritage education programs using digital technology are being actively conducted in European countries than in the Asia Pacific region.

Digital recording technology plays an important role in the conservation of cultural heritage, and the 'Principles for The Recording of Monuments, Groups of Building and Sites (1996)' codified the importance of documenting cultural heritage. In this study, 3D scanning, and photogrammetry were compared, and the photogrammetry technology, which provides the advantages of relatively low price, easy access, and fast data acquisition, was selected as the target of the education program.

Photogrammetry is based on photography, and the adjustments in ISO (Sensor sensitivity), aperture, and shutter speed play significant roles. The handbook selected relatively small relics, found in huge proportion in museums, and accordingly, a macro lens, a tent for lighting control, a turntable, a scale bar, and a color checker were selected. The practice module was developed by confirming the need for the photogrammetry technology studied in this paper, and the procedure of 3D model production was explained with actual photographs. Celadon, one of the relics mainly found in the Asia–Pacific region, was selected as the target relic. A celadon is apt to teach the concept of light control and is advantageous because beginners can easily access them due to their simpler appearance. Then, using Reality Capture, which is easier to operate than other softwares, the practical methods and procedures for photogrammetry were introduced.

Although this study did not provide an in–depth understanding of photogrammetry, it served its purpose of providing a working knowledge of its techniques to the laypeople working in the field of heritage. It allowed for non–major professionals in the heritage field to apply digital technology to the cultural heritage easily. It made it easy for them to acquire the theoretical understanding and practical skills regarding digital heritage, digital recording technology, and photogrammetry through the textbook without any other learning programs. Consequently, starting with this textbook, it is expected that

educational programs on the application of technology onto the heritage field for people who work in this field will continuously be developed in the Asia–Pacific region.

In the future, producing and managing content related to cultural heritage will become a priority for the related institutions. Therefore, a curriculum should be proposed for people working in the heritage field to learn the database management method and the concept of metadata required for museum artifact data management. Additionally, the digital heritage objects generated in this manual can lead to the production of digital heritage content such as virtual museums and H–BIM. In conclusion, we will suggest a curriculum based on the concept of digital heritage and the manual of content production as a future study.

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Software

3DF Zephyr (Photogrammetry Software)
Reality Capture (Photogrammetry Software)

Acknowledgements

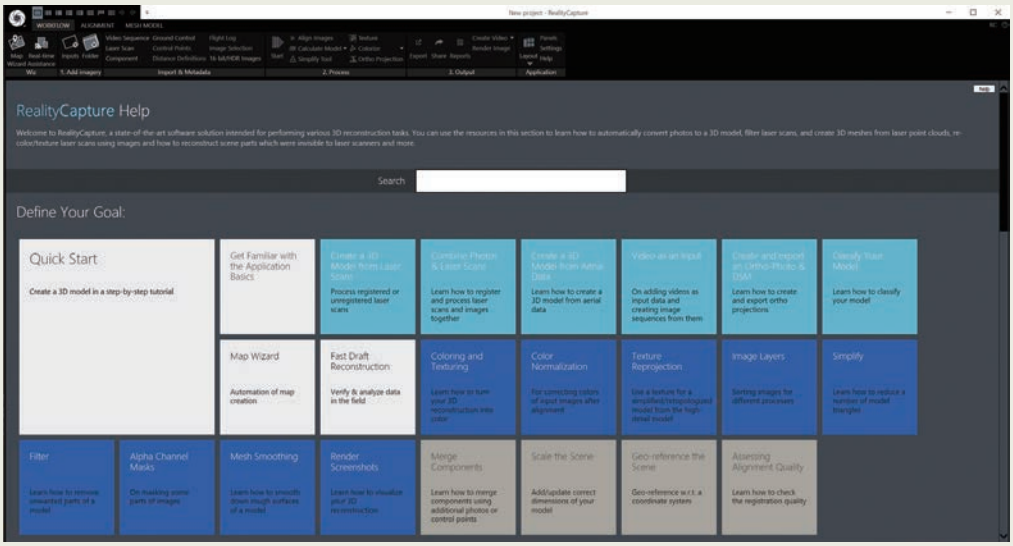
This research was funded by the 2021 UNESCO Chair Research Grant Project of Korea National University of Cultural Heritage.

Appendices

Appendix 1. The handbook for photogrammetry (Reality Capture)

1) Program Running

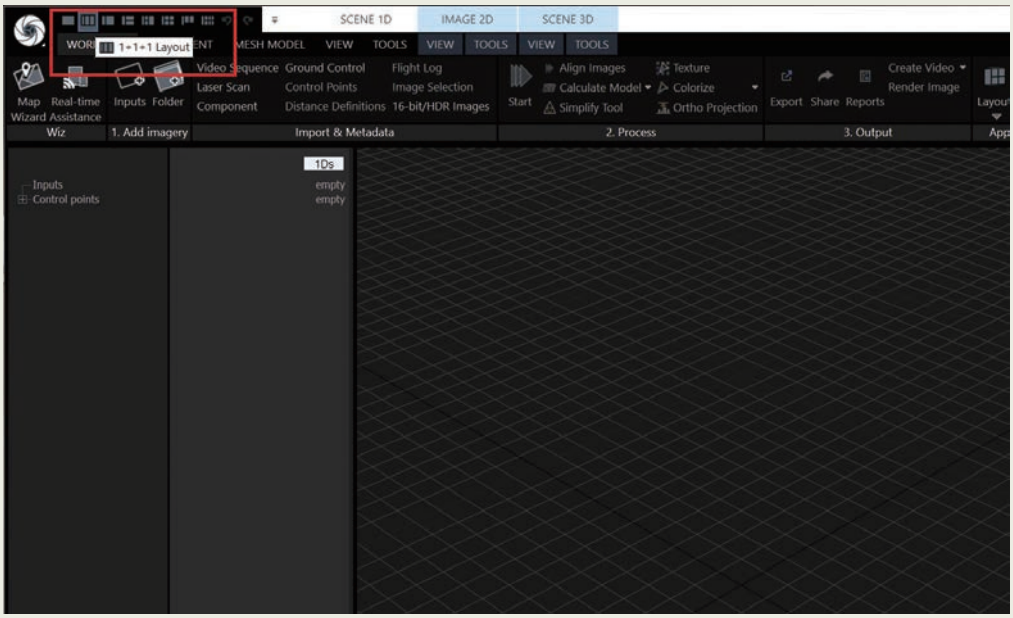
To run the Reality Capture.



<Figure 1> Running Reality Capture

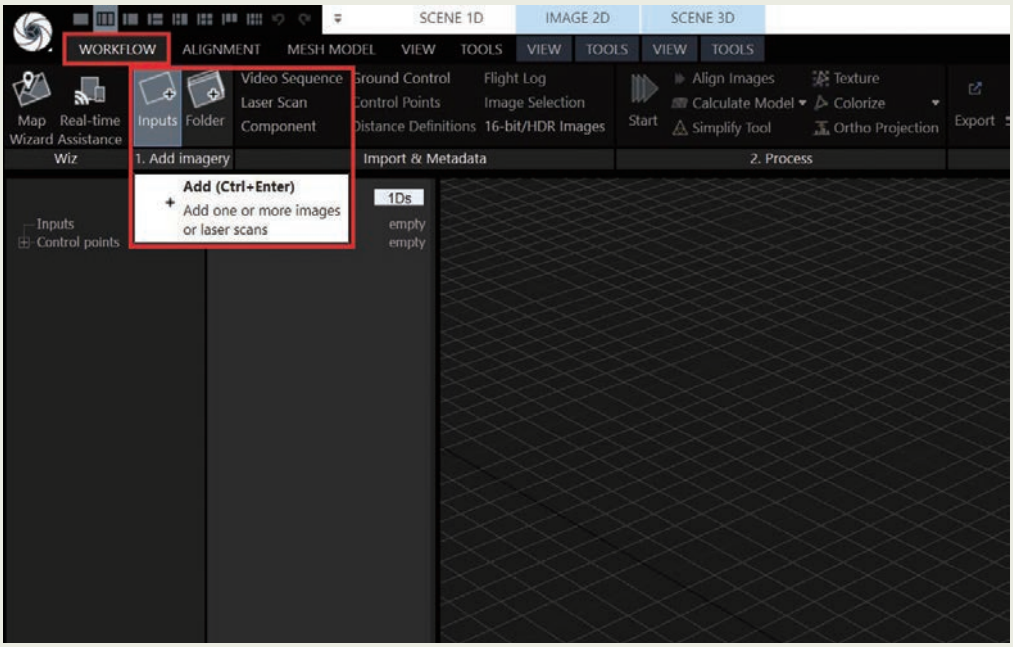
2) Layout settings

To click [1+1+1 Layout] in the [LAYOUT] tab at the top left. If you click this setting, the work screen is divided into 3 parts.



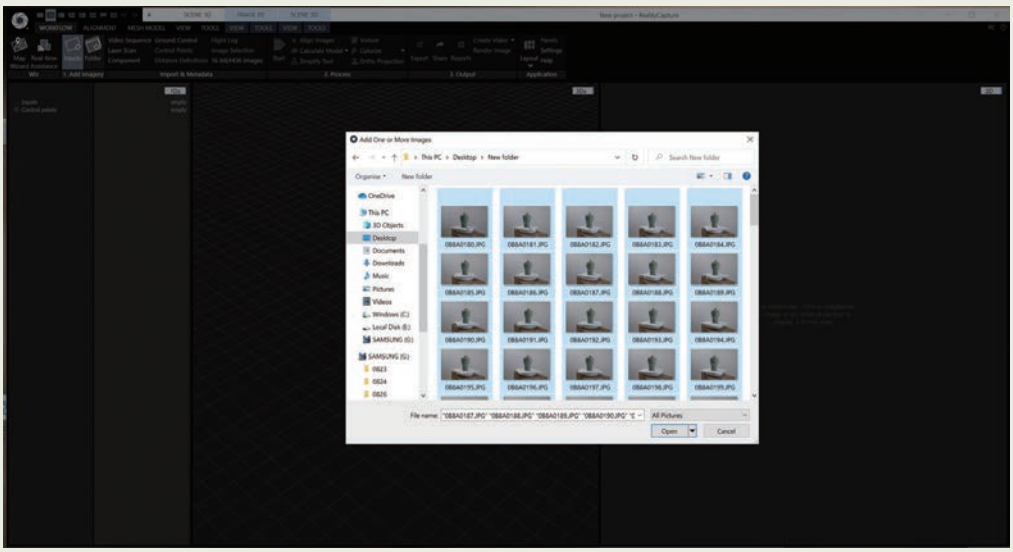
<Figure 2> Setting up the working environment

3) Input of photos — To click [Inputs] in the [WORKFLOW] tab at the top left to input a photo.



<Figure 3> Inputting photo

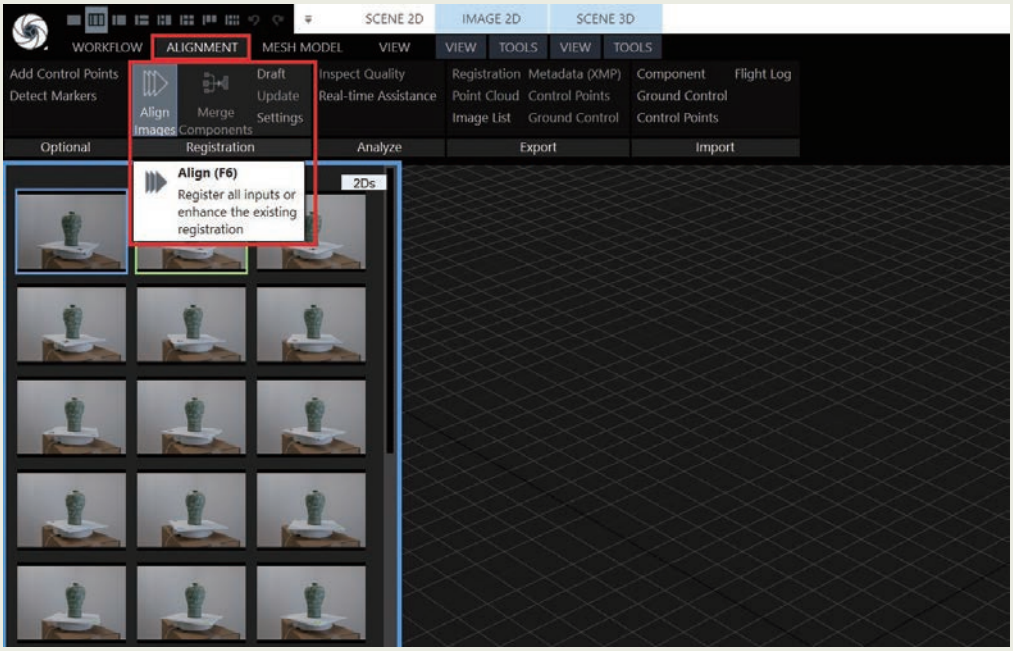
4) Selecion of photos — To input photos by selecting a path with pre–taken photos.



<Figure 4> Selecting photos

5) Running the Alignment of Images

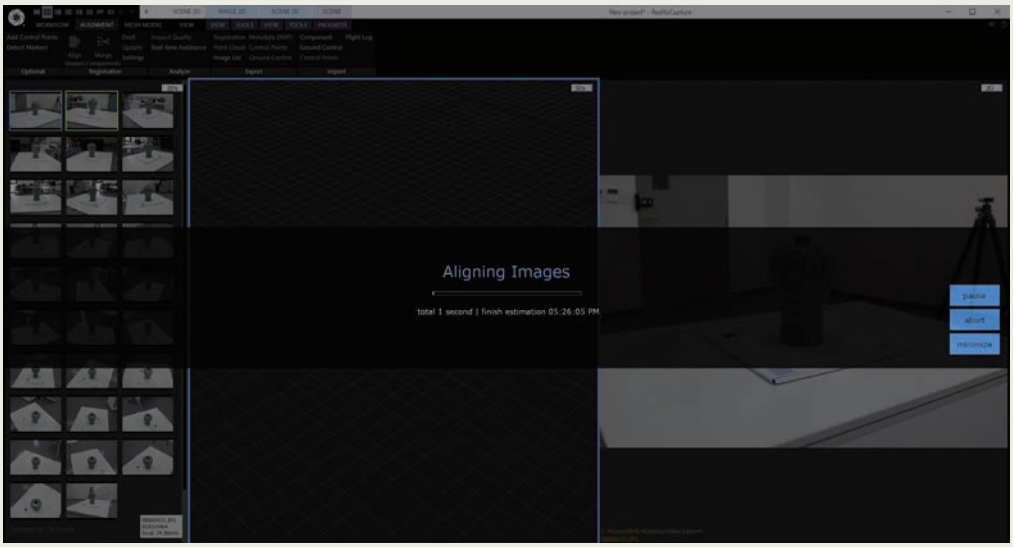
To align the photos by selecting [Align Images] in the [ALIGNMENT] tab at the top left. Point cloud data is generated with the data imported through this process.



<Figure 5> Clicking Align Images

6) Alignment of Images

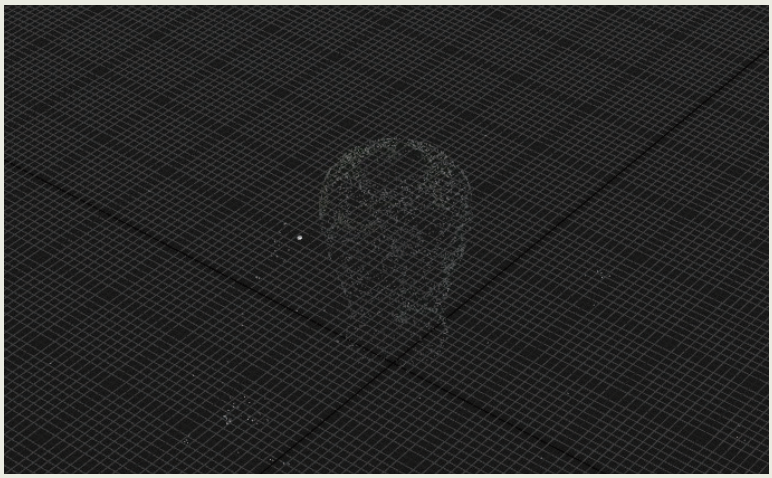
When the photos are matched, the progress time and completion time are displayed as shown below. Through this operation, the images are matched.



<Figure 6> Aligning Images

7) Generation of Point Cloud Data

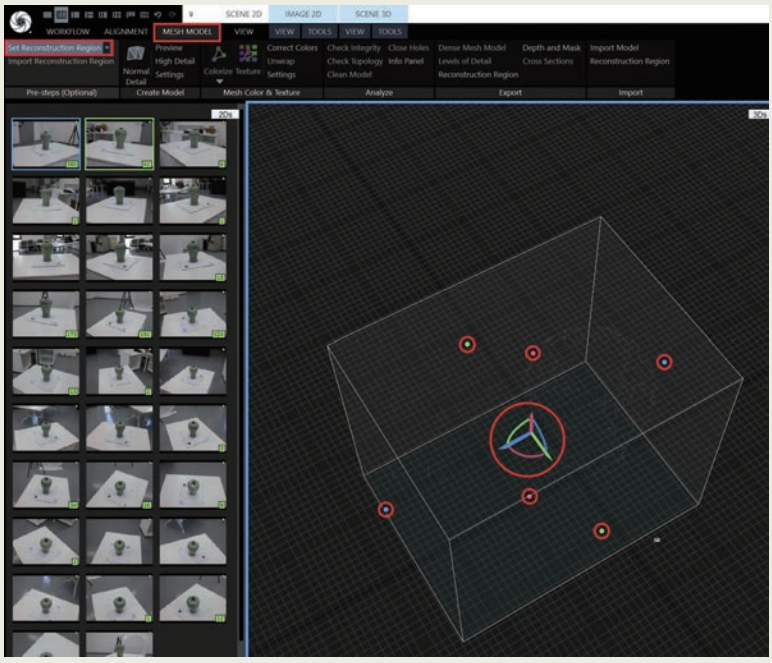
Point cloud data are generated as shown in the picture below.



<Figure 7> Generated Point Cloud

8) Setting modeling area

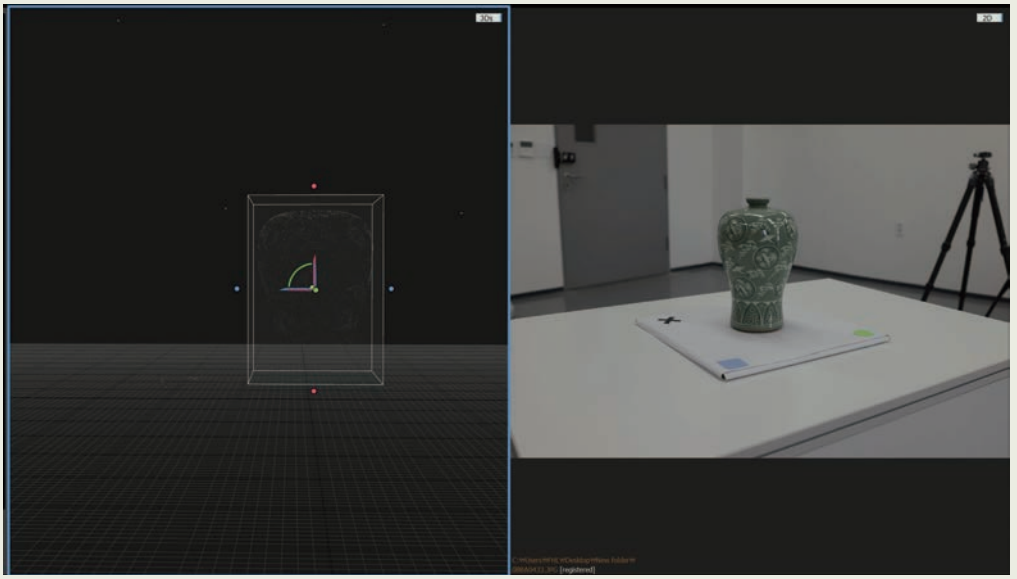
To click [Set Reconstruction Region] in the [MESH MODEL] tab at the top left to open a box where you can select a modeling area. As shown in the picture below, you can set the size of the box with 6 small folds and rotate the model through the large coordinate system in the middle. The white box indicates the area to be modeled finally.



<Figure 8> Selecting Modeling Area

9) Completion of Ground Plane Arrangement

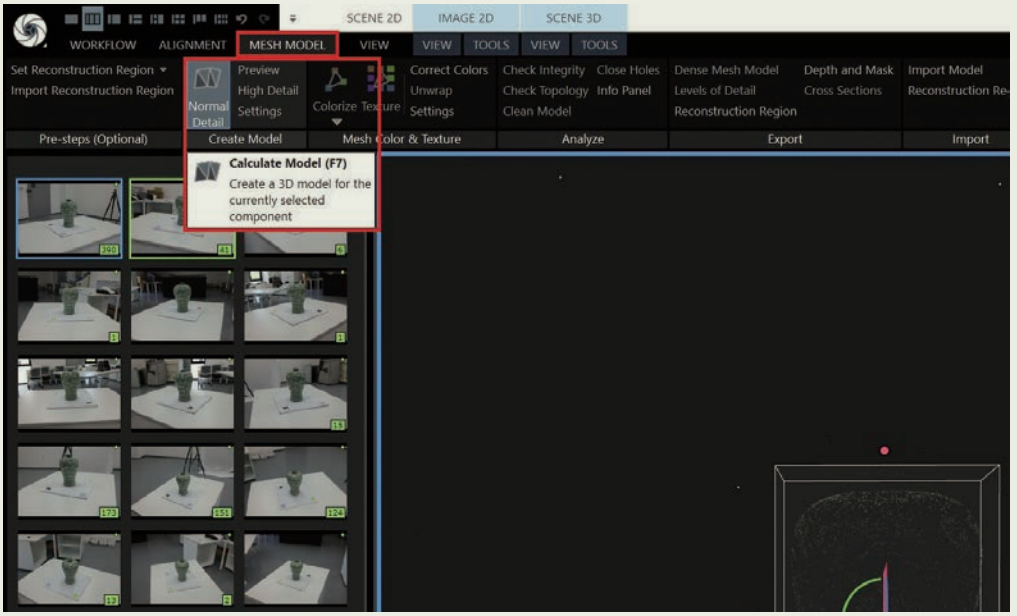
When the ground plane is arranged, a box centered on the artifact is formed as follows



<Figure 9> Point cloud data with ground plane arranged

10) Running Mesh Generation

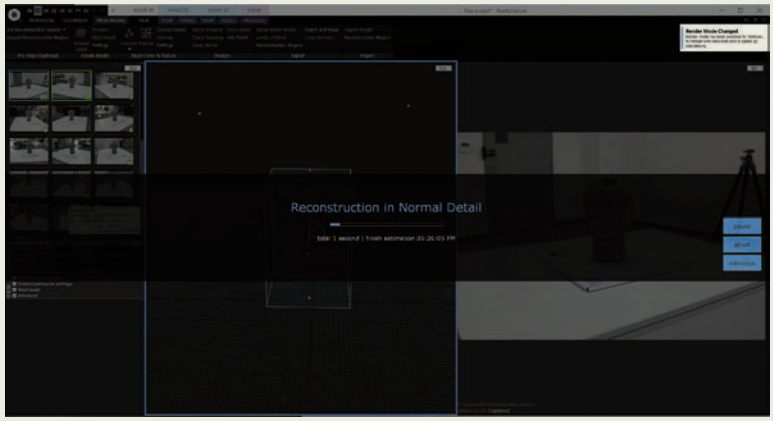
To select [Normal Detail] from the [MESH MODEL] tab in the upper left. This operation generates mesh data.



<Figure 10> Click Normal Detail

11) Mesh Generation in Progress

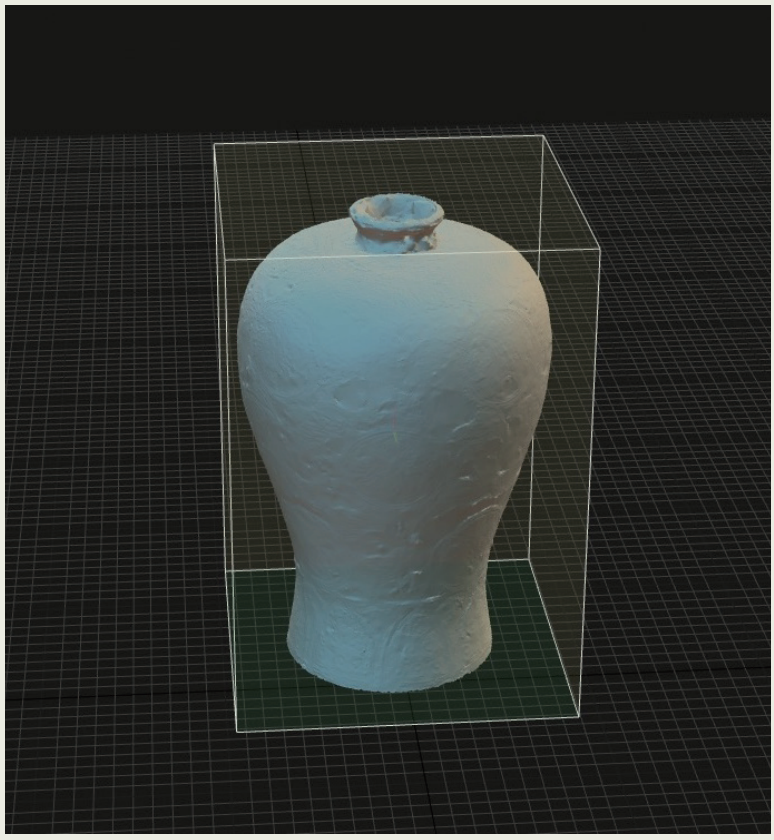
When mesh generation is in progress, the progress and completion times are displayed as shown below. This operation generates mesh data.



<Figure 11> Generation of mesh data

12) Generation of Mesh Data

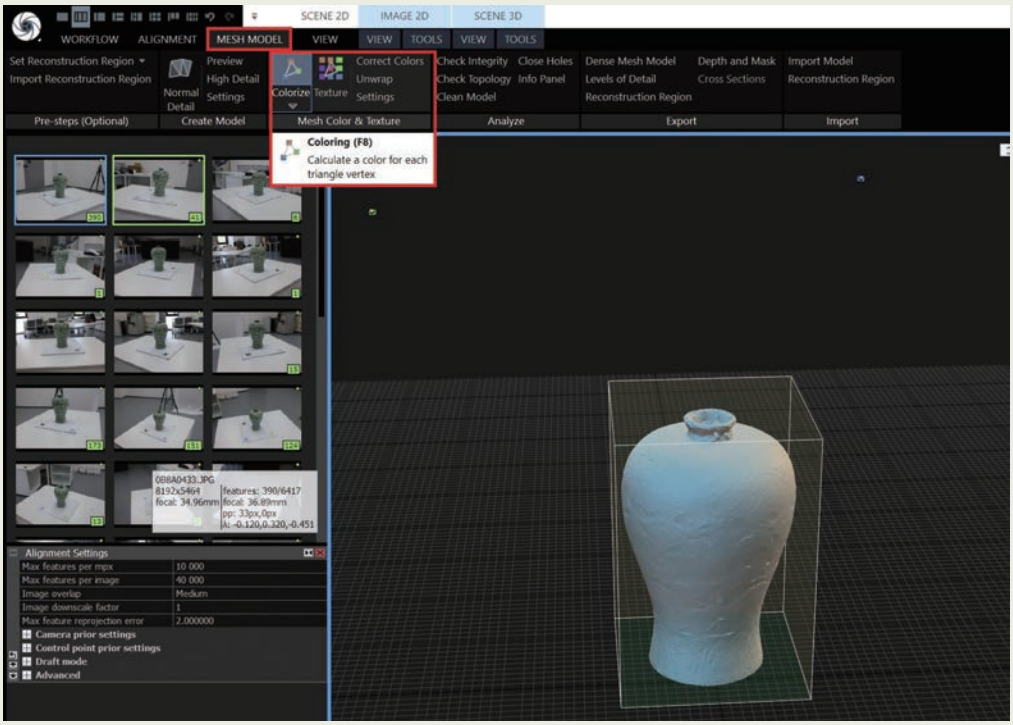
As shown in the figure below, a mesh with no texture is generated.



<Figure 12> Generated mesh

13) Coloring Mesh

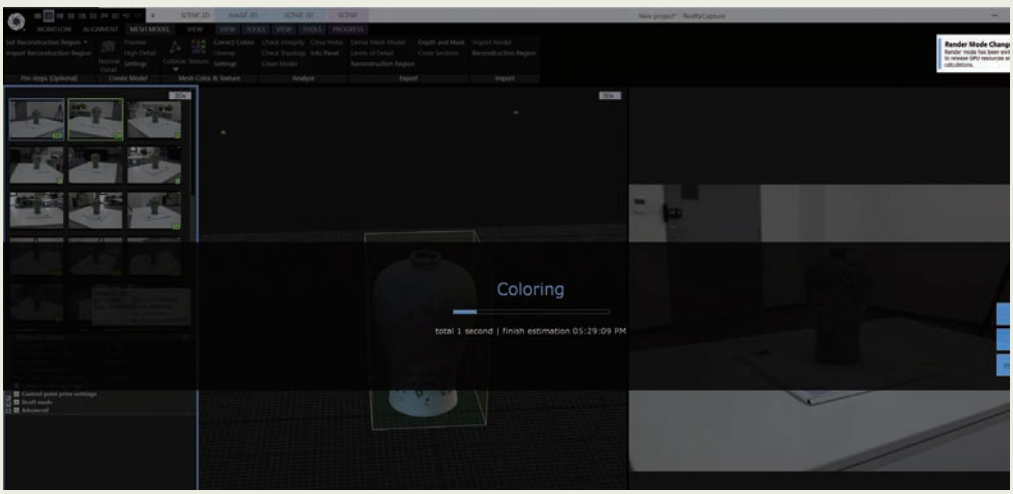
To click [Colorize] from the [MESH MODEL] tab at the top left. This gives the mesh a color.



<Figure 13> Clicking colorizing

14) Coloring Mesh in Progress

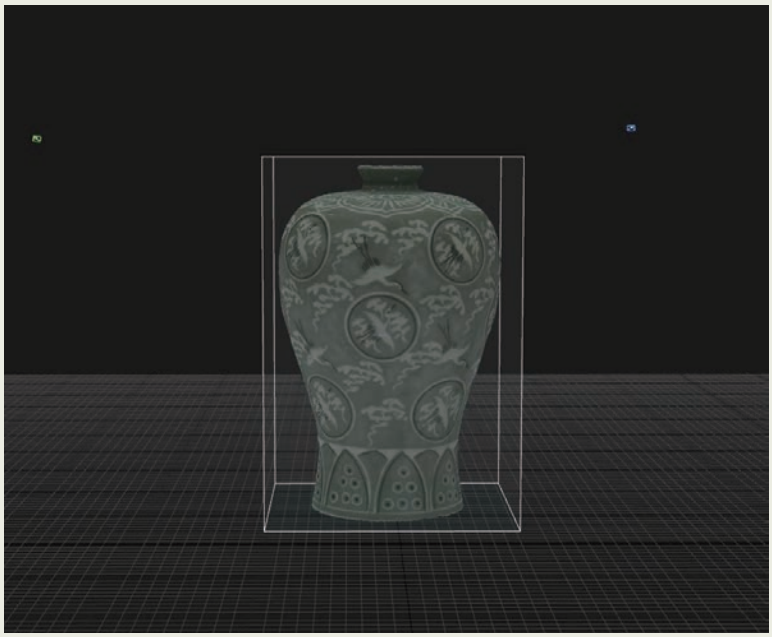
When coloring mesh is in progress, the progress and completion times are displayed as shown below.



<Figure 14> Coloring mesh in progress

15) Generation of Colored Mesh Data

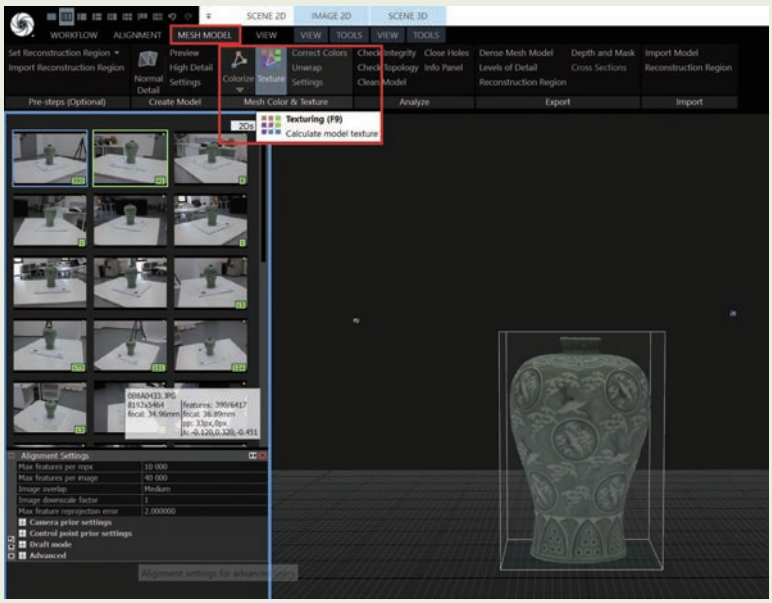
Colored mesh data are generated as shown in the figure below.



<Figure 15> Colored mesh

16) Running Texture Mapping

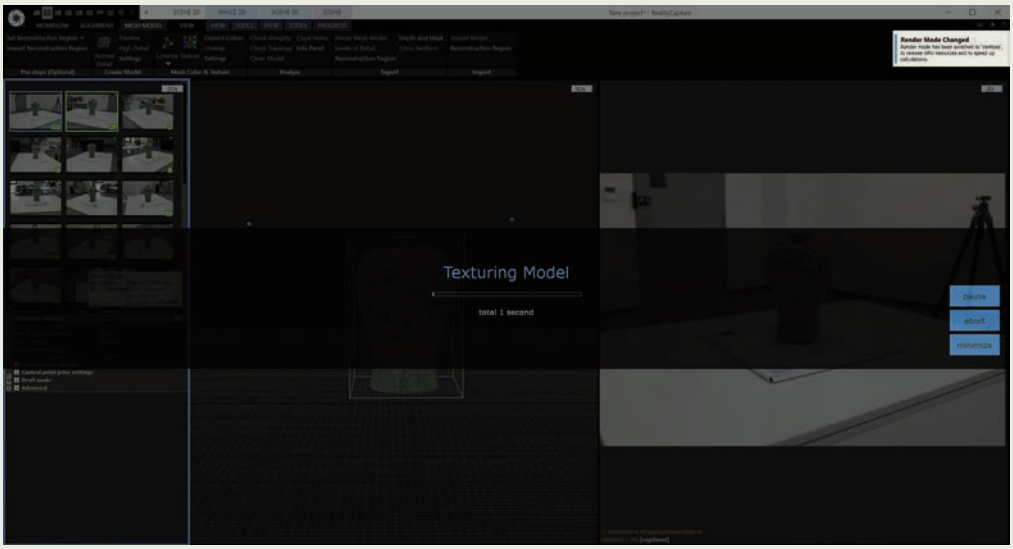
To click [Texturing] in the [MESH MODEL] tab at the top left. This operation maps the texture to the colored mesh.



<Figure 16> Clicking texturing

17) Texture Mapping in Progress

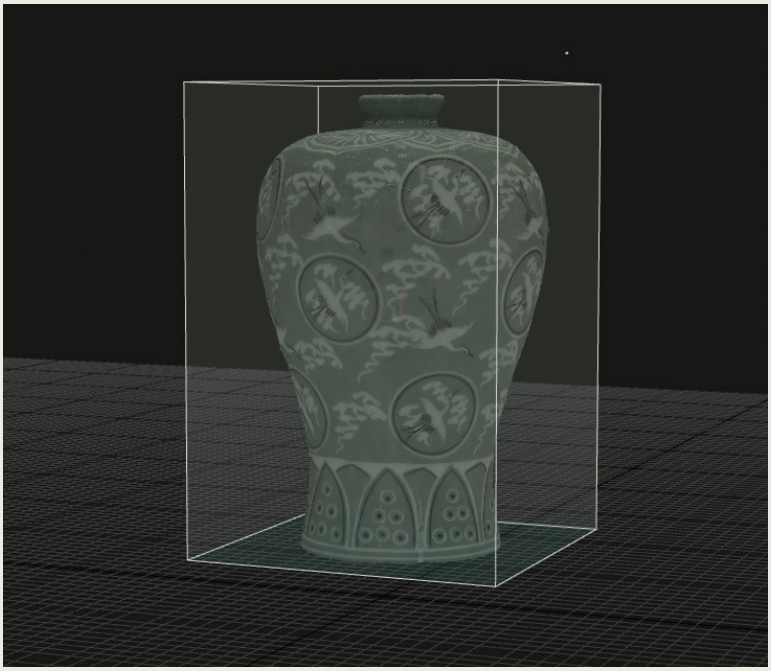
When texture mapping is in progress, the progress and completion times are displayed as shown below. The texture is mapped through this operation.



<Figure 17> Texture mapping in progress

18) A Texture–mapped Model

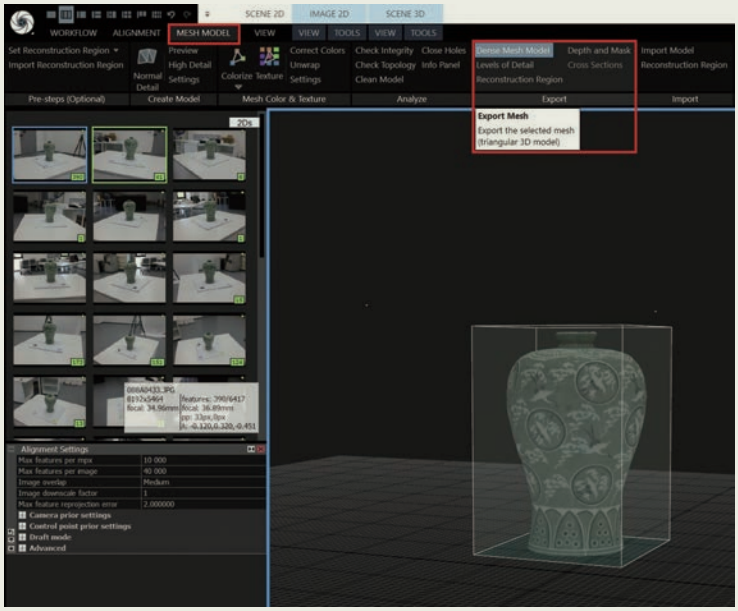
As shown in the figure below, a texture–mapped model is generated



<Figure 18> Texture–mapped model

19) Exporting Modeling Data

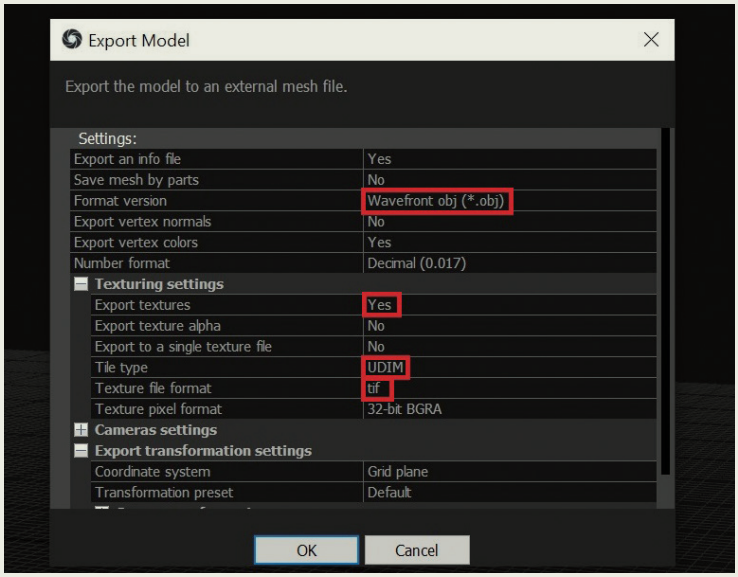
To click [Dense Mesh Model] in the [MESH MODEL] tab at the top left. The mesh and texture data generated through this operation are exported to a file.



<Figure 19> Clicking Dense Mesh Model

20) Setting up Data Format

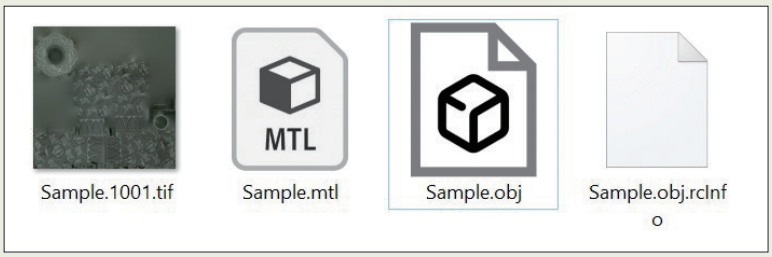
When exporting the model, select the path to save and set up the format as follows



<Figure 20> Setting up data format

21) Check of the Exported File

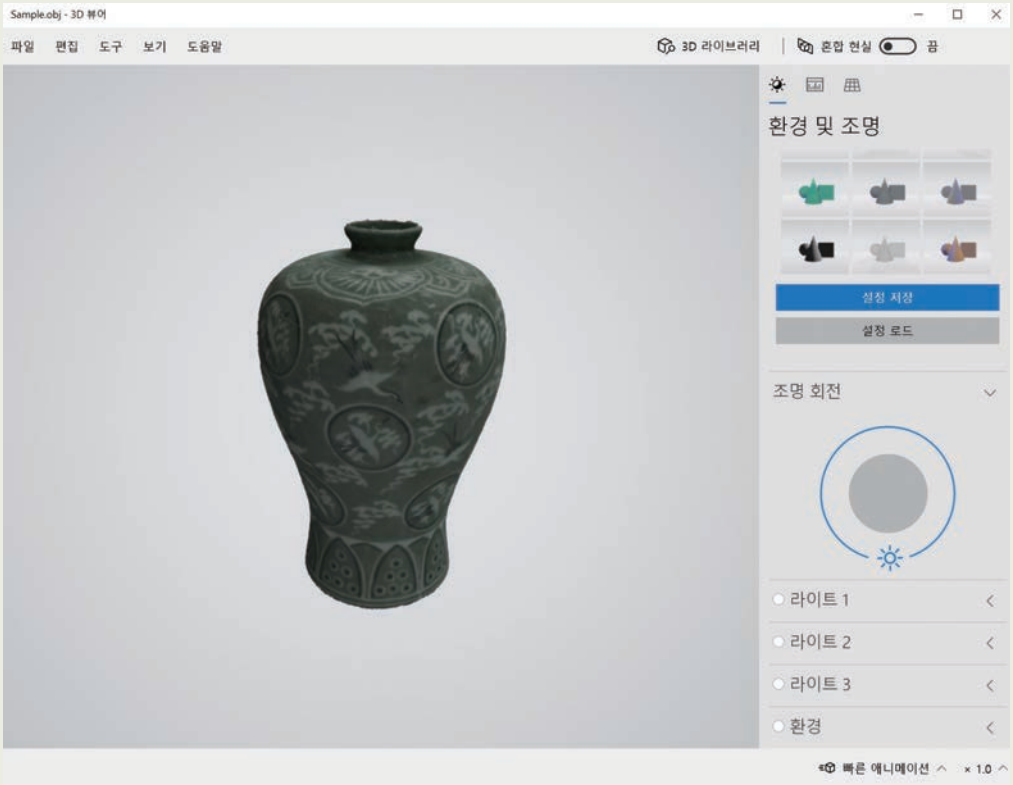
To go to the selected path and check the exported file. The tif file is a texture one, and the obj file is a modeled mesh one.



<Figure 21> Generated obj, tif, mtl files

22) Utilization of the Generated 3D Data

To utilize the generated data by creating content.



<Figure 22> 3D Goryeo celadon viewed through a 3D viewer

Appendix 2. Glossary

– Aperture

: A small and often narrow opening, especially one that allows light into a camera.

– Image sensor

: A component that detects the strength and color of an optical image and converts it into digital image data, and is an electronic component for image storage, transmission, and playback.

– ISO

: The standard that defines the sensor sensitivity to light as per the International Organization for Standardization (ISO)

– Macro lens

: A type of lens that can capture a subject closely because the focal length between the subject and the lens is short

– Mesh

: A method of digitally representing a surface using line-connected points to define a large number of small polygons (typically triangle or square).

– Point cloud

: A set of points in a 3D coordinate system used to represent the surface of a subject.

– SfM (Structure from Motion)

: A technology such as a photogrammetry skill that constructs a 3D structure of an object by grasping 2D images and information generated as the object moves.

– Shutter speed

: The length of time the camera shutter is open.

– White balance

: The process of neutralizing the color of reflected light and adjusting the color balance when shooting with a camera.

02

Survey Research Papers on UNESCO Chair Research Grant

The 'Sense of Place' Creation through Cultural and Architectural Preservation of Timber Construction of Malay Mosque Architecture

Case Study: Chepor Raja Mosque, Lenggong, Perak, Malaysia

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Abstract

This study focuses on the unique features of the architecture of Malaysia's Chepor Raja Mosque in Lenggong, Perak, using the theoretical framework of "sense of place" and the creation of "sacred places" through its architectural and cultural heritage. These factors are based on interrelated elements of Islamic religious beliefs. A an important sacred symbol of Islam, the typology of the humble Malay mosque architecture demonstrates strong cultural and architectural heritage. However, presently, the mosque architecture in Malaysia is mostly dominated by monumental domes and towers—two non–local elements that have replaced the local ones, thereby altering the official expression of Malay mosques. Consequently, the mosques lack a local sense of place. To fill the research gap regarding Malay mosque architecture, this study uses the conceptual framework of sacred places through the creation of a sense of place. The Chepor Raja Mosque was constructed over 400 years ago, when Sufism began to spread. Its spatial planning demonstrates simplicity in architectural scale and the use of localized timber construction conveys a traditional image. The mosque also demonstrates the value of hybrid assimilation through Hindu–Buddhist syncretism and tolerance, indicating the Nusantara hybridization of the Malay and Javanese architectural styles and cultural heritage. This research employs qualitative methods of phenomenological and case study approaches and architectural documentation analysis to emphasize the symbolic and semiotic aesthetics in the construction of sacred spaces through the local sense of place. Ultimately, Chepor Raja Mosque's sense of place was established through various cultural influences and architectural components.

Keywords

Sense of place; sacred places; mosque architecture; cultural and architectural heritage

1. Introduction

Within mosque architecture, producing the structures required to create a "sacred place" requires an understanding of Islam. The Quran and hadiths provide detailed information on designing appropriate spaces for house activities. The term mosque, also known as Bayt Allah or the house of God (Baitullah), conveys the idea of a house meant for worship and religion, whose sole owner is God (Allah). The concept of Baitullah further confirms that the Ka'aba (Haram Mosque) in Mecca and the Al–Aqsa Mosque in Jerusalem were the first global contributions to Islamic architecture (Othman, 2015). The Ka'aba became the Qibla (the direction of prayers toward the Ka'aba) for Muslims' tawhid (belief in the oneness of Allah) around the world for more than 15 centuries. The Ka'aba represents a universal concept that encompasses and overcomes one's whole life and the hereafter (Bakar, 2008). Praying towards the Ka'aba while performing ritual purifications is one of the key practices of Sufism. These rituals include dhikr (rhythmic repetition chants in the name of Allah), prayers, zakat (giving alms), and recitation of the Quran and Tawaf (circumambulations of the Ka'aba). All these rituals are tied to the path of the Nubuwwah (prophethood), which includes performing Umrah (the non–mandatory lesser pilgrimage) and Hajj (the greater Muslim pilgrimage to Mecca), the fifth pillar of Islam. In reference to the Ka'aba architecture, the value of the philosophy of tasawwuf (the process of realizing ethical and spiritual ideals) goes beyond the boundaries of reasons and feelings. This is because of the Ka'aba's is supposed to contain answers to the question of reality.

1–1 Problem Statement

All sacred places require an understanding of the concept of sense of place. Based on Le Lefebrve's spatial triad theory, comprising "conceived," "perceived," and lived" spaces, we argue that the sense of place in Malaysia's mosque architecture serves to establish it as a "sacred space." That is, the cultural and architectural heritage embedded in a mosque strengthens the creation of the sacred spaces based on local traditions and the architectural components of

Figure 1. Chepor Raja Mosque

the mosque. However, the mechanisms through which this sense of place is created in reference to the sacred spaces within Malaysia's mosque architecture has not been examined in depth. Therefore, to fill this gap, this study applies the theoretical framework of sense of place to Chepor Raja Mosque, Lenggong, Perak (Figure 1), as a research setting, whose characteristics are relevant to the aims of this research. For instance, it exhibits the elements of local vernacular mosque architecture and provides opportunities to analyze the role of these features in creating a sense of place through the spatial planning of the sacred spaces found within its architecture and compound.

1–2 Justification for the Case Study:

- Lenggong, where the Chepor Raja Mosque is located, is associated with the Old Malay Perak kingdom and UNESCO–listed Lenggong valley, which is a relevant historical factor influencing the mosque's sense of place.
- The mosque's building materials were sourced from the iron ore mining industry surrounding the Lenggong area, although its jointing systems were constructed out of timber.
- The mosque follows the unique Perak architecture style with a multilevel pyramidal roof system.
- In terms of its setting, the mosque is surrounded by rivers and greenery, which allows the worshippers' emotional experience to be well immersed in their religious beliefs while contributing to the creation of its sense of place.

1–3 Perak State

The Perak state had undergone many religious influences in the past, but the people who brought along these religious beliefs were still the Malay people. The state predominantly followed animistic beliefs before the arrival of the Hindu–Buddhist influence. Buddhist beliefs were the main belief system during the Srivijaya Kingdom (7th–12th centuries AD), while Hindu beliefs appeared in the Malay Peninsula in the 12th–15th centuries AD and peaked during the Majapahit Kingdom rule. Islam came to the Malay Peninsula in the 14th century and has been the the main religious belief in Malaysia since then. Many theories have debated the influence of these religious beliefs and the people who have brought them to Malaysia. However, the influences of these beliefs are apparent in the simple details and ornamentations of the Chepor Raja Mosque, and the creation of its sense of place and sacred place.

1–4 Research Objectives

This study aims to (i) examine the architectural components of the mosque architecture of Chepor Raja Mosque that contributed toward the construction of its sense of place based on spatial triad theory; (ii) analyze the architecture of Chepor Raja Mosque to understand the relationship between the spatial triad and sacred spaces; and, (iii) construct the sense of place of this mosque based on the Sufistic beliefs and the creation of the sacred places based on the spatial triad.

2. Mosque Architecture

One of the major problems in the discourse of Islamic architecture is the relevance of the idea of a "style" as opposed to the more fundamentalist approach of vernacular revivalism or the radical approach of interpreting the Sunnah of the Prophet Muhammad (Peace be upon him (PBUH)). In the context of architectural theory and history, one must establish the latter to derive ideas from the former. Historical descriptions and classifications are the building blocks of architectural theory. In architecture, theory is used as an approach to design. Most importantly, mosque architecture embodies the teachings of Islam while simultaneously producing a sense of place. This sense of place is further enhanced by the construction of sacred places to complement all the religious activities that occur within vicinity of the mosque. At the beginning of the Prophet's (PBUH) life, before the Hijrah year, the mosque was not a special building or a specific architectural work.

Physically, the early building of the Masjid Nabawi (the Prophet's Mosque) (Figure 2) was a rectangular building constructed using mud brick construction methods. The building had four walls and three protected areas. The roofs were

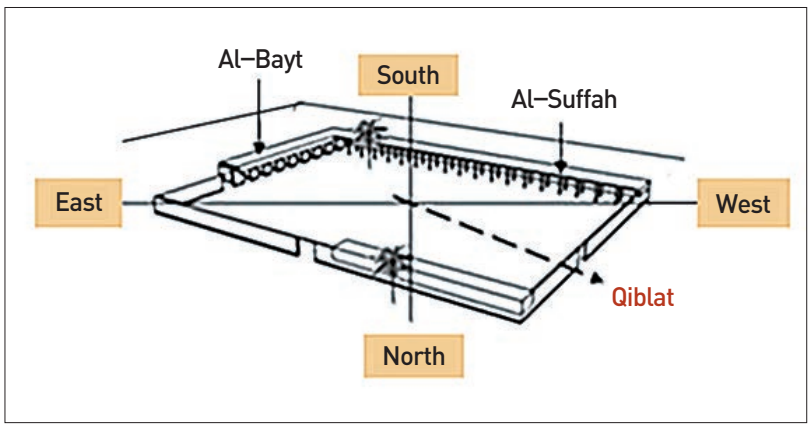

Figure 2. Masjid Nabawi Complex, Madinah (Creswell, 1968)

supported by posts made of palm tree trunks. The first part of the roof protected the main space on the wall facing the Qibla. The second closed part to the left of the main hall was intended to protect the house of the Prophet Muhammad (PBUH) and his wives. The other side of the roof was in front of the mosque where the Sufis (Al–Suffah) spent their nights. These were poor but educated immigrants. They learned from Prophet Muhammad (PBUH) and served him.

2–1 Sense of Place

Sense of place is a subjective perception based on the physical characteristics of a place and involves cognitive and perceptual factors in a sense of time (Hashemnezhad, Heidari & Hoseini, 2013), (Najafi & Shariff, 2011; Scannell & Gifford, 2014). Through the passage of time, the sacredness of a place develops, and becomes intimately tied to the sense of authenticity of that place (Birch & Sinclair, 2013; Mazumdar & Mazumdar, 2004). According to the theoretical perspective of the spatial triad, the formation of sense of place is affected by the (i) "perceived" spaces/spatial practices, (ii) "conceived" spaces/representations of space, and (iii) "lived" spaces/representational spaces (Lefebvre, 1991). In a traditional building, the perceived space refers to the physical character of the building that helps develop its sense of place based on its historical form, cultural characteristics, and functional setting (Ali, 2019). Architectural design, symbols, iconography, and artifacts are essential to any religion. As a subset of culture, religion affects people's attachment to a sacred place, which includes a space that is purposely created to uphold the basic concept of religion and acts as a mediator for experiencing faith (Gojnik & Gojnik, 2019a). The rich cultural values and meanings of a sacred place, particularly in traditional architecture, enable the community to form a place identity. The Chepor Raja Mosque offers a base for investigating the concept of sense of place' for attributes based on this theory.

2–2 Sacred Places

In the context of Islamic religion, haptic experience is defined by the presence of the tactile elements of the sacred place, such as touching the ablution water and the praying mat. To fulfil the criteria of the sacred place, the believers must touch the tactile elements of this space and participate in the transcendent to complete the experience of faith. The element of smell through the olfactory sense also contributes to the experience of a sacred place. Building materials have their own distinctive smell, which characterizes the place. In terms of sound, each sacred space has different degrees of silence and echo. It is believed

that hearing creates a connection to the place, as well as to the Supreme Being, as shown in the call to prayer/azan and the recitation of the Quran. Another experiential aspect of Islamic sacred places is the visual element. The design and décor of sacred structures also help to create a sense of place and bring worshippers into religious ideals. Building ornaments, calligraphy, the Qibla compass, images of Ka'aba in Mecca, and other sacred cities also function as place artifacts, which are visual reminders that solidify one's tangible physical connection to a place. Hence, sacred places involve several dimensions of sensory experiences that interact and fuse to form a sense of place (Gojnik & Gojnik, 2019a; Mazumdar & Mazumdar, 2004; Pallasmaa, 2012). As a place of worship, the Chepor Raja Mosque and its unique sense of place is the best example for understanding the meaning of sacred places.

3. Methodology

This study uses descriptive qualitative approaches, especially in the context of phenomenology, to obtain accurate and systematic information regarding the characteristics and values of the architecture of the Chepor Raja Mosque and the construction of its sense of place. According to Groat and Wang (2013), qualitative methods help researchers interpret the meanings behind symbols and forms. This study began by comparing the early documentation of the mosque's evolution and observing the typology of this mosque and the construction of its sense of place. These observations also focused on the overall composition of the mosque space contained in the hybrid components of some mosque architectural design styles. However, this study concentrated only on the more dominant components, such as the appearance of the roof, prayer room, porch space, ablution space, and azan tower. It also involved several surveys of the architecture and the sense of place, analysis of architectural documentation and secondary sources from the authorities, and a review of the history and the philosophy of the mosque. Architectural documentation was strengthened by visual data that helped validate the positioning of the mosque's architectural components and spatial planning.

4. Architectural Documentation

Architectural documentation is critical for understanding the design of mosque architecture planned for the Chepor Raja Mosque. This includes acquiring the exact measurement of the mosque and space planning that was designed for the mosque.

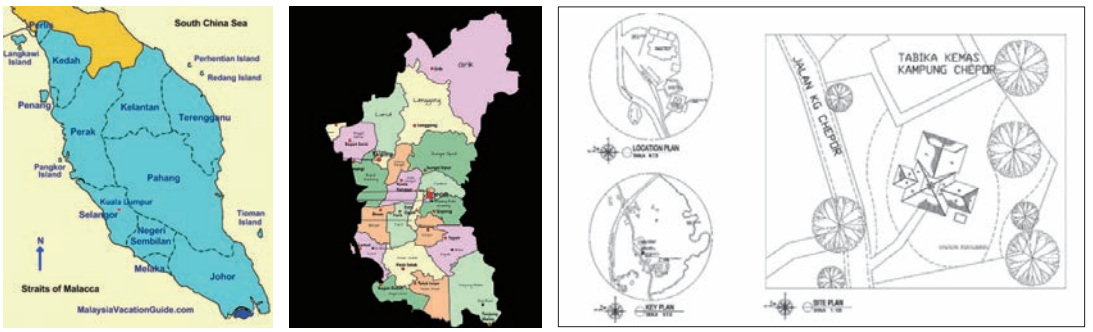

Figure 3. Chepor Raja Mosque Location Plan

4–1 Site Orientation and Layout

This mosque is located on the main road of Chepor Village (Figure 3) in Lenggong District, Perak. The strategic location of this mosque provides an easy access to the congregation, as it is located on the main road of Kampung Chepor. The surrounding verdant provides the mosque with cool air at all times (Figure 4). Furthermore, the open–space plan of the mosque has already maximized the natural cross–ventilation in the interiors of the mosque. These conditions further enhance the coexistence of mosques with the environment. The sacred ambience created for the believers is another component of the mosque as a sacred place, and to some extent, many believers believe that the mosque uplifts their spiritual level to make their worshipping experience full of humility towards Allah. The strong connection between sacred places and the theoretical framework of a sense of place of perceived, conceived, and lived spaces depict the narrative of the Chepor Raja Mosque. Ultimately, the "lived" space of the mosque is experienced with respect to the spirituality emanating from absorbing Islamic religious teachings and performing rituals. Each of the spatial triad concepts come together to form a sacred place.

Figure 4. Chepor Raja Mosque Environment

4–2 Site Survey and Measured Drawings

The measured drawings were taken over a period of two weeks, which included an analysis of the site and the mosque's location.

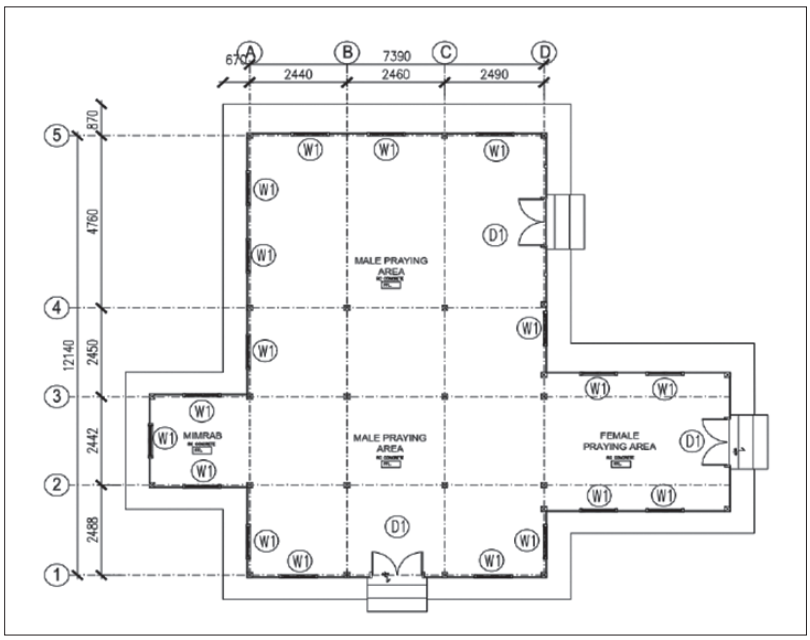

Figure 5. Chepor Raja Mosque Floor Plan

4–3 Floor Plan

The shape of the mosque has been influenced by the architecture of the Malaysian archipelago, with symmetrical motifs applied to the building, especially in terms of the building facade. The original structure was made of wood with gable walls and a zinc roof. This mosque has undergone five renovations, and in the third change, the board walls were replaced with a betel–roof arrangement and a zinc roof. The mosque's rectangular shape allows the space to be further expanded for additional prayer rows for the congregation, and is added accordingly for a sequential and tidy arrangement. Masjid Raja Kampung Chepor has a floor area of 109 m² (Figure 5). The building space includes the Imam's room (pulpit), men's prayer room, and women's prayer room. The layout of the mosque space is centered on half of the men's prayer room,

Figure 6. The Unique Chepor Raja Mosque Perak Roof

Figure 7. Chepor Raja Mosque Left Side Elevation

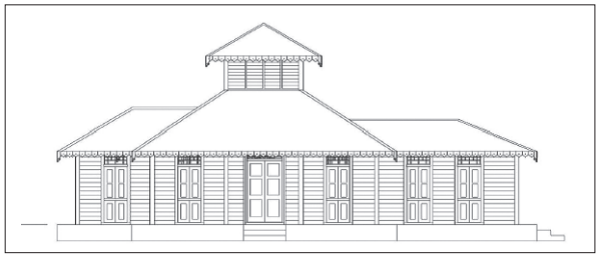

Figure 8. Chepor Raja Mosque Right Side Elevation

which lies in the original building of the mosque. This mosque has additional space on the right side of the men's prayer room for the increased number of male worshipers.

4–4 Building Components

The Chepor Raja Mosque is designed according to the concept of a layered five–fold roof, known as the joglo roof, owing to its multistory roof. The design of the mosque is influenced by the architecture of Sumatera, which can be seen in the design of its layered roof (Figure 6) called bumbung limas bungkus, which is said to have originated from the Netherlands and Britain. This type of architecture was first introduced in the Riau archipelago in the 17th and 19th

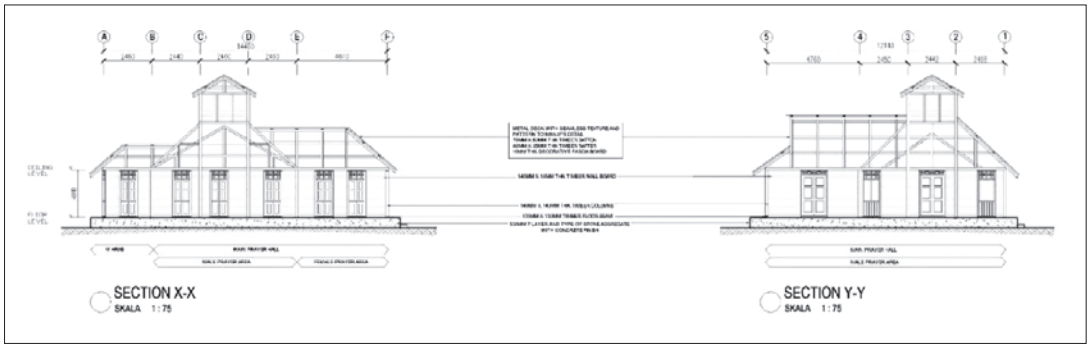

Figure 9. Sections

Figure 10. Mihrab

Figure 11. Chepor Raja Mosque Female Praying Room

centuries. There is a ventilation space in the middle covered by "louvers" to let the hot air out and replace it with new air.

As this mosque has gone through five major changes, the use of the roof has also changed due to age factors. The previous use of roofs was believed to be thatched or nipah roofs. However, its use has been replaced by zinc (Figure 7 and 8), which is more durable and provides greater protection to consumers.

The roof design of the building, which is influenced by this traditional design, simultaneously applies Islamic values to the multi–story roof. The use of a multistory roof in the central part of the mosque is supported by four main pillars (Figure 9). The use of the four pillars in the mosque symbolizes the four sects that are practiced and held in Islam. Windows are among the most important elements because they can influence and control the quality of ventilation and lighting in a house. The size and type of materials used vary according to the function of the space in which the window is placed. Similar to doors, windows are also places where cross–ventilation takes place. Windows were built during wall construction. Window frames were installed and placed in vacated spaces on the wall. Steel anchors were used to strengthen the window positions on the wall.

4–5 Interior Space Planning

Figure 12. Open Space Planning for the Creation of the "Sacred Spaces"

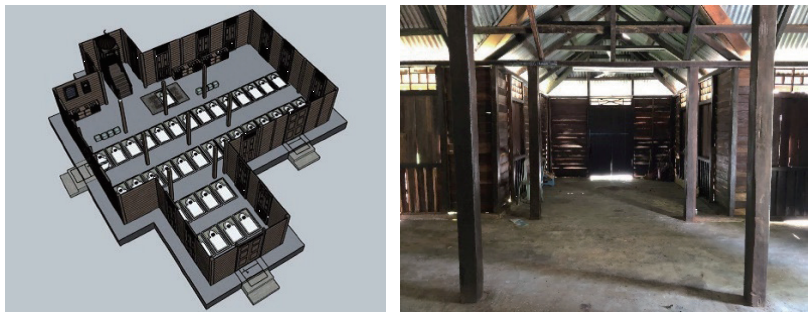

Figure 13. Interior Space Configuration

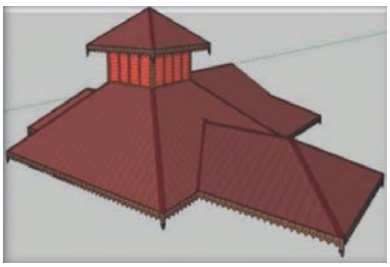

Figure 14. Pyramidal Roof

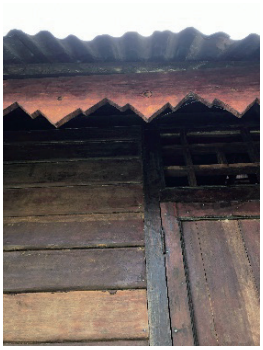

Figure 15. Roof Eaves – Bamboo Shoot


Figure 16. Lizard's Tail Roof Fascia Board

The Chepor Raja Mosque has only three spaces: the mihrab (the wall in the mosque that indicates the Qibla) room (Figure 10), the main prayer room, and the women's prayer room (Figure 11). The construction for the floor of this building is a concrete type of floor, and only one type of finish is used in different spaces. In the main prayer room, women's prayer room, and pulpit space, a carpet–type floor finish is used, which also serves as a prayer mat for the congregation. The short parts of the mosque's building, such as the main prayer room and the women's prayer area, are oriented from east to west (Figures 12 and 13). The long part of the building that houses additional prayer and ablution spaces faces north and south orientations. Therefore, the space is blocked by the glare of the sun rising from the east.

4–6 Detailing / Traditional Furnishings / Ornamentations

Every design and element of the mosque has some intriguing features. The construction of this mosque also has an interesting history that should be known to the public so that the knowledge about this mosque continues to last and can be utilized to construct its sense of place and sacred places. Being one of the oldest mosques in the region, and in Southeast Asia, this mosque is deeply

embedded in Islamic teachings. The pyramidal roof (Figure 14) carries Hindu–Buddhist influences. For example, the roof can be related to Mount Meru or the stupa, whereas in Islamic belief, a pointed roof indicates the relationship between humans and God. In any belief, a pyramid roof highlights the connection between humankind, the environment, and divine power, such that the humankind must understand the environment to understand divine power.

However, the traditions of Malay people from various religious beliefs can be observed in this humble architecture of the Chepor Raja Mosque. Details such as the roof eaves (Figure 15) reflects the teaching of behaviors in communities, while the fascia board in the lizard's tail (Figure 16) design indicates respect for nature in terms of the fauna as a part of the environment and the beauty of lizard as a small creature.

5. Conclusion

As a sacred place, the mosque not only functions as a place of worship, but also functions as a monumental display in the form of a landmark showing the ruling authority in the conquered land. Its architectural forms are diverse according to the influence of the local traditions, regional characteristics of its geographical location. The non–confessional use of its space is also a significant part of the local inhabitants' raison d'être (Baharudin & Ismail, 2014). In addition, as religious institutions, mosques are built as platforms for social bonding. Hence, the concept of communal or jamek mosques has evolved since the early era of Islamic development. In other words, mosques are a prominent space for community socialization as well as for daily religious activities (Jaffar Harun & Abdullah, 2020; Gutiérrez, 2018). For Muslim believers, the mosque is an essential element in their lives that creates strong emotional ties based on the religious experiences and memories that are built over time, in which a sense of place is formed. The sense of place within a mosque's architecture is based on Islamic teachings and offers the worshippers the experience of the sacred places through its architectural style and components and the cultural factors that house the mosque. This experience is further strengthened by Islamic teachings in terms of communities and environmental education, as demonstrated by the surroundings of the mosque. The Chepor Raja Mosque epitomizes the creation of "sacred places" despite its modest appearance. The sense of place in the architecture of the Chepor Raja Mosque has been created by the preservation of the various cultural influences and architectural components of the mosque. The religious beliefs of the communities surrounding the Mosque and its heritage

all contributed to the development of the sense of place in the Chepor Raja Mosque by sustaining its cultural wellbeing and respecting the environment. The established sense of place in turn enhanced the creation of the mosque as a sacred places, as found in its architectural details and space planning. These characteristics reflect the principles followed in earliest mosque architecture during the Prophet Muhammad era, when the design of the mosque space included big open spaces supported by other spaces meant for communal activities. The new knowledge of the establishment of the sense of place in the Chepor Raja Mosque can be further extended to other heritage mosques in Malaysia, and could serve as a benchmark for preservation activities in other religious institutions in a way that validates their sense of place.

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Acknowledgements

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Investigating the Significance of Toponym to the Outstanding Local Values of Heritage Places for the City's Cultural and Economic Competitiveness

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Abstract

The heritage value of a place is marked by its uniqueness that can be recognized for a long time. Space will change to a place when the messages sent or the meaning entrenched by catalysts is well received by the surrounding and spread out both in quantity and quality to a broader context. The spread of the message and meaning is often reflected in the naming of a place is called Toponymy. This study used the historic city of Surakarta (or Solo) in Indonesia as a case. The qualitative methods and an ethnographic approach are employed for the data collection. The mapping technique is using the photographic method by fiend study, combined with direct and virtual interviews. The initial research has found some essential elements of a creative place or city, such as (i) value and uniqueness of a place that many people realize; (ii) catalysts' superior ethos and ability to instil inspirative messages to the community from one to the next generations, and (iii) the superior creative production that able to sustain competitiveness and to grow the local economy for a long time. The synergy between these elements is embedded in the "Outstanding Value" that can be preserved, nurtured, and developed as a valuable heritage. The purpose of the proposed research is to investigate the origin, meaning, expressions, and implications of a name to a place uniqueness, the Outstanding Local Values of a local historical place, or the Outstanding Universal Value of a globally significant place

Keywords

city identity, city DNA, toponym, local OUV

1. Introduction

"Geographical names as cultural heritage," is a statement that affirms the study of the names of geographical places (toponyms) as significant as it is part of the national culture. Toponyms are part of the local culture that cannot be separated from human impressions of the place. A place's name is a juncture where language, culture and human thoughts or impressions meet. The study of toponyms will help in tracing the geographical conditions, environmental factors, linguistic diversity and local history of a place.. In fact, in some countries with unstable administrative conditions, toponyms have become points of attraction that enhances local geopolitics. Some of these aspects make toponyms an interesting subject to be studied further (Segara, 2021).

Space and time are fundamental elements in the dimensions of human perception that organize the experiences that one goes through (Leidner, 2008). Consequently, all documents and narratives regarding various artefacts are related to the human experience of space and time–frequency. Toponymy is the study of place names, their origin and history. It is a field that has hardly been recognized by geographers, psychologists, architects and philosophers who have written about places and their spirits. However, the understudied field of toponymy influences various other fields of study concerning places, roots, dwellings, attachments, openings, throwntogetherness, boundaries and sense of place.

According to the research conducted by Deroy and Mullen, place names should be simple and to the point (e.g., money denominations, such as Dollar or Euro), so that they don'tdistract people from their daily utilitarian activities. They serve as geographic abbreviations that help us find our way around the world and are indispensable for communication because they eliminate the need for complicated descriptions. Place names are taken for granted hence, their importance as symbols of specificity is largely ignored by those who wish to contemplate places on a more abstract level. (Wang et al., n.d.).

The traditional toponymic approach is to study place names. It delves mostly into etymology, archives, and local history in order to uncover the meaning of place names. However, it does not take into account the naming process. Many Anglo–European place names may not have much of a story to tell and only appear as descriptions understood by the local people. Nevertheless, it gives individuality to a place and sometimes have broader connotations. In some cases, the spelling of the names would have changed over the centuries.

Some place names sum up the narrative, although the meaning is not always clear or not known. Place names can be influenced by historical events

or incidents and can reveal obscure origins that is invaluable to historians, archaeologists and so on. Place names can serve as a means to remember the geography of the place and reinforce traditions and cultural memories. For example, when anthropologist Basso asked a native American Apache, "What is wisdom?" the answer was: "Wisdom sits in places." For Apache, place names have stories associated with them that can be used to teach their own community members and to inform others and convey correct behavior (Feld and Basso, p56). Basso referred to this as "living topographic ethnography."Toponyms involve more than classification and delving into etymological origins. It also plays an essential role in ensuring consistency in spelling and usage, overseen in most political jurisdictions by legally constituted councils or committees. For example, the UK has a Permanent Committee on Geographical Names. The US Council on Geographic Names, a federal council, was created in 1890, and the Council on Geographic Names was formed in Canada, in 1897.

This study investigates the significance of toponyms to the outstanding local values (OLV) of heritage places for the city's cultural and economic competitiveness. The OLV can be used for protection and conservation of the local identity and significance and to develop policies and management systems rooted in local history, identity, and traditions. Toponym, in this case, can be regarded as an "intangible DNA" of a place that generates a sense of rootedness and pride and gives a reason to defend as well as promote the place's identity or "place branding."

2. Surakarta as the Case Study

The reasons for selecting Surakarta in Central Java, Indonesia, as the case study in this research are: as follows: i) Continuation of a previous study, "Formulating the 'Local HUL' Instrument for Community Based Cultural Heritage Management in the Historic Urban Core of a Medium City – with Semarang and Solo in Indonesia as Case Study," supported by the 2020 Korea National University of Cultural Heritage UNESCO CHAIR Research Grant, ii)

Familiarity and accessibility to the city, places, communities, expertise and resources, and iii) The history and significance of the city.

Surakarta, better known as the City of Solo in Indonesia, was founded in 1745 and is a part of the Islamic Mataram Kingdom, which was established two centuries ago in 1586 (Wirutomo, 2014). "Sala" was one of the three hamlets chosen by Sunan Pakubuwana II on the advice of his officers (Tumenggung Hanggawangsa, Tumenggung Mangkuyudha) and the commander of the Dutch troops, J.A.B. van Hohendorff, when he was about to build a new palace, after the Mataram

succession war took place in Kartasura (Prayitno, 2007).

The official name of the place is "Surakarta," while colloquially it is known as Sala or Solo. The name Solo carries with it widespread cultural connotations. The word "sura" in Javanese means "courage" and "karta" means "prosperous"; thus named in the hope that Surakarta becomes a place where its inhabitants will dare to fight for the good and prosperity of the country and the nation. It can also be said that the name Surakarta is Kartasura in reverse, the name of the older capital city before it moved to Sala. Sala used to be the name of the village where the new palace is located. It is named after Shorea Robusta, a sacred tree of Indian origin.

Figure 1. a) The position of the city of Surakarta on the island of Java; b) the city of Surakarta or Solo. Source: Author's analysis, 2021

As a historical city, Surakarta can be divided into three main domains: (A) Kasunanan—the King's ("Sunan" in Javanese) palace area, (B) Mangkunegaran—the prince's residential area and (C) the Local Initiatives Area—the urban development area outside the two areas A and B that was developed after the city of Surakarta became part of the Republic of Indonesia and was no longer part of the Surakarta Kasunanan Kingdom.

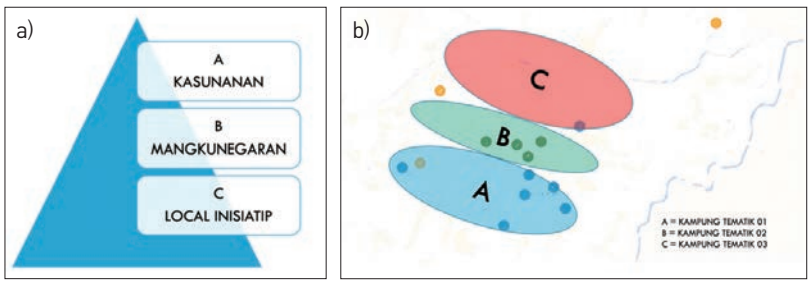


Figure 2. a). The social and cultural hierarchy b) The socio–cultural hierarchy of the geographical area. Source: Author's analysis, 2021

Figure 3. a). The image of the Kasunanan area b) Mangkunegaran area c) The image of the village mural created as part of a community initiative. Source: Author's analysis, 2021

3. Research methodology

The research uses grounded theory to gauge the relationship between community members and the toponym. Grounded theory intends to generate theories about phenomena from the context (Creswell, 2013, Pidgeon and Henwood, 2003). The purpose of grounded theory is to explain the everyday experiences of the people involved. However, it must also be sufficiently abstract and comprehensive to apply to other situations where the phenomena are experienced (Strauss & Corbin, 1990). Grounded theory begins with a literature review, followed by the formulation of the theory from the context through comparison with other existing theories.

a. Sampling

Qualitative research is aimed at developing a theory through an iterative process of analysis–sampling progressive cycle. This study targets a specific urban settlement population by selecting a manageable subset of the population. Theoretical sampling is the process of data collection whereby the researcher collects, codes and analyzes the data on the basis of which they determines what information is to be collected next and where to find it in order to develop the theory as it emerges (Glaser and Strauss, 1967). The systematic sampling method aims to select information–rich cases for an in–depth study. Effective sampling strategies that change during data collection and analysis enable the researcher to complete the task with minimal waste and without entering any conceptual blind alleys to produce an excellent grounded theory (Bryant & Charmaz, 2007).

The sampling was carried out at two levels: a) selection of localities at the urban level and b) selection of respondents within each locality. In this study, the localities or "kampungs" were selected based on the historical growth of the city (time factor) and the hierarchy of space functions (social–cultural factors).

b. Data Collection

The data were collected using three methods: A structured questionnaire that included the following components: a) personal background (age, gender), b) localities (city & kampung), c) length of residency (attachment to place), d) familiarity with places and local products (place impression), e) production and consumption

(need, possession, appeal), f) catalyst and locus (familiarity, identity).

Photography & Videography observation: Direct and comprehensive on–site observation over a prolonged period of time could not be carried out owing to the COVID–19 pandemic safety regulations and limitations. An expert photographer or videographer, who is also a cultural anthropologist, was employed to capture the relationship between people and places by observing their social, cultural and economic activities. Interview validation: Validation was conducted through a structured interview that allowed the researcher to gain the richness of information, the possibility of probing and the depth of reasoning through the "why" questions.

Figure 4. Questionnaire prepared using Google Forms. Source: Author's analysis, 2021

c. Data Analysis

The analysis involved two iterative processes: a) Coding, an interpretive technique that organizes the data and provides a means to introduce its interpretations into specific quantitative methods. The analyst demarcates segments within the data and labels them with a 'code', a word or short phrase that is the gist of that segment, or introduces concepts that the researcher considers relevant to the research objectives. Data can be precoded (the process of assigning codes to expected answers), field–coded (the process of assigning codes during fieldwork) or postcoded (the process of assigning codes after fieldwork). The coding process can be divided into two steps: 1) basic coding to distinguish overall themes, and 2) in–depth interpretive coding, in which more specific patterns and trends can be interpreted; and b) Categorization, where the completed codes are clustered into categories based on function, time, meaning, setting and similarities. Categories that frequently emerge and appear to relate to other categories would be selected for further analysis. The interpretation of the categories is further analyzed and validated through interviews. The subsequent interview may reveal additional categories that trigger an iterative process for re–analysis. Relevance of the categories may change as the study progresses and if some categories are found not to have explanatory value, they will be omitted from further analysis. At the end of the iteration process, some categories would be merged and divided into several parts. This is the dynamics of the categorization process.

Overall, in this study, we clustered the emergent codes based on similarities in meaning and function and categorized them. Subsequently, these categories were reviewed and rectified several times. Later, the organization changed by comparing and combining codes and categories from other parts of the interview and other interviews. As a result, some categories were merged and some were divided into two or more parts in order to draw results from the analytical process.

4. Result and Analysis

This research is mainly concerned with the practical possibilities of analyzing urban toponyms and their interpretation, which may be of interest to the multidisciplinary fields of sociology, history and geography. Our aim is to verify that the names of streets, squares or parks in the city's historical center serve as indicators of official points of view and ideological impressions of political, social and historical events in the context of heritage cities on the island of Java. This study analyzes the current road network of the historical center of Surakarta City. We will attempt to define the fundamental trends in the process of the vocabulary of streets. At the same time, we will pay attention to their thematic focus. Toponym research aims to determine the intensity of local, regional,

and national identities, based on geographical research, in the city's historical center's model area through place names, street names and squares. (Radding, 2010).

Determining geographic interpretations of place names or toponyms involves resolving various types of ambiguity. Place names usually occur in lists and data tables. Authors often omit qualifiers (such as city or state containers) for place names, because they expect the meaning of individual place names to be evident from the context. We present a new technique for place name disambiguation (also known as toponym resolution) that uses Bayesian inference to assign categories to lists or tables containing place names and then interpret individual toponyms based on the most likely category assignment. Categories are nodes in a hierarchy along three orthogonal dimensions: type of place (city, capital city, river and so on), geographic container and prominence (by population and so on) (Adelfio, 2013).

4–1 Place mapping

Publicly well–known places in Surakarta are currently dominated by 14 thematic villages with three main structures: seven villages in the Kasunanan heritage area, five villages in the Mangkunegaran heritage area and three villages in the urban development area outside the Kasunanan and Mangkunegaran areas.

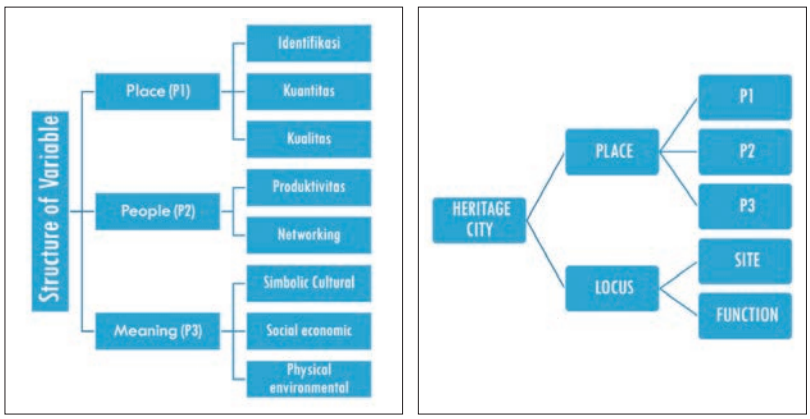


Figure 5. Structure of the research questions and the findings. Source: Author's analysis, 2021

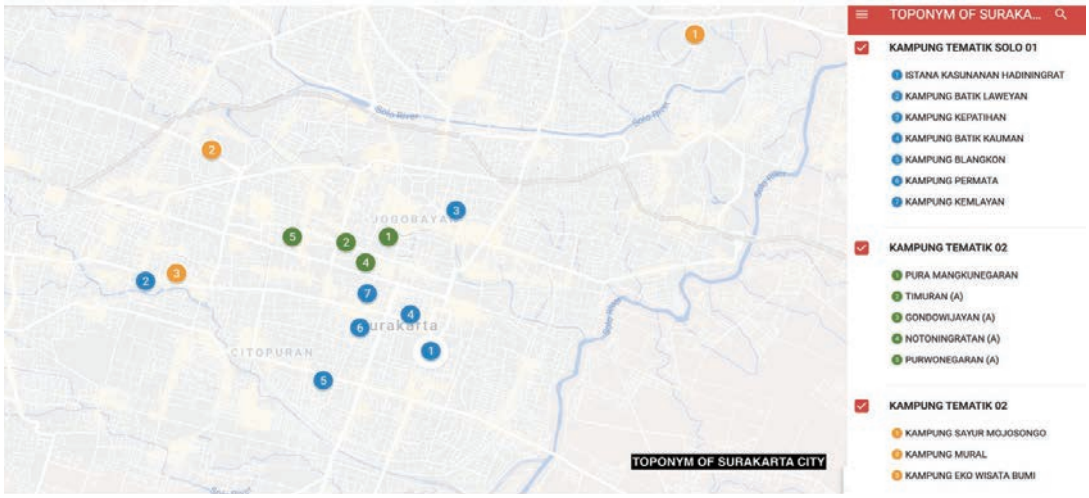


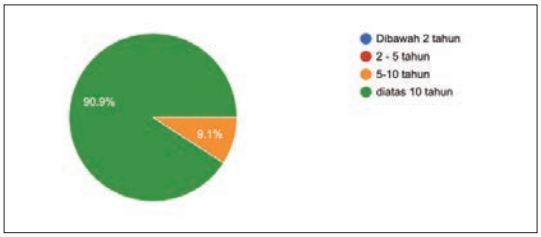
Figure 6. Seventeen popular village names in Surakarta Source: Author's analysis (2021)

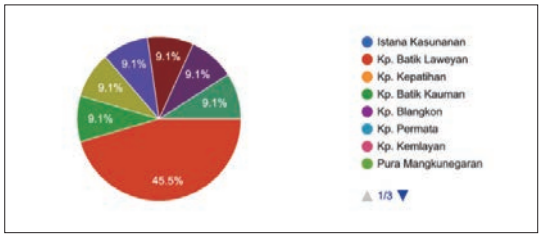
4–2 People mapping

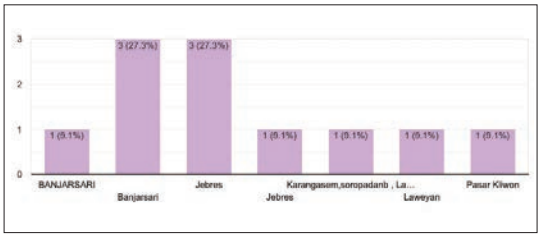
The grouping in the above section is closely related to the formation of the characteristics of the communities in each area. The main activity of the people in the Kasunanan area (A) is serving the interests of the Kasunanan Kingdom, both in terms of economics and religion. At the peak of the Surakarta Kasunanan Kingdom, the king was not only considered a government leader but also a religious leader.

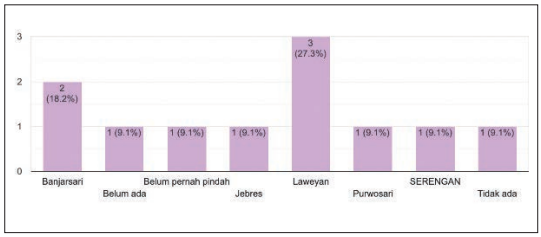
Interim compilation of data collected from respondents of the questionnaire (around 30% of the targeted respondents) till August 31, 2021, is presented below. A detailed explanation and interpretation of the statistical findings are presented after this interim report.

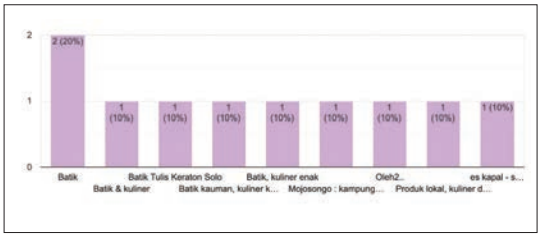
Figure 7. Samples of people's activities in areas A, B, and C. Source: Authors, 2021


90.9%
9.1%
Dibawah 2 tahun
2 - 5 tahun
5-10 tahun
diatas 10 tahun

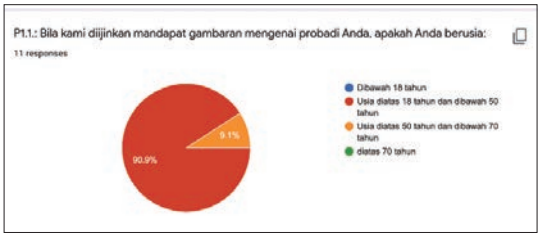

9.1%
9.1%
9.1%
9.1%
9.1%
9.1%
45.5%
Istana Kasunanan
Kp. Batik Laweyan
Kp. Kepatihan
Kp. Batik Kauman
Kp. Blangkon
Kp. Permata
Kp. Kemlayan
Pura Mangkunegaran
1/3

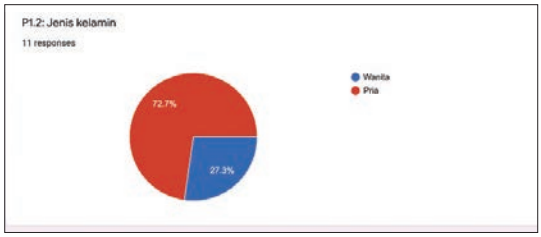

3
2
1
0
1 (9.1%)
3 (27.3%)
3 (27.3%)
1 (9.1%)
1 (9.1%)
1 (9.1%)
1 (9.1%)
BANJARSARI
Banjarsari
Jebres
Jebres
Karangasem,soropadanb , La...
Laweyan
Pasar Kliwon

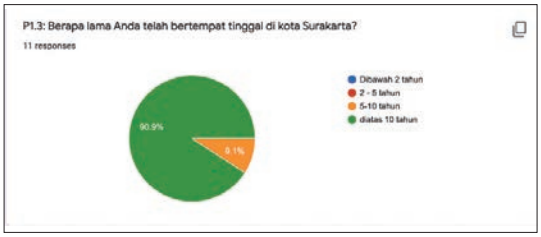

3
2
1
0
2 (18.2%)
1 (9.1%)
1 (9.1%)
1 (9.1%)
3 (27.3%)
1 (9.1%)
1 (9.1%)
1 (9.1%)
Banjarsari
Belum ada
Belum pernah pindah
Jebres
Laweyan
Purwosari
SERENGAN
Tidak ada

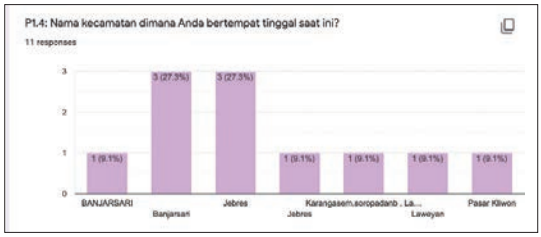

2
1
0
2 (20%)
1 (10%)
1 (10%)
1 (10%)
1 (10%)
1 (10%)
1 (10%)
1 (10%)
1 (10%)
Batik
Batik & kuliner
Batik Tulis Keraton Solo
Batik kauman, kuliner k...
Batik, kuliner enak
Mojosongo : kampung...
Oleh2...
Produk lokal, kuliner d...
es kapal - s...


P.3.1: Apakah Anda memiliki kebiasaan rutin mendapatkan salah satu kebutuhan Anda pada sebuah tempat tertentu?
11 responses
45.5%
9.1%
18.2%
27.3%
Ya
Tidak
Kadang-kadang
Folo

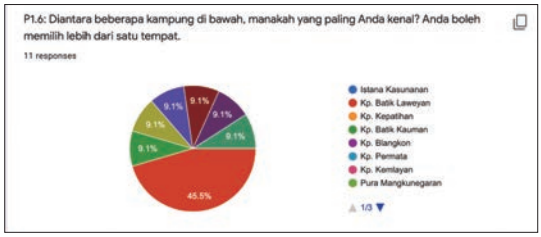

P1.1.: Bila kami diijinkan mandapat gambaran mengenai probadi Anda, apakah Anda berusia:
11 responses
90.9%
9.1%
Dibawah 18 tahun
Usia diatas 18 tahun dan dibawah 50 tahun
Usia diatas 50 tahun dan dibawah 70 tahun
diatas 70 tahun

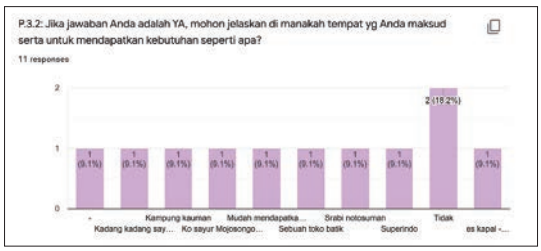

P1.2: Jenis kelamin
11 responses
72.7%
27.3%
Wanita
Pria


P1.3: Berapa lama Anda telah bertempat tinggal di kota Surakarta?
11 responses
90.9%
9.1%
Dibawah 2 tahun
2 - 5 tahun
5-10 tahun
diatas 10 tahun

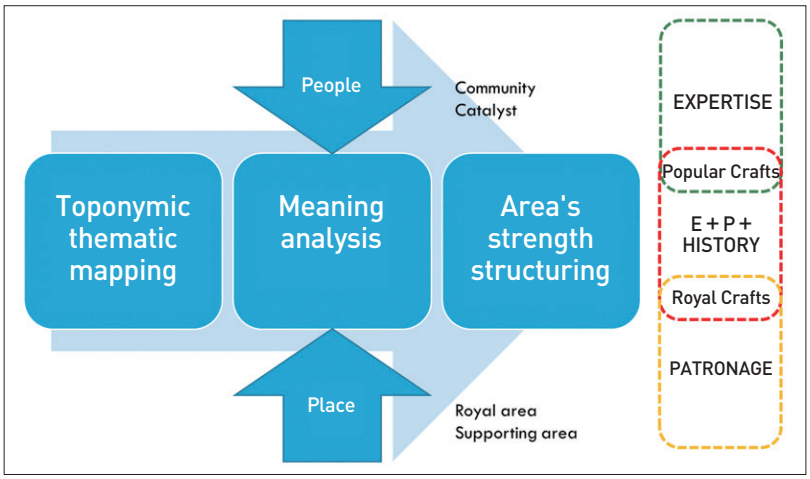

P1.4: Nama kecamatan dimana Anda bertempat tinggal saat ini?
11 responses
3
2
1
0
1 (9.1%)
3 (27.3%)
3 (27.3%)
1 (9.1%)
1 (9.1%)
1 (9.1%)
1 (9.1%)
BANJARSARI
Banjarsari
Jebres
Jebres
Karangasem,soropadanb , La...
Laweyan
Pasar Kliwon

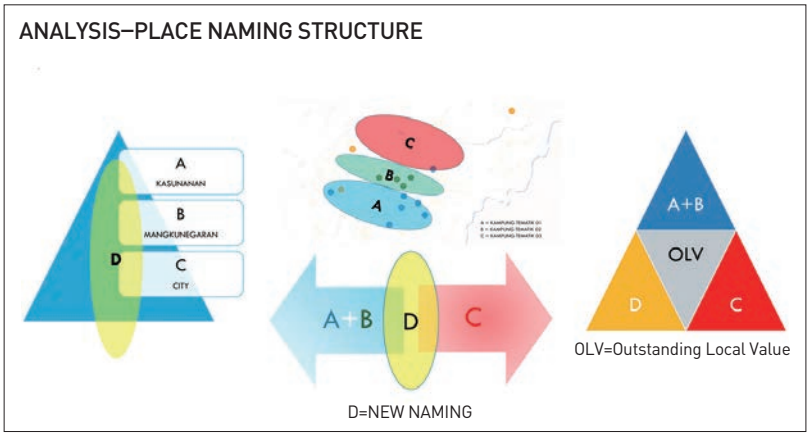

P1.5: Nama Kecamatan lain yang pernah Anda tempati dan cukup berkesan dan berperan penting bagi Anda Selama ini?
11 responses
3
2
1
0
2 (18.2%)
1 (9.1%)
1 (9.1%)
1 (9.1%)
3 (27.3%)
1 (9.1%)
1 (9.1%)
1 (9.1%)
SERENGAN
Count: 1
Banjarsari
Belum pernah pindah
Laweyan
SERENGAN


P1.6: Diantara beberapa kampung di bawah, manakah yang paling Anda kenal? Anda boleh memilih lebih dari satu tempat.
11 responses
9.1%
9.1%
9.1%
9.1%
9.1%
9.1%
45.5%
Istana Kasunanan
Kp. Batik Laweyan
Kp. Kepatihan
Kp. Batik Kauman
Kp. Blangkon
Kp. Permata
Kp. Kemlayan
Pura Mangkunegaran
1/3



5. Mapping Place, People, Culture and Meaning





The spread of 51 points in 4 Thematic Kampung in Surakarta city

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Acknowledgements

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TIME TABLE OF RESEARCH

Please indicate the activities to be conducted during the research period.		
Month	**Activities**	**Outputs**
May	Preparations: 1. Consolidation of resources 2. Detailing working plans	• Working plan (finished)
June	Inventory: 1. Collecting data (archives, literature, records) 2. Interviewing respondents (patrons, experts, artisans, community, visitors, etc.)	• Working plan (finished)
July	Inventory & analysis: 1. Continuation of inventory process (as above) 2. Synchronic & diachronic analysis	• Working plan (finished)
August	Analysis & report writing: 1. Continuation of analytical process 2. Additional fieldwork & interviews 3. Progress report writing	• Working plan (finished)
September	Presentation & formulation: 1. Drafting research progress report paper 2. Consolidation of analytical findings	• Draft of research presentation
October	Formulation & writing: 1. Presenting research progress report paper 2. Writing the manuscript for journal publication	• Research Progress Report Presentation
November	Publication: 1. Finalizing manuscript for journal publication 2. Writing final report	• Research Paper for The Journal of Korean Cultural Heritage
December	Final report: 1. Writing final report 2. Final report submission	• Final Report

Preservation and Historical Study of Early Architectural Drawings and Pictorial Records of Heritage Buildings in Seremban, Malaysia

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Abstract

In architectural conservation work, early records of the buildings are essential references to know the original design, authenticity of the building elements and periods of transformation or changes to the buildings. These early records can be in the form of architectural drawings, photographs and other pictorial records as visual records are directly useful in architectural work. This research aims to preserve, digitally archive and conduct historical study of early architectural drawings and pictorial records of heritage buildings in Seremban, Malaysia. Based on availability and accessibility to the records for restoration and digitization, this research utilized two long scrolls of architectural drawings which present the site plan of the large railway station yard in Seremban from the British colonial period. The two drawings measured approximately 400 cm (length) by 75 cm (width) each before restoration and physically they are one whole site plan when placed together. It is estimated that the drawings were produced between 1936 and 1951. The historical study emphasized the significant heritage values of the site, in terms of commodity transportation including tin and rubber, that linked Seremban to the maritime trade route via Port Dickson since 1891. Hence, the site was the core of economy, movement and society in Seremban. Compared to other early maps of Seremban Town covering the period from 1893 until 2016, this set of site plan drawings provide the finest details of the Seremban Railway Station Yard in terms of the organization pattern of the railway tracks and facilities, two–dimensional building block–plans and their block numbers or tenant names, and the land and building utilization. This implies that the site plan drawings are an invaluable source of historic information to understand the allocation and distribution of railway–related activities and functions on the site in the past, and the drawings are worth preserving.

1. Introduction

In architectural conservation work, early records of the buildings are essential references to know the original design, authenticity of the building elements, and periods of transformation or changes to the buildings (National Heritage Department, 2017). These early records can be in the form of architectural drawings, photographs, and other pictorial records, as visual records are directly useful in architectural work. Yeoh (2021) stated that a city without old buildings is like a person without memory. Hence, early architectural drawings and pictorial records can help retain the memories of a city and are extremely useful for carrying out accurate conservation works.

Malaysia is situated in the southernmost part of mainland Asia and has been an important center for the maritime Silk Road since ancient times. It functioned as an essential location for the amalgamation and exchange between Eastern and Western cultures. Since the 19th century, the country was colonized by the British, seeing advancements in various modes of transportation, and subsequently became the Eurasian trade route. As the frequency of cultural exchanges increased, this naturally fostered the flourishing of colonial architecture, rich with multiple influences in the country (Chen, 1998).

Nevertheless, many developing cities do not possess proper and complete archives of their heritage buildings, including those in Malaysia. For example, the Public Works Department of Malaysia is yet to organize an archive of architectural drawings and building records of government buildings in the state of Negeri Sembilan, where Seremban is located (Public Works Department, Negeri Sembilan, 2021). The record is so fragmented that very few early drawings of heritage buildings are still in the department. The factors behind this could be the damage caused by the war in 1941–1945, the keeping of Malaya government records in Singapore when it was the main administrative center, and their relocation by the British (or in certain cases destruction) after Malaya gained independence. Architectural drawings thus become precious artifacts for preserving the histories of postcolonial cities. In the context of postcolonial cities, the modern heritage of the 19th and 20th centuries is particularly vulnerable because of their weak legal protection and low appreciation (van Oers and Haraguchi, 2003). Presently, "Demolish and Build" (Meroboh dan Membina Semula, in Malay) projects are more commonly found than conservation projects on sites with old buildings in Malaysia (Yeoh, 2021). Ironically, due to a lack of historical records and studies, heritage buildings with historical value are easily dismissed as insignificant (Goh, 2021). The bulk of professional architectural education and practice is heavily focused on large–scale new developments, instead of heritage

conservation (Yeoh, 2021).

The scarcity of early architectural records and other factors have led to the abandonment of many heritage buildings in historic urban cores and contributed no solution to conserve them. Seremban, Malaysia, is a serious example. According to Idid (1995), Seremban town had 446 pre–war buildings, which amounted to 45% of the Negeri Sembilan state's total of 999. The inventory pointed to the importance of heritage conservation in Malaysian towns; however, no further effort was made to preserve the architectural records. In fact, there were more than 70 sites comprising more than 100 units of abandoned and dilapidated pre–independence buildings, some in states of disrepair, damaged by fire, or demolished, including railway facilities in the heart of Seremban town in 2018. Unlike world–renowned cities such as Kuala Lumpur, George Town (Penang) and Melaka, serious preservation work in Seremban is still rare.

This research project aims to preserve, digitally archive, and conduct a historical study of early architectural drawings and pictorial records of heritage buildings in Seremban, Malaysia, as references for architectural conservation work. The objectives are (1) to find a suitable technique for the restoration and digitization of early architectural drawings and pictorial records, and (2) to conduct a historical study to identify the dates of the records and understand the history of the records and buildings. This paper discusses findings based on the two stated objectives.

2. Restoration and Digitization of Early Architectural Drawings

2–1 Description of the Selected Drawings

The main objects for restoration in this project are architectural drawings in paper form. For this purpose, we inquired at the Public Works Department, Negeri Sembilan, which is responsible for the construction and maintenance of public infrastructure in the state of Negeri Sembilan for access to early architectural drawings. The Public Works Department was established by the British government during the colonial period and housed drawings concerned with the planning, design, and construction of public heritage buildings. However, our inquiry discovered that there was no proper archive of architectural drawings and building records in the department and our request for access was denied; even on–site viewing was not possible for the few drawings kept due to improper storage and other reasons. We also looked for early architectural drawings and pictorial records at non–profit associations and other sites.

Based on limited availability and accessibility to the records, this project

utilized two long scrolls of architectural drawings that present the site plan of the large railway station yard in Seremban from the British colonial period (Figure 1). The drawings were salvaged from the waste at the railway yard. The site plan is composed of upper and lower parts. The two drawings measured 403.4 cm (length) by 75.5 cm (width) (upper part) and 380.1 cm (length) by 76.3 cm (width) (lower part) respectively before restoration, and physically, they composed one whole site plan when placed together (Figure 2). Based on our inquiry to the National Archives of Singapore, it was found that several old survey maps of British Malaya were originally published and compiled in this fashion, that is, smaller maps covering specific quadrants to make up parts of a larger map, because of the number of details that needed to be included in the maps (National Archives of Singapore, 2021). Hence, the dual site plan drawings adopted a similar map format, containing fine details of the railway station yard (Figure 2).

Figure 1. Overall view of the architectural drawings for restoration, digitization and historical study used in this research

Figure 2. Detailed view of the Seremban Railway Station Yard site plan

2–2 Identification of Paper Restoration Techniques

The nature of the paper used for the plan is fragile. Though it is an important carrier of cultural heritage, paper will inevitably age and face various damage issues with the passage of time. Damage by external and internal factors can deteriorate the quality of the paper and change its original appearance, information, and value. Therefore, paper restoration work is given primary importance.

The purpose of paper restoration is to restore documents to their original appearance and preserve their invaluable information. Paper cultural relics, if not properly protected for a long time, lose their information and appearance. For example, the original color might change, and cause difficulty in reading the information on the paper. Therefore, the principles and requirements of paper restoration must be carefully followed during the process. This section reviews two types of paper restoration – the Victorian era map (relatively thick paper) and

the ancient Chinese deed (relatively thin paper) and proposes a feasible paper restoration plan for the architectural drawings in this study.

2–2–1 Principles of Paper Restoration

There are four principles to fulfill the requirements of a good paper restoration process (Han, 2020).

1) Maintain the paper's authenticityThe best way of preserving paper cultural relics in their original state is to preserve all the information of the document. As stated above, paper cultural relics contain important cultural heritage data. Hence, the authenticity of the data and the paper condition must be closely adhered to.

2) Privilege restoration of damaged parts, treatment is supplementary

Restore the severely damaged and important paper documents first, and then consider restoring the less damaged parts of the paper documents. Additional treatment can be applied as supplementary to achieve the effect of recovering the damage.

3) Reversible restoration technique

In the restoration process, the restoration technique may not be mature and the materials may be used incorrectly, which might cause damage to the paper cultural relics. Therefore, the restoration techniques and materials used must be reversible. The use of natural restoration materials such as flour paste and seaweed gum is recommended because of their reversibility and authenticity.

4) Minimal intervention

In line with the first principle of maintaining authenticity, it is not advisable to modify the documents by adding and subtracting information. This situation is encountered, for example, when a portion of the paper is lost, torn, or damaged. Moreover, the coloring and restoration of calligraphy depend on the damage conditions.

2–2–2 Identification of Paper Damage Factors and Solutions

Table 1 lists the common types of paper damages, their leading factors, and the recommended solutions. From the examination of the architectural drawings used in this research, the Seremban Railway Station Yard drawings were exposed to all of the paper damages listed in Table 1, except for burn marks and microbial damage (Figure 2). One of the drawings was incomplete due to damages caused by mice, while the other drawing was damaged due to adhesion of the strip tape along the paper edges. The recommended solutions must be carefully considered, according to the paper storage environment, after restoration.

Table 1. Damage factors and solutions for paper cultural relics (Source: Adapted from Han, 2020)

Paper Damage	Factors	Factor Description	Recommended Solutions
Water stains Stains Wrinkles Creases Deformation Fractures Incompleteness Adhesion Discoloration Microbial damage Blurred writing Burn marks	Biological destruction	Mice, microbes and insects will eat paper; their excrement will contaminate the relics and become a site for mold growth.	Use low temperature (−16°C, 24 hours) to freeze insects and exterminate them; use a refrigerator or cold storage
	Moisture	The increase in humidity of the environment will increase the moisture absorption of the paper and deform it, which is conducive to the reproduction of microorganisms. Low humidity will turn the paper hard and brittle.	Humidity control (monitoring and controlling the temperature and humidity of the storage environment)
	Temperature	High temperature will intensify paper aging; whenever the temperature rises by 5°C the deterioration rate of paper cultural relics will increase, increasing the growth rate of microorganisms. The transitional low temperature will cause the moisture in the paper to freeze and cause structural damage.	Control the storage temperature (it should not be lower than the freezing temperature of the paper)
	Air	Acid gases (SO2, H2S, CO2), oxidizing gases (NO2, CI2, O3) and dust in the air	Purify the air (reduce acid gases, oxidizing gases, dust and microorganisms)
	Light	Light has radiant heat which triggers physical and chemical reactions, turning the paper yellow and brittle. Cellulose and hemicellulose will accelerate hydrolysis under light and produce sugars which will destroy the original structure and affect the strength of the paper; sugars are microbial food, which makes the paper moldy.	Light control (reduce ultraviolet rays and heat from light)
	Others	Fire, accident	Store in a safe storage location

2–2–3 Review of Paper Restoration Techniques

There are various types of paper. According to the form of paper, it can be used for maps and drawings, documents, books, calligraphy and manuscripts, postcards, newspapers, photographs, certificates, etc. According to the material of the paper it can be divided into papyrus, hemp paper, vellum paper and rag paper which are usually made of basic raw materials like linen, cotton rags and wood pulp. Alternatively, according to the paper–making method, it can be categorized into handmade paper (mainly practiced before the Industrial Revolution) and machine–made paper (practiced after the Industrial Revolution) (Cantavalle, 2019). The selection of the appropriate paper restoration technique depends on the type and condition of the paper. Different kinds of paper like hemp paper, straw paper, and rag paper are similar in their production process and the use of raw

Figure 3. Steps in paper restoration process

materials, but the color and thickness are different, which require precautions during restoration.

A common method used in identifying paper type is to distinguish the era of the paper based on the information on the paper (document), for example, pictures or fonts with time–specific characteristics. For undated documents or if there is a need to obtain a more accurate time of production or publication, the more scientific method of using apparatus appraisal by Carbon 14 is an option. Because the architectural drawings used in this research were undated, further analysis of their date was done based on a historical study in Section 3.3.

As stated above, the paper restoration technique differs depending on the condition of the paper, but the restoration process is similar. The process is divided into three stages: preparation, restoration, and completion (Figure 3). The data collected by taking photographs and recording in the preparation stage can provide the original information to be retained in case of errors that cannot be remedied in the restoration process. This is in line with the aforementioned principles of paper restoration. The main restoration process consists of using clean water and a small amount of chemical agents to clean the surface and internal stains of the paper. The next step is to restore the missing parts and the information on the paper, without compromising the authenticity of the information. The final process of restoration is reinforcement and stabilization by adding a small amount of chemical agent to the reinforcing agent (paste) to stabilize the internal structure of the paper and prevent further damage. After the restoration work is completed, the paper is photographed again and recorded information of the restored document is organized, and the final protective measure is carried out on it for long–term preservation.

The ambient temperature and humidity must be strictly controlled in the repair room, and the fluctuation range of temperature and humidity should not be too large, especially during the drying process of the paper after being supported and strengthened. Otherwise, inappropriate temperature and humidity may cause mold growth and secondary destruction. Restored

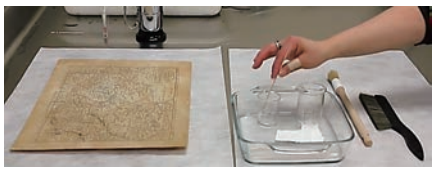
archives have an increased chance of mold reproduction owing to pasty and damp conditions. Therefore, the restored paper must be dried and sterilized before storage. To avoid creating new conditions of damages in the storage, the restoration room should also be ventilated frequently, kept clean and sanitary, and the air should be purified regularly. If possible, the environmental indicators of the restoration room should be kept to a range similar to that of the archive storage.

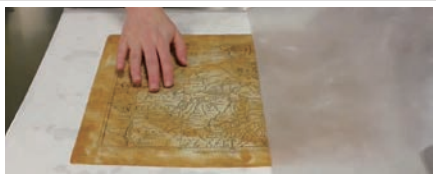
The following review focuses on restoration techniques of paper sheets, including maps, drawings, photographs, postcards, and certificates, which are suitable for this research. There are differences in restoration techniques for books and bound documents. Two examples of paper restoration techniques are presented: one on a Victorian era map, representing relatively thick paper, and the other on an ancient Chinese deed, representing relatively thin paper.

1) Restoration of a Victorian era map (thick paper) by The University of Iowa Libraries

This is an example of thick paper restoration. The main reasons for the map needing restoration were that it was dirty, and aging material needed to be repaired. Moreover, the primary objective was to separate the historic map from the acidic cardboard backing and remove the adhesive residue from the paper. This technique would be useful for the Seremban Railway Station Yard drawings, which also have adhesion along the paper edges and backing paper in some parts. The level of damage to the Victorian era map was not serious. Therefore, it was relatively easy to repair. The sequence of the restoration techniques is presented in Table 2.

Table 2. Restoration process and techniques on a Victorian era map as an example of thick paper sheet (Source: Adapted from Butler and *Konger Gongzuo Shi*, 2020)

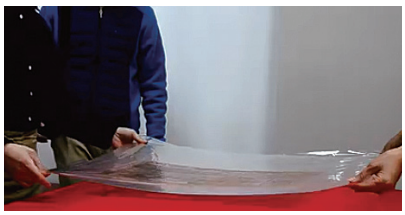
Step	Figure	Description
1		The document was examined to determine if it would benefit from washing.
2		The surface was cleaned with a brush and vulcanized rubbers.

Step	Figure	Description
3		Different types of ink were tested with alcohol and water.
4		The pH level of the de–ionized water was tested for the bath.
5		The document was sprayed to help the water soak through faster.
6		It was dipped gently in the water with the support of sheets of spun polyester for soaking.
7		The backing board softened and the map could be separated.
8		The backing board was pulled away and adhesive residue was brushed off.
9		The document was pulled out of the water with polyester to support it.
10		The map would then be air–dried and the restoration was complete.

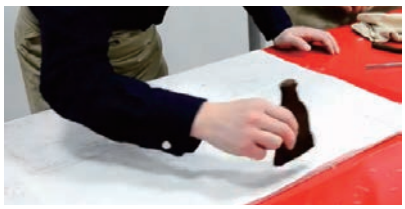
2) Restoration of an ancient Chinese deed (thin paper) by the China Printing Museum and Jinyiqiao (Beijing) Wenhua Keji Youxian Zeren Gongsi

The paper in ancient China was relatively thin because of the paper production process. This paper was old and more difficult to restore due to its thinness and fragility. There were also patches of missing parts of various sizes. Restoration by hand was required. Table 3 describes the sequence of the restoration techniques used for this paper.

Table 3. Restoration process and techniques on an ancient Chinese deed as an example of thin paper sheet
(Source: Adapted from China Printing Museum and *Jinyiqiao (Beijing) Wenhua Keji Youxian Zeren Gongsi*, 2021)

Step	Figure	Description
1		The paper deed was moistened with water mist, and tools such as needle cones and tweezers were used to safely unfold the folds and curls on the paper.
2		The paper was rinsed carefully with warm water using a brush to control the water flow and strength to distribute it evenly on the surface of the paper, remove dust and stains on the surface, and reduce the acidity of the paper.
3		A clean towel was rolled up and gently rolled on the surface of the paper to absorb the moisture.
4		The towel was then wrung dry. Steps 3 and 4 were repeated until the water for cleaning the paper was not obviously turbid.
5		A transparent plastic sheet was laid on the workbench to facilitate movement and restoration operations without causing damage to the paper and to smoothen it out. (This technique of using a transparent plastic sheet to aid the paper handling is often necessary.)

Step	Figure	Description
6		A cloth was used to further smoothen the paper and plastic.
7		A pre–dyed patch paper was placed on the paper deed where there were missing parts, and moistened with a brush to trace the outline shape of the missing part of the deed. The patch paper was then shaped (hand–torn) accordingly.
8	 	Thin paste was brushed evenly on the back of the paper deed around the area of the missing part, and the patch paper prepared in Step 7 was pasted evenly at the area.
9		Tweezers were used to tear off the excess part of the patch paper. A smaller overlap leads to better overall flatness, ensuring its strength.
10		To fill the smaller holes, a small part of the patch paper was directly torn off and pasted gently on the hole using thin paste. The patch paper was selected to fit the actual condition of the documents. Generally, the patch paper is of the same or similar material, and the color is similar but slightly lighter than the document.
11		After all the missing parts were filled with patch paper, a board strip was pasted with thin paste along the perimeter of the paper deed in sequence; the long side first, then the short side. The width of the board strip was approximately one inch.

Step	Figure	Description
12		After pasting the board strip along the perimeter of the paper deed, a support paper was placed on the back of the paper deed. Thin paste was evenly brushed on the back of the paper, and the support paper was flattened.
13		A piece of absorbent paper was put on the previous papers to absorb excess water from the paper deed. A brush was used to drain the water at the same time.
14		After draining the excess water (semi–dry condition), the paper deed was turned around on its front side. The plastic sheet on the front side was carefully uncovered.
15		Thick paste was applied on the back of the support paper along the perimeter edges.
16		For the final drying process, the paper deed along with the support paper was put on a smooth surfaced wall. The paper was brushed against the wall, starting at the corner and keeping in the same direction.
17		After five days, the drying process was finished and the restoration was complete. This figure shows the ancient Chinese deed before and after the restoration.

2–2–4 Proposed Paper Restoration Plan

The thickness and fragility of the paper of the architectural drawings used in this project fall between those of the Victorian era map and the ancient Chinese deed reviewed above. Based on the two restoration cases studied above, we proposed to restore the Seremban Railway Station Yard drawings by combining the techniques, which include cleaning and removing the acidic backing paper

and adhesive residue (the Victorian era map case), and handwork—restoration in patching, strengthening and stabilizing the structure of the paper (the ancient Chinese deed case). Moreover, because of the lengths of the site plan drawings, which are approximately 4 m and considering their storage after restoration, we proposed to restore the drawing sheets in scroll–type support paper for convenient roll storage in the future. This technique is similar to that of the ancient Chinese scroll.

2–3 Actual Restoration and Digitization

Unfortunately, the actual restoration and digitization of the architectural drawings could not be carried out. The main reason was the closure of restoration and digitization facilities during the COVID–19 pandemic lockdown in Malaysia. Interstate travel from Negeri Sembilan (Seremban) to Kuala Lumpur and Selangor, where such facilities are located, was restricted. Nevertheless, despite limited physical meetings, we established dialogues with the Centre for Malaysian Chinese Studies in Kuala Lumpur and other experts in heritage preservation and digitization.

Another major challenge in the restoration in this research project is the large size of the paper sheet, particularly in length. The large paper size requires a flat and smooth work surface, larger than the drawings for the restoration process (handling and drying). It is also difficult to digitize large drawings owing to the limitations in the size of the scanning hardware. One option is digitization using a photographic image (camera technique). Due to these restrictions and as per the evaluation in the interim report of this project, we progressed to the historical study (Section 3) in this final report. The actual restoration and digitization of the drawings will be conducted in the future.

3. Historical Study of the Seremban Railway Station Yard

3–1 History of the Sungei Ujong Railway

The Seremban Railway Station was first built as a station serving the Sungei Ujong railway line, which was inaugurated on July 28, 1891. The 24 miles and 66 chains (approximately 40 km) long railway line connected Seremban and Port Dickson in Negeri Sembilan, Malaysia (Figure 4). The Sungei Ujong Railway was one of the three earliest railway lines in Malaysia, which played an important role in tin transportation from the interior mines to ports along the Straits of Malacca (Kaur, 1985). Among these three earliest railway lines, the Sungei Ujong Railway line still exists in its entirety, including the station buildings and sites of its two

major stations, i.e., Seremban and Port Dickson (Figure 5), and the entire railway line reserve.

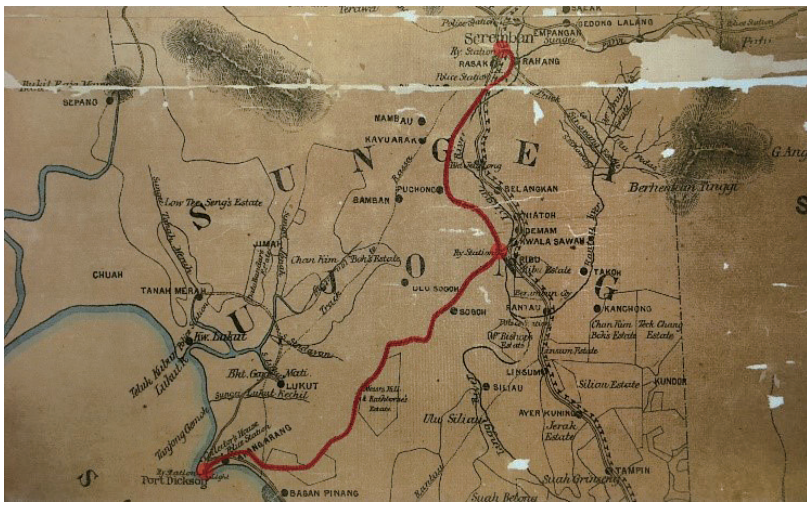


Figure 4. The Sungei Ujong Railway line (in red) on partial Map of the States of Sungei Ujong and Jelebu, 1894 (Source: National Archives of Singapore with permission of Singapore Land Authority)

(a) Seremban Railway Station

(b) Port Dickson Railway Station.

Figure 5. Early photographs of the two major railway stations of the Sungei Ujong Railway line (Source: (a) Old Seremban *Furong De Huiyi*. 2013; (b) National Archives of Malaysia)

It was the only railway line in British Malaya owned and operated by a private company, which was styled The Sungei Ujong (Malay Peninsula) Railway Company, Limited and the entirety of the capital investment came from London; nearly all the subscribers having at some time or other been interested in the Straits [of Malacca] (Straits Times Weekly Issue, 1891). This reflects the pivotal position of the Sungei Ujong Railway, including the Seremban Railway Station in early commodity transportation to the maritime trade route when a large–scale economy was introduced under British colonization. Its importance is emphasized further by the railway station yard in Seremban housing nearly all the railway departments (Section 3.2).

Besides tin, the railway later became a common transportation mode for other commercial commodities, including rubber (Fisher, 1948; Leinbach, 1975; Kaur, 1985). Since 1903, the Seremban railway line has been connected to Kuala Lumpur in the north (Kaur, 1985). In fact, 1903 was a memorable year in the history of railway of the Federated Malay States, due to the establishment of communication from Penang to Seremban (Spooner, 1904). This likely extended the capacity of the Seremban station and the station was moved to a larger site (Figure 6b), which is the site drawn in the Seremban Railway Station Yard drawings featured in this research project. The Seremban Railway Station, which was built in 1903 (Cheah, 2008) is still in use today.

3–2 Periods of Changes to the Site

Figure 6 shows the morphological changes to the site of the Seremban Railway Station Yard studied in this research project. As shown, the development of railway facilities at the site increased in general between 1920 and 1953. Figure 6a shows the earliest map of Seremban Town in 1893–1896. It shows the earliest railway yard site before moving to the current site in 1903. Even then, there were station buildings, goods yards, and two buildings for the station master and railway foreman. The latter might serve as their living quarters, although this point needs further study. Since the date of this map (1893–1896) is very close to the opening of the Sungei Ujong Railway (1891), it demonstrates the significant role of the railway in the early urbanization process of this town, the history of which could not be separated from the history of its railway. Tin mines are largely seen in the area that forms the historic urban core of Seremban today (Figure 6a).

Figure 6b shows Seremban Town circa 1920. The first railway station had been moved to the present site, leaving a mark of the old diverting railway track

on the 1920 map (Figure 6b). According to the annual report by the Federated Malay States Railways (1910), the Seremban Station Yard underwent remodeling, and all works in connection with this item were completed by 1909. It stated that the line was realigned, both north and south of the signal cabin, and the platform was widened and brought forward to the main line (Federated Malay States Railways, 1910). During this period, a preliminary survey of the Seremban to Port Dickson line was conducted in 1913 to improve the existing railway line as it had heavy gradients and short excessive curvature (Federated Malay States Railways, 1914) (Figure 4). It is observed from further reports that earthworks, foundation works, and basic infrastructure works, including roads and drains, were carried out at the station yard site from 1918–1924 (Federated Malay States Railways, 1921, 1924, 1925). This implies that a large station yard site had been acquired and was being developed, although there were few building block plans in the south of the railway track drawn in the c.1920 map (Figure 6b).

In Figure 6c, the 1933 map shows a clear boundary of the railway reserve and railway yard land. It can be seen that the facilities on the site included goods sheds or godowns, customs, District Railways Engineer's Office, coal stage, engine and carriers sheds, railway quarters, and railway coolie lines. A building of interest to note on this map is the District Railways Engineer's Office constructed between 1920 and 1923 (Federated Malay States Railways, 1921, 1924) (Figures 6c and 6d). This building was later turned into the Railway Club with an adjacent field (padang, in Malay) alongside huge bungalow–style railway quarters seen in the 1951 map (Figure 6f). This planning layout reflects the provision of recreational facilities to cater to the social lifestyle of higher–ranking officers.

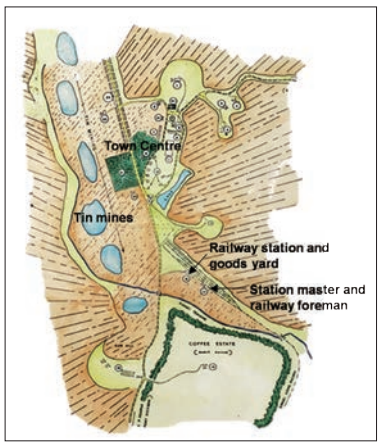
A noteworthy event in the 1940s was the Japanese occupation (World War II) of Malaya, which lasted from 1941–1945. Figure 6e was produced by the War Office in 1945. This means that the map represented the site condition towards the end of the war or after the war. It remains unknown whether any railway building or facility at this site was destroyed during the war period. Moreover, some of the buildings on this site had changed function throughout the years, but there was less indication of this in the 1945 map. Nevertheless, it is known that railway transportation remained important to the Japanese during their occupation in Malaya because the Japanese also needed tin ore, rubber, and steel from Malaya (Kaur, 1985). At the end of the war the notice boards (for train timetables) at railway stations provided convenient public space for posting printed proclamations to inaugurate the British Military Administration in Negri Sembilan (Gullick, 2003); the Seremban Railway Station might have served this purpose as Seremban was

the state administrative center.

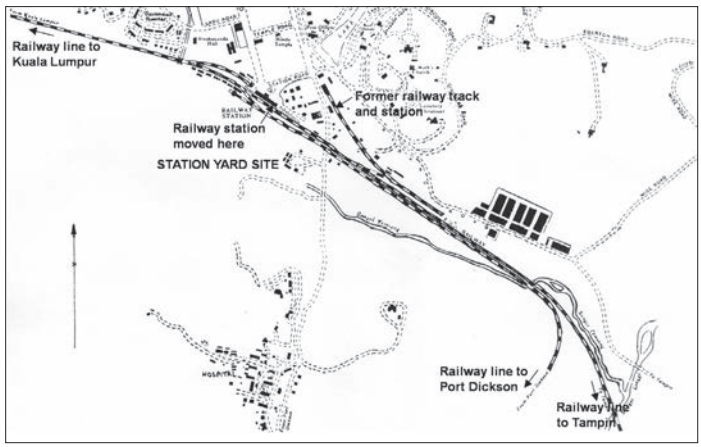
The development of the Seremban Railway Station Yard probably peaked in the 1950s, based on the number of railway tracks, buildings, and other facilities seen on site (Figure 6g). Nevertheless, the level of details in each map might differ, as they were produced by different offices in different years. For example, the engine turntable that was erected in 1924 (Federated Malay States Railways, 1925) was only shown in the 1945 and 1953 maps (Figures 6e and 6g). Rubber godowns are indicated in the 1953 map (Figure 6g), which shows that the railway was used for rubber transportation.

Based on a comparative analysis of the site plan drawings discussed in this study and the other early maps of Seremban Town covering the period from 1893 until 2016 (Figures 6a–j), it can be established that this set of site plan drawings provides the finest details of the Seremban Railway Station Yard's organization pattern of the railway tracks and facilities, two–dimensional building block plans and their block numbers or tenant names, and the land and building utilization. This implies that the drawings are worth preserving as they are an invaluable source of historic information to understand the allocation and distribution of railway–related activities and functions on the site in the past.

Figures 6h–j present the maps of Seremban Town after Malaya's independence in 1957. It can be observed that the Seremban Railway Station Yard maintained most of the buildings and functions of the 1950s in the 1975 map (Figure 6h). However, further development of the site is not observed thereafter (Figure 6i). In fact, many of the heritage railway structures were abandoned and demolished, and the site is almost an empty brownfield at present (Figures 6j and 7). Considering the historical value of the Seremban Railway Station Yard, any further demolition of the remaining heritage buildings on the site must be prohibited. These heritage buildings and the authenticity of the entire railway yard site must be carefully conserved. It is further recommended that serious evaluation including Heritage Impact Assessment precedes any future development. As the site is still authentic despite being abandoned, it gives a golden opportunity to conserve this gem of the Seremban city and Malaysian railway heritage.



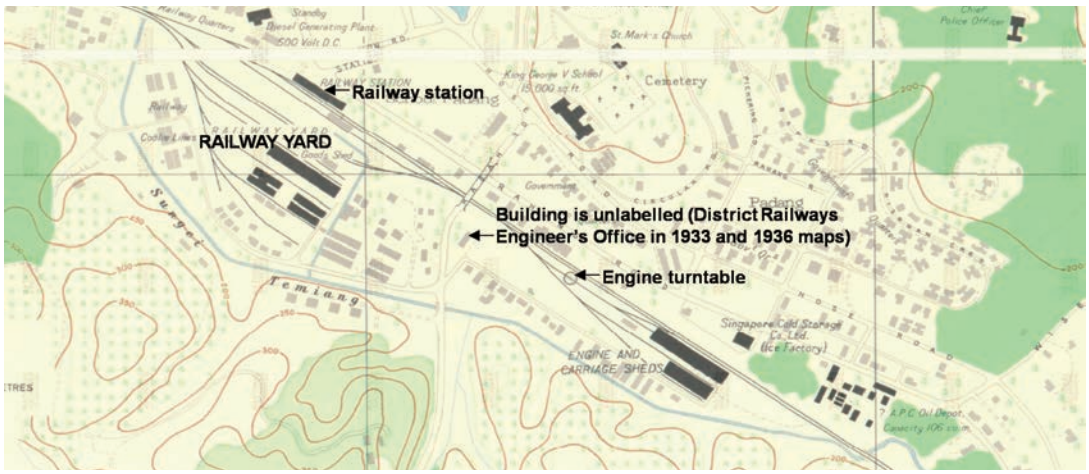
(a) 1893~1896



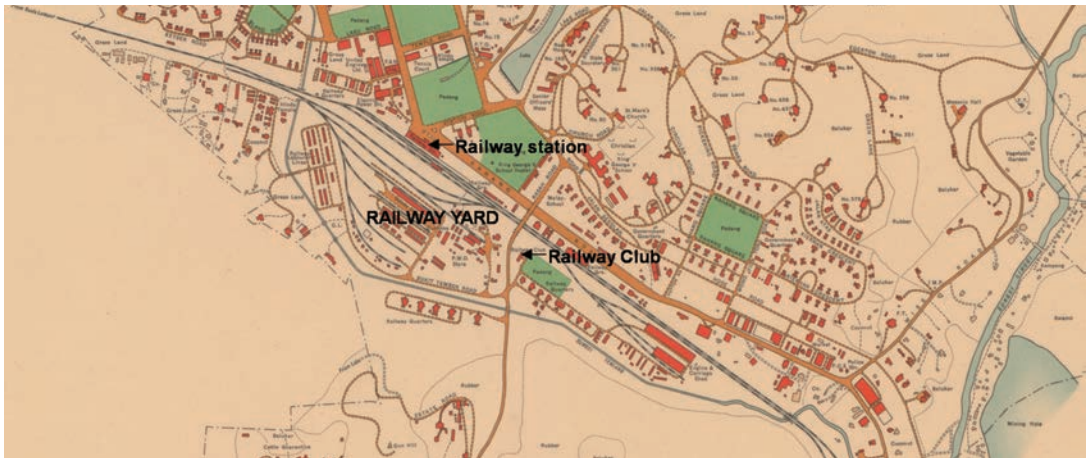
(b) c.1920

(c) 1933

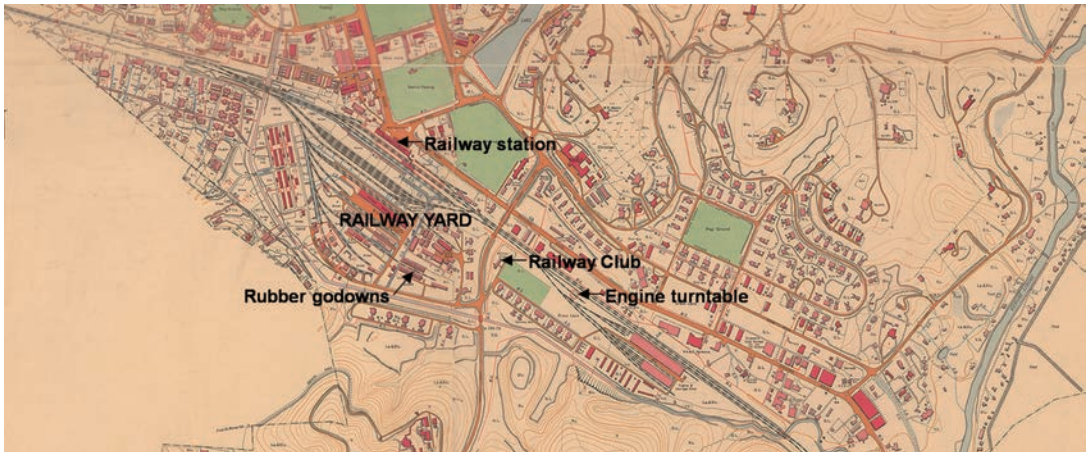
(d) 1936



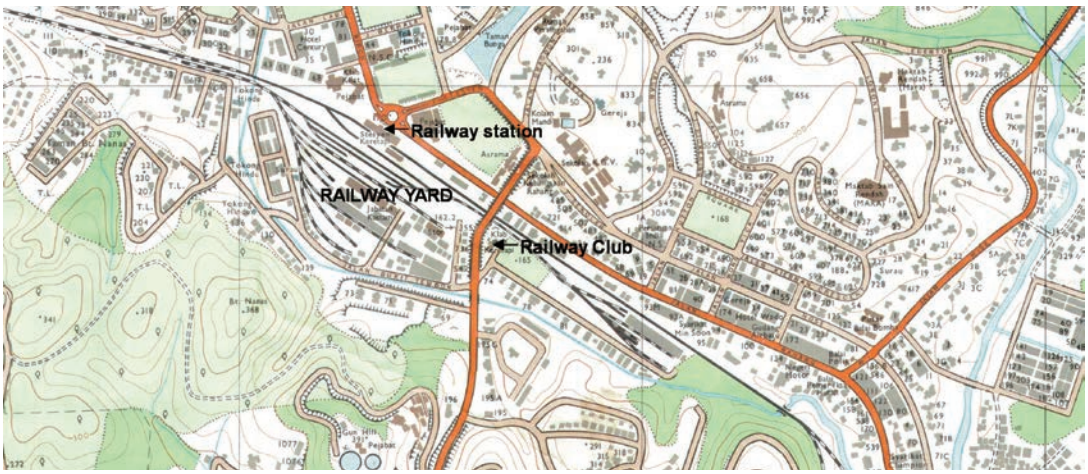
(e) 1945



(f) 1951

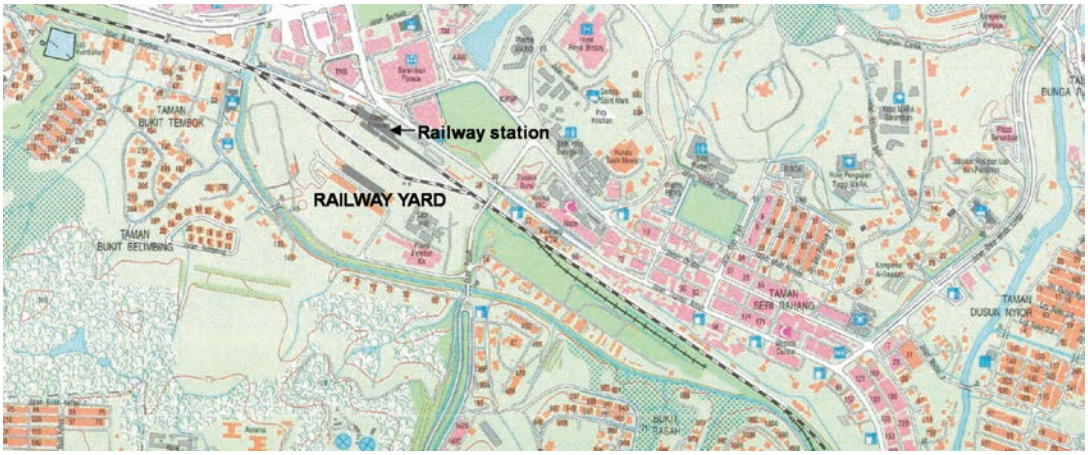


(g) 1953



(h) 1975

(i) 1993



(j) 2016

Figure 6. Maps of Seremban town in various years showing morphological changes to the site of the Seremban Railway Station Yard (Source: (a) Sri Balathandayuthapani Temple, Seremban, 2018; (b) Gullick, 2003; (c, f, g) National Archives of Singapore with permission of Singapore Land Authority; (d, e) National Archives of Singapore; (h, i) Director of National Mapping, Malaysia; (j) Department of Survey and Mapping Malaysia)

3–3 Year Identification of the Site Plan Drawings

The two site plan drawings of the Seremban Railway Station Yard were undated. In this research project, we inferred the year of production from the historical study. The characteristics of the site plan indicate that they were drawn in the style of the British colonial office before the independence of Malaysia in 1957. Further, by referring to the morphological changes to the site in Figure 6, it is estimated that the drawings were produced between 1936 and 1951. First, as explained in Section 3.2, the District Railways Engineer's Office was constructed between 1920 and 1923. This was indicated by the 1933 and 1936 maps. From the maps of 1951 until 1993, the same building was labelled as Railway Club. As the 1945 map does not put any label for this building, the function of this building between 1936 and 1951 remains unknown. It is interesting to note that the site plan drawings of this study indicate the same building as a Railway Institute (Figure 8a), which does not appear in any of the maps. Therefore, it is probable that the building was used as the Railway Institute between 1936 and 1951. Unfortunately, this building is gone at present.

Second, there are parachute tanks located at the platform along the railway track according to the site plan drawings of this study (Figure 8b). It is inferred that the parachute tanks refer to parachute–style water tanks for watering steam locomotives on the railway line. Steam locomotives were used between 1885 and 1946 in Malaya (Murphy, 1985). In 1946–1957, steam locomotives were replaced with diesel and diesel electric locomotives (Kaur, 1985). The latter was used at the Seremban–Port Dickson railway line for heavy–duty traffic (Kaur, 1985). It is likely that the parachute tanks would be obsolete in later years.

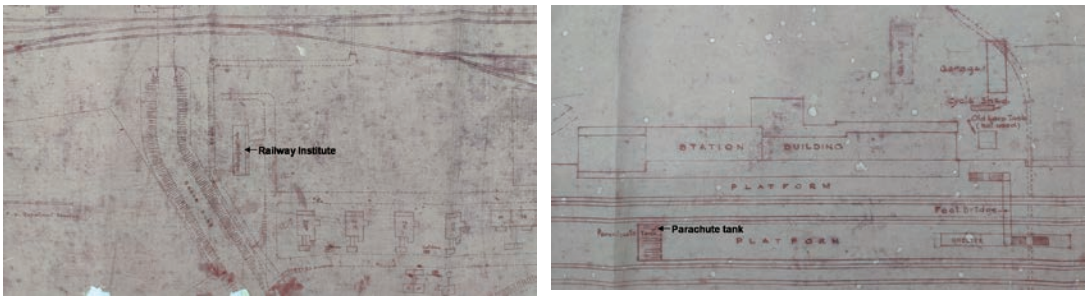
Third, the site plan drawings of this study portray similar organization patterns of railway tracks and facilities and building block plans, as observed in the peak development period of the site in the 1950s. It would be noteworthy to further determine whether the site plan represents the railway station yard development before or after the Japanese occupation (World War II) in Malaya. This is an interesting point because the architectural drawings might have survived the war; otherwise, they might be important documents used by the British to reconstruct and improve the site after the war. This ties back to the possibility of having a Railway Institute at the site.

Figure 7. Aerial view showing the current site conditions of the Seremban Railway Station Yard, 2021

4. Conclusions

Architectural drawings are essential references for understanding the history and construction processes of historical buildings. Based on availability and limitations, this research utilized two long scrolls of architectural drawings that present the site plan of the large railway station yard in Seremban from the British colonial period for restoration and historical study. Preserving the architectural drawings of the Seremban Railway Station Yard site is significant because they serve as fundamental data for researchers to study not only the Seremban Railway Station but also the urbanization along the Seremban railway line and the local history of Seremban.

The historical study emphasized the significant heritage values of this site, related to the history of commodity transportation, including tin and rubber, that linked Seremban to the maritime trade route via Port Dickson since 1891. Hence, the site was the core of the economy, mobility, and society in Seremban. Due to the comprehensive development of the Seremban Railway Station Yard and the fine details contained in the site plan drawings of this study, the site could represent the significant universal values of railway station yards of the British colonial period. This research project further aims to carry out the actual paper restoration and digitization of the drawings.



(a) Railway Institute (b) Parachute tank at the platform

Figure 8. Partial view of the Seremban Railway Station Yard site plan drawings of this study

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Outstanding Universal Value of George Town, Penang: Surviving Covid-19

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Abstract

George Town and Melaka were inscribed as World Heritage Sites (WHS) in 2008 because they fulfilled criteria (ii), (iii), and (iv) of the Outstanding Universal Value (OUV). Criteria (ii) and (iii) are linked to the living heritage in George Town, while criterion (iv) is linked to the ensemble of town houses and shophouses that are distinctive in Southeast Asia. In 2020, the OUV, especially criteria (ii) and (iii), faced a new and unsuspecting threat in the form of the Covid–19 pandemic. Among the measures imposed by the Malaysian government to control the spread of the Covid–19 virus is the Movement Control Order (MCO), which is a partial lockdown on all activities except essential services. The MCO has greatly impacted the OUV of George Town. Hence, this study aims to examine how the Covid–19 pandemic has impacted the resilience of criteria (ii), (iii), and (iv) of the George Town World Heritage Site (GTWHS). This study fills a huge and important research gap given the currency of the Covid–19 pandemic. Data were collected via face–to–face and online surveys; they were triangulated through online interviews conducted with selected stakeholders. The findings indicate that the impact on criteria (ii) and (iii) is greater than that on criterion (iv) and the government's existing assistance was insufficient. This research posits that strategies should focus on capacity building of the custodians of the OUV to build resilience in the long run rather than on providing assistance only when the situation calls for it.

1. Historical background of George Town

George Town has been the capital city of Penang since 1786. As a free trade port, it was once Penang's leading economic artery. Before Penang became a part of the first Straits Settlement of the British, it originally belonged to the Kedah Kingdom. The East India Company took control of Penang when Captain Francis Light landed on the northeastern part of the island in 1786 and named it George Town after Britain's King George III. With burgeoning commercial activities, the number of traders and workers from different parts of the world, such as Arabia, Aceh, India, China, Siam, Myanmar, and Europe, increased rapidly and marked their presence in George Town; subsequently, this increase in population marked the growth of the town.

The size of the town has expanded naturally since then. The inner city of George Town is the core area of the United Nations Educational, Scientific and Cultural Organization (UNESCO) World Heritage Site, owing to its unique heritage characteristics (criteria (ii) and (iii)) and the well–known historical pre–war buildings like the two–story shophouses that were built before World War II (criterion iv). Figure 1 shows the core and buffer areas of the George Town World Heritage Site (GTWHS).

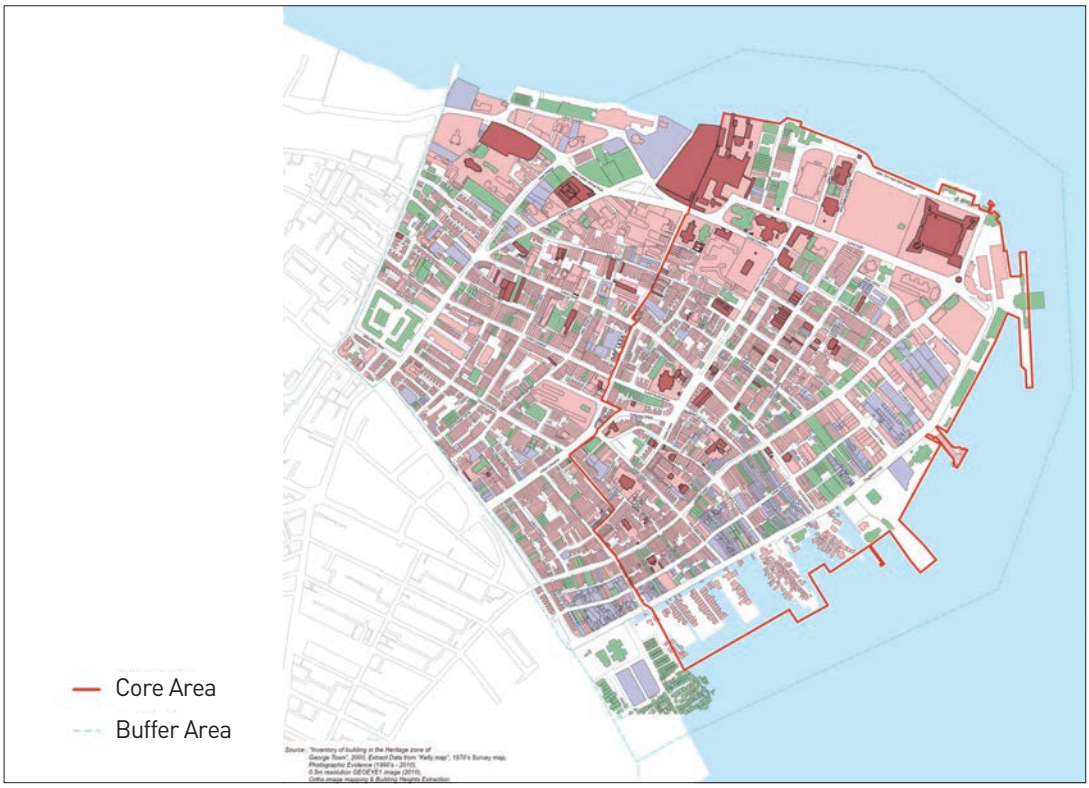

Figure 1. GTWHS Core and Buffer Area (Source: Special Area Plan George Town (2016))

The history of these heritage buildings dates back to the late 18th and early 19th centuries. According to a letter from Captain Francis Light dated June 28,1793, brick buildings such as dwelling houses and offices, shops, taverns, bakehouses, and godowns were already in existence (City Council of George Town, 1966). More brick buildings were built, especially after major fires in 1789, 1808, 1812, and 1826 (City Council of George Town, 1966; Khoo, 1994) when timber and attap roof buildings were no longer allowed to be built. By 1887, the timber buildings in George Town had been fully replaced by brick buildings (City Council of George Town, 1966). Among the oldest buildings that still survive are Fort Cornwallis (1786, rebuilt in 1793 and 1810) and religious buildings such as the Nagore Shrine at Lebuh Chulia built in the 1800s; Kapitan Keling Mosque and Goddess of Mercy Temple along Jalan Masjid Kapitan Keling built in the early 1800s; Acheen Street Mosque built in 1808; St. George Church (1818); Mahamariamman Temple at Lebuh Queen (1833); and clan houses such as Cheah Kongsi at Lebuh Armenian (~1801). Other early buildings are the former Government House (1804), which is now part of the Convent buildings; rows of shophouses (lot 92) on Lebuh Armenian, which were built in the 1830s and 1840s; Syed Al–Atas Mansion at Lebuh Armenian in the latter half of the 19th century; and the Town Hall at Jalan Padang Kota Lama (Esplanade Road) in 1880 (Khoo, 1994). Until 1997, there were approximately 13,000 pre–war buildings in George Town. However, in the Special Area Plan of George Town, which was gazetted in 2016, there were only 2569 and 2444 units of heritage buildings in the core and buffer zones respectively, making a total of 5013 units.

1–1 Outstanding Universal Value (OUV) of George Town

The World Heritage Committee (WHC) launched the Global Strategy to ensure a representative, balanced, and credible World Heritage List (WHL); it stated that a site must have OUV and fulfil at least 1 of its 10 selection criteria, to be inscribed on the WHL (UNESCO WHC, 2021). With reference to paragraph 49 of UNESCO's Operational Guidelines for the Implementation of the World Heritage Convention, OUV means "cultural and/or natural significance which is so exceptional as to transcend national boundaries and to be of common importance for present and future generations of all humanity" (UNESCO, 2019). By the end of 2004, UNESCO WHSs were chosen based on 6 cultural heritage and 4 natural heritage criteria.

The WHL describes Melaka and George Town this way:

> Melaka and George Town, Malaysia, are remarkable examples of historic colonial towns on the Straits of Malacca that demonstrate a succession of historical and cultural influences arising from their former function as trading ports linking East and West. These are the most complete surviving historic city centres on the Straits of Malacca with a multi–cultural living heritage originating from the trade routes from Great Britain and Europe through the Middle East, the Indian subcontinent and the Malay Archipelago to China. Both towns bear testimony to a living multi–cultural heritage and tradition of Asia, where the many religions and cultures met and coexisted. They reflect the coming together of cultural elements from the Malay Archipelago, India and China with those of Europe, to create a unique architecture, culture and townscape. (UNESCO WHL, 2021)

The inscription for the Melaka WHS and GTWHS mention criteria (ii), (iii), and (iv) of the OUV that fall under the cultural heritage category. The full statement of the OUV for criterion (ii) is as follows:

> George Town and Melaka represent exceptional examples of multi–cultural tradingtowns in East and Southeast Asia, forged from the mercantile and exchanges of Malay, Chinese,and Indian cultures and three successive European colonial powers for almost 500 years, each withits imprints on the architecture and urban form, technology and monumental art. Both townsshowed different stages of development and the successive changes over a long span of time andare thus complementary. (UNESCO WHL, 2021)

Figure 2. Scenes reflecting criterion (ii)

The fulfillment of criterion (ii) is due to George Town's role as a multicultural trading port city in East and Southeast Asia forged by the commerce and exchanges of the Malay, Chinese, and Indian cultures, and European colonists. Although George Town has evolved over the years, the footprints of yesteryear trading and commerce are still evident. The scenes found in George Town that reflect criterion (ii) are depicted in Figure 2.

The full statement of the OUV for criterion (iii) is as follows:

> Melaka and George Town are living testimony to the multi–cultural heritage and tradition of Asia, and European colonial influences. This multi–cultural tangible and intangible heritage is expressed in the great variety of religious buildings of different faiths, ethnic quarters, the many languages, worship and religious festivals, dances, costumes, art and music, food, and daily life. (UNESCO WHL,2021)

George Town showcases criterion (iii) of the OUV as a living exemplar of Asia's multiplicity of cultural heritage and traditions and colonial powers displayed through multicultural tangible (ethnic quarters, religious establishments, etc.) and intangible (dialects, daily life, food, dances, etc.) cultural heritage. The vibrancy of multicultural traditions is evident in the annual events, religious festivals, and daily activities. Figure 3 depicts scenes reflecting criterion (iii) in the GTWHS.

Figure 3. Scenes depicting criterion (iii)

George Town's fulfillment of criterion (iv) is displayed through the shophouses and townhouses found in the city that showcase a mix of influences that established a unique architecture, urbanscape, and culture that are not found elsewhere in South and East Asia. The full statement of the OUV for criterion (iii) is as follows:

> Melaka and George Town reflect a mixture of influences which have created a unique architecture, culture, and townscape without parallel anywhere in East and South Asia. In particular, they demonstrate an exceptional range of shophouses and townhouses. These buildings show many different types and stages of development of the building type, some originating in the Dutch or Portuguese periods. (UNESCO, WHL,2021)

One of the main attributes of criterion (iv) would be the shophouses of George Town, exhibiting an exceptional range that was developed over 170 years. Throughout this period, 6 main styles evolved: Early Penang, Southern Chinese Eclectic, Early Straits Eclectic, Late Straits Eclectic, Art Deco, and Early Modern (Tan 2015). Figure 4 depicts some of the unique heritage buildings of different typologies found in the GTWHS. Collectively, the fulfillment of the 3 aforementioned criteria was integral to George Town's inscription on July 7, 2008, as a UNESCO WHS.

Figure 4. Examples of heritage buildings in the GTHWS

1–2 Post–inscription and Covid–19 threats and resilience in safeguarding OUV

Globalization and the manner in which urban areas are implicated have been widely debated in the past. Often viewed as a double–edged sword, globalization and urban restructuring have their fair share of both advantages and disadvantages. On the one hand, advocates, who are predominantly pro–

growth political leaders, welcome growth–led and market–driven strategies to stimulate urban development and increase their city's competitiveness (Brenner & Theodore, 2013). On the other hand, anti–globalist critiques cautioned against the vagaries of globalization, such as unchecked gentrification, marginalization of vulnerable groups, spiking real estate values/rents, indiscriminate conservation of historic buildings, displacement of local communities, and infiltration of modern cultures by gentrifiers as some of the concerns that threaten local character, place identity, indigenous knowledge, and livelihoods of the locals (Smith, 2002). This scenario becomes more challenging for heritage and historic cities, where urban spaces get contested between urban conservation and the appeals of urban modernism. Arguably, a city's cultural heritage will be jeopardized and at risk of vanishing if a historic city loses its people, culture, monuments, and traditional livelihoods.

Like the fate of most cities confronting the forces of globalization, George Town is also at a crossroads juggling between urban conservation and modernization with incidences of gentrification, the presence of new businesses and dwellers (Foo & Krishnapillai, 2018), and cases of social exclusion (Khoo, 2020). The unregulated transactions of shophouses in the GTWHS by foreign investors (e.g, World Class Land) who bought them en bloc caused rents to increase by more than 500 per cent (Loh, 2016a, 2016b; Mok, 2016). Many of these properties were purchased, restored, and converted/adaptively reused as boutique hotels, museums, or café bistros. Tourism quickly became the cash cow sector, although critiques have cautioned against the unsustainable nature of the mass tourism unfolding at the heritage site. This is how economic globalization and its discontent—has manifested in the GTWHS since the city's inscription on the WHL in 2008. To an extent, the status quo challenges the city's OUV and the GTWHS's readiness and resilience to safeguard the city's authenticity and integrity. Resilience in heritage can be examined from the perspective of an ecological resilience framework in which resilience ensures the continuity of heritage values within the WHS (Seekamp & Jo, 2020). This continuity recognizes the "continuous process of evolving tangible and intangible heritage expressions in response to changing circumstances" (Poulios, 2014).

The GTWHS's resilience was further tested in 2020 when Malaysia was exposed to another global shock—the Covid–19 pandemic which is still unfolding during this study. Since March 2020, the partial lockdowns and Movement Control Orders (MCO) imposed by the Malaysian government had their fair share of impacts on the GTWHS and the activities, livelihoods, and fanfare of the people,

which are attributes of criteria (ii), (iii), and (iv) of George Town's OUV. Inevitably, George Town's socioeconomic and cultural landscapes were impacted and implicated by the Covid–19 pandemic. The unprecedented Covid–19 pandemic has exposed and put the resilience, survival, and sustainability of George Town's OUV at risk. In a local context, this results in a need to examine and comprehend the extent to which the 3 selection criteria of GTWHS's OUV are at risk of being impacted or resilient to Covid–19. This scenario must be understood against the backdrop of the aforementioned situation where the GTWHS was already experiencing a myriad of transformations, issues, and challenges and how they were exacerbated by the Covid–19 pandemic. Hence, this study focuses on identifying the extent to which George Town's cultural heritage is resilient to Covid–19 coupled with the tensions and challenges of existing changes, to ensure that the historic city's authenticity and integrity remain intact for posterity.

Given that Covid–19 is ongoing globally, limited academic research has been conducted on its impact on the readiness and resilience of GTWHS's OUV; only a handful of preliminary studies have been conducted using local think tanks (e.g., Penang Institute, Think City) to capture quick snapshots of the situation (Lim, 2020; Think City, 2020). Hence, this study aims to examine how Covid–19 has impacted the resilience of the selection criteria (ii), (iii), and (iv) of GTWHS promptly and fill an important research gap. The findings of this study will lead to better–informed and evidence–based policymaking as a quest to brace the GTWHS for unanticipated shocks and increase its resilience in the future.

2. Objectives and Methodology

2–1 Objectives

The objectives of this study are as follows:

1. To establish the survival skills and resilience of the custodians (i.e., urban dwellers) in safeguarding the OUV of George Town, Penang, during the Covid–19 pandemic.
2. To identify the issues and challenges faced by the custodians (i.e., urban dwellers) of the OUV of George Town, Penang, during the Covid–19 pandemic.
3. To determine solutions and strategies to shape resilient policies to safeguard George Town's OUV, which can serve as examples for other WHSs during the Covid–19 pandemic.

2–2 Methodology

To gain insight into the experiences and issues faced by the custodians of OUV, this study will collect data from the perspectives of the Penang State residents and business traders in the heritage core zone of GTWHS. By studying their perspectives, we can capture the pertinent issues and experiences of the community. In this manner, constructive solutions or alternatives can be formulated to meet their needs.

The original design catered to respondents who are "custodians" (i.e., business owners and residents in GTWHS) of the 3 criteria of George Town's OUV. The objective of the survey was to collect data on the perceived survival skills and resilience of the custodians and to identify factors that can be used to safeguard George Town's OUV during the Covid–19 pandemic despite the MCO implemented by the government. To achieve our objectives, data were collected using a questionnaire. This method was chosen because it is an established method to obtain information from the target population about their attitudes, behaviors, viewpoints, and opinions through a set of standardized questions (Wates, 2002). Although the original methodology consisted only of a questionnaire survey (quantitative), we had to redesign the methodology since access to business owners and residents was restricted owing to the multiple MCOs imposed by the Malaysian government. Due to the amendment to the original methodology, an additional component—key informant interviews—was added to ensure richer and more in–depth data. The additional data obtained from the interviews aided in triangulating the results. However, towards the end of the research period, the MCO was lifted, and the researchers took this opportunity to collect the third round of data through a face–to–face questionnaire survey. The data were checked and organized once the surveys and interviews were completed; subsequently, the data were analyzed using descriptive statistical methods.

2–2–1 Online Survey

During the Covid–19 pandemic, several lockdowns were imposed by the Malaysian government since 2020. Due to the lockdowns from May 2021, to October 2021, the scheduled face–to–face survey for this project could not be conducted and was replaced with an online survey. The switch to an online survey ensured no further delay in the data collection phase. The online survey was prepared using Google Forms. A brief introduction to this project and a link to the online survey were sent to various stakeholder groups on July 2, 2021. The online survey was conducted for approximately 1 month and ended on July 30, 2021.

Two Google Forms were created for the online survey. As Malaysians conversed mainly in English, Malay, and Chinese, the Google Forms were created in these 3 languages. One form was created in English and Chinese, while the other was in the national language (Bahasa Malaysia); this was done to reach as many respondents as possible. A copy of the survey questionnaire (English and Chinese) is provided in Appendix A of this report. As the Bahasa Malaysia version is a translation of the English one, it is not included in this report to avoid duplication.

Creating a Google Form in 3 languages makes it too cumbersome to navigate and answer, thus, 2 forms with the same questions were created as mentioned above. Although the online survey lasted for 1 month, the response rate was rather disappointing, as we only managed to obtain 107 responses (N=107). The low response rate could be due to the survey fatigue experienced by potential respondents during this period, where most, if not all, research projects and data collection are migrated online. In addition, some key informants explained that most of the targeted respondents/custodians of OUV in GTWHS are not IT savvy and may not be able to answer via Google Forms. The experience gained from this research indicates that using technology to conduct surveys may not be suitable for every study. Suitability relates to the characteristics of the targeted respondents; in this research, an online survey was not suitable because the target respondents did not possess sufficient knowledge to use social media/web–based platforms. Nevertheless, the data are still useful as they reflect the perceived resilience of the custodians of the OUV in the GTWHS.

2–2–2 Online Interviews and Focus Group Discussion

Considering the limitations of the online survey data, an additional data collection component was used to triangulate the data. To that end, online interviews and focus group discussions were conducted after the online survey. Qualitative data from online interviews and a focus group discussion allowed for richer and more in–depth findings. Purposive and snowball sampling methods were used to obtain key informants relevant to this research. Eight interviews and 1 focus group discussion were conducted. The research endeavors to locate key informants that represent the multifarious custodians of the GTWHS's OUV. To that end, the key informant lists range from residents in GTWHS to the manager of the WHS. The key informants interviewed are listed in Table 1.

Table 1. List of interviewees

1	Executive Secretary of Penang Clan Association and Chair of Penang Cultural Inheritors Society
2	Architect/Town Planner, business, and property owner in George Town
3	General Manager of George Town World Heritage Incorporated
4	President of Indian Muslim Community Organization Malaysia
5	Money Changer in George Town
6	Property Valuer
7	Resident in George Town
8	Business owner in George Town
9	Special Project Officer of Penang Think–tank*
10	Analyst of Penang Think–tank*

(NOTE: Key informants 9 and 10 are participants for the focus group discussion. They are from the same organization.)

The interviews were conducted online via Webex or Zoom, as the MCO was still in place. The online interviews were successfully conducted with the abovementioned key informants from July 20, 2021, to August 11, 2021, with the exemption of key informant no. 3. Due to her busy schedule, she requested that she be permitted to provide written answers to the questions. The interviews were recorded, transcribed, and used for data analysis. Data from the interviews enabled a deeper understanding of the survey findings.

2–2–3 Face–to–face Survey

Towards the end of the research, the MCO was lifted; this allowed us to conduct the face–to–face survey. Although we had already conducted an online survey and interviews, a face–to–face survey was conducted to enhance the credibility of our data. The face–to–face survey used the same survey tool (Google Forms) and was conducted on October 10, 12 and 13, 2021. Using mobile devices during data collection, enumerators asked the questions and keyed the answers into Google Forms on behalf of the respondents. The face–to–face survey allowed us to select the relevant respondents, such as the traditional businesses, owners, and tenants in the heritage core area. This enhances the representativeness of the findings to the heritage core area of George Town. The selected areas for the face–to–face survey were within the heritage core zone of George Town, covering the following streets and locations: Queen Street, King Street, China Street, Masjid Kapitan Keling Street, Market Street, Chulia Street, Bishop Street, Church Street, Cannon Street, Armenian Street, Carnarvon

Street, Lim Chwee Leong Street, and the Padang Kota Lama area. The face–to–face survey obtained 100 respondents (N=100), making a total of 207 respondents (N=207) for this research.

3. Research Findings

3–1 Respondents Profile

The following findings were derived from the consolidated data of the online and face–to–face surveys and triangulated with the data from the online interviews and focus group discussions. The respondents' ethnicities are listed in Table 2. The survey data were compared against the population statistics data of George Town (GT) in 2010 and the Northeast District (NE) in 2015. The comparison indicates that the data collected from the survey have similar and comparable composition of the ethnic groups in George Town. This is important to ensure the representativeness of the data to George Town's population.

Table 2. Respondent's ethnicity compared with the ethnic demography of GT and NE district of Penang

Ethnicity	Frequency	Percentage of ethnic groups from the survey (%)	Composition of ethnic groups in GT (%)*	Composition of ethnic groups in Northeast District (%)**
Malay	65	31	32	23
Chinese	117	57	53	65
Indian	23	11	9	12
Did not state/ Others	2	1	6	–

(Note: *2010 statistics, **2015 statistics)

The survey also looked at the employment category of respondents to ensure that we had a good representation of traditional businesses in our data. Figure 5 shows the percentage of respondents according to employment category. In this survey, respondents from traditional businesses were the highest (37%), followed by students (17%), and new heritage–related businesses (15%). New heritage–related businesses include heritage–themed cafés, souvenir shops, tour agencies, guides, and tourist attractions. Respondents in the categories of non–heritage–related comprised businesses (14%), academics (10%), retirees (4%), government agencies (2%), and art and culture groups (1%).

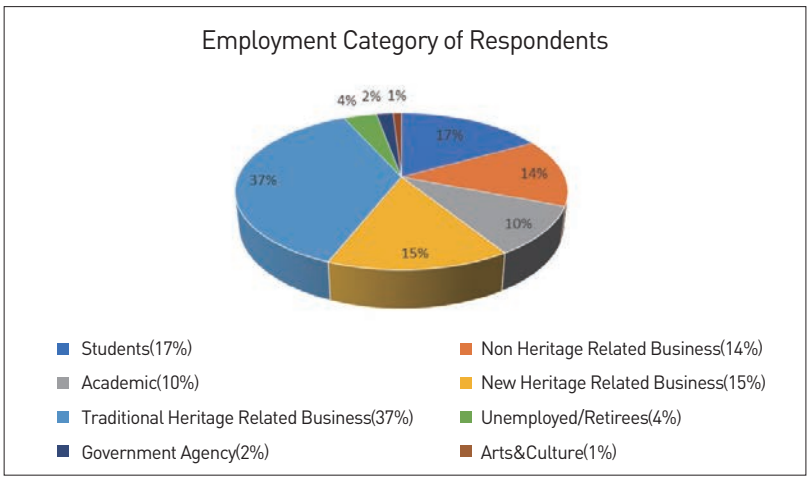

Figure 5. Employment Category of Respondents

3–2 Impact of Covid–19 on the OUV (Criterion (ii))

With reference to Table 3 and Figure 6, respondents were asked about the impact of Covid–19 on criterion (ii), which is George Town's role as a historic port and trading town. The findings show that a large majority of respondents (72%) indicated that a severe reduction in customers/sales threatened the survival of traditional businesses. This is followed closely by the impact of the reduction in port activities and cruise tourists, which will cause some businesses/activities to eventually disappear. Some of these activities include cruise tour agencies and petty trishaw businesses. The petty trishaw business is a traditional trade and an endangered mode of mobility at the GTWHS. Another severe impact is the risk of traditional businesses closing (69%) due to prolonged MCO. This is followed by the impact on traditional businesses that suffer losses but survive (64%). Another anticipated impact, though less severe, is "using online platform during lockdown is insufficient to sustain traditional businesses" (45%).

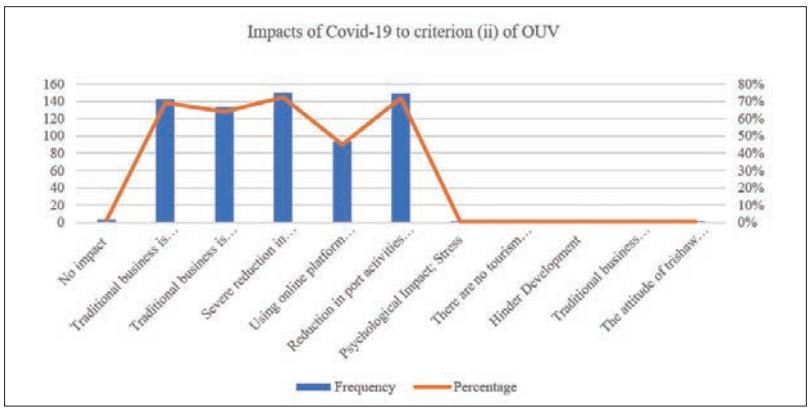

Figure 6. Impact of Covid–19 on criterion (ii) of the OUV

Table 3. Impact of Covid–19 on criterion (ii) of GTWHS's OUV

In your opinion, which of the following is/are the impact(s) of Covid–19 to criterion (ii) of George Town?	Frequency	Percentage
No impact	3	1%
Traditional businesses are closing due to prolonged MCO.	143	69%
Traditional businesses are suffering losses but still surviving.	133	64%
Severe reductions in customers/sales threaten the survival of traditional businesses.	150	72%
Using online platforms during lockdown is insufficient to sustain traditional businesses.	93	45%
Reduction in port activities and cruise tourists will cause some business/activity to disappear (e.g., trishaws, cruise tour agencies).	149	72%
Psychological Impacts (e.g., stress)	1	0%
There are no tourism activities due to the MCO. Thus, it significantly impacts cultural heritage tourism, such as the cancellation of festivals and celebrations which results in the lack of employment opportunities for practitioners in performing arts.	1	0%
Hinders development	1	0%
Traditional businesses cannot sustain	1	0%
The attitude of the trishaw driver is bad	1	0%

Interviews with key informants revealed that the impacts on criterion (ii) of the OUV varied based on business type. The socioeconomic scenario of George Town has changed drastically since its heyday as a full–fledged port city due to factors such as the revoking of the free port status and the subsequent shift of port and logistics activities to Butterworth. Interestingly, an interviewee perceives that the "wholesale activities" which are often affiliated with George Town's port city role, can still be sustained amidst Covid–19 given that such businesses are not tourism–reliant:

> "Because you look at George Town, whenever we talk about the multicultural trading and things like that, it's a lot of wholesale activities. Because most of these businesses that we are looking at···the wholesale side, that's why this is where I have two different answers. If you are talking about the wholesale. The wholesale businesses are not relying on tourism. And if you are talking about wholesale, the difference is the small traders and small retailers who still go to these wholesale outlets to go and get their stuffs. So, if you are looking at the wholesale···I will think they will still survive, because their priority is about selling it to the downstream."
>
> (Architect Planner, July 20, 2021)

At the same instance, the "port element" is viewed differently by some local traders by linking the impacts of criterion (ii) to modern and contemporary maritime activities like the arrival of international cruises and tourists aboard who stop over. In this regard, businesses that rely on such modern maritime activities are hugely impacted, as depicted by a local trader:

> "Yeah, I think the impact definitely is very huge. I think in terms for the port, a lot of international cruises. They come and they are one of the main sources that we get our customers, especially for the traders around George Town area. For me myself, I'm actually a trader. I have a shop. From March (2020) onwards, we can hardly do any business. You see···so many months already we can't open shop."
>
> (Batik trader in GTWHS, August 6, 2021)

In addition to wholesale trading and cruise activities, criterion (ii) is linked and intertwined with other upstream and downstream activities, such as selling food to urban folks at the heritage site. During the lockdowns and MCOs, retail and petty businesses were impacted as they could not open and operate.

> "There are different kinds like the selling food one here is OK but the others really suffer. They all cannot open their business."
>
> (All Clans Executive Secretary, July 22, 2021)

3–3 Impact of Covid–19 on the OUV (Criterion (iii))

With reference to Table 4 and Figure 7, respondents were asked about the impact of Covid–19 on criterion (iii), which is George Town as a living testimony to the multicultural heritage and tradition of Asia, and European colonial influences. This multicultural tangible and intangible heritage are expressed in the religious buildings of different faiths, ethnic quarters, languages, worship and religious festivals, dances, costumes, art and music, food, and daily life. The findings indicate that the loss of cultural and heritage tourism has been the most impacted (58%) Most of our interviewees agreed with this, and one of them explained it as follows:

> "Those shop near to the Cannon Square and outside Khoo Kongsi, there are many shops. I think (now) they are actually closed down. They did not even open at all because I would say that they are 100% dependent on tourists, I mean local people seldom come down (here to shop)."
>
> (Resident in GTWHS, August 7, 2021)

Additionally, annual events and festivals have been curtailed, contributing to the loss of heritage tourism. Although there have been efforts to migrate festivities to online platforms, they have not been very successful, as mentioned by one of the key informants:

> "So, I understand also they are trying that time early of the Chinese New Year, they are trying to do the online type of festival but online is very different···because you are seeing it through PC (personal computer) then there is no feeling, I think. So, I think it is very quiet... this year tourism is very quiet."
>
> (Property Surveyor, August 11, 2021)

Another finding suggests that the reduction in the businesses of traditional traders/artisans such as the songkok (a traditional hat worn by the Malays) maker puts them at risk of extinction (56%). This is an important point for policymakers to note where the additional threat of Covid–19 has contributed to the traditional traders/artisans becoming the endangered attribute in the heritage ecosystem of the GTWHS.

Interestingly, the survey found that although Covid–19 negatively affected religion–based businesses, such as the supply of prayer paraphernalia and food, the respondents thought that such businesses would survive (46%). This point is explained by 2 of the key informants:

> "The thing is interestingly about food, they don't only cater to the tourists, they are actually catering to the locals as well. So, I think they will stay on. Yeah."
>
> (Architect Planner, July 20, 2021)

> "Effect for the supply of prayer requisites is negative but still will survive. As I said, it is still difficult but still survives. Like I see near the Kuan Yin Teng (Temple of Goddess of Mercy), the joss–sticks shops are all open. In front of Carnarvon Street, there are also 3 shops, I saw they have tried to sell prayer requisites in Shopee and Lazada (online shopping platform).
>
> (Money Changer in GTWHS, August 19, 2021)

However, the same percentage of respondents (46%) also think that the practices of traditional prayer rites and rituals may phase out and gradually disappear. Data from interviews with key informants also concurs with these findings:

> "But what I'm saying is that younger generation already don't go to temples now, 10 years down the road the older generation started to 'taper off' then you get less and less young people going and ultimately it will be become a fan base or the place for tourists, people come in and see."
>
> (Architect Planner, July 20, 2021)

> "For example, in gatherings for celebrations or prayers, it is usually done in a group gathering. Traditionally, the more people the better but with social distancing, the allowable gathering of 200 people is slowly being reduced to 10 or 15 people only. As this has dragged on for a year, many will not attend anymore. (They will think) it is alright, I will just pray from my home or I just attend the prayer online. That means the foundation of group prayer will gradually disappear."
>
> (President, Indian Muslim Community Organization Malaysia, August 14, 2021)

A smaller percentage (36%) thought that Covid–19 restrictions would cause the prayer requisites businesses to disappear, while 13% thought that there was no impact at all. One of the key informants explains why he believes that the prayer requisites business will disappear:

> "Maybe the small stalls, they will disappear. A lot of the sellers are already very old. I remember near the Kuan Yin Teng, there is a lady selling red colour bread (usually used for prayers). Now I don't see her anymore. She seems like just suddenly disappeared. Since young, I am always in this area so I can see the changes."
>
> (Money Changer in GTWHS, August 19, 2021)

From the above data, it seems that larger prayer requisites businesses that are conducted in shops could be more resilient, as they can adapt and migrate to online businesses to survive. However, the small stalls could disappear, especially if the owners are already old. Usually, government would have missed out giving aids to this group, as they are usually overlooked based on the small volume of their business. However, it is this type of stall traders that make up the OUV of George Town, as the way they produce their products and conduct their business is still in a traditional way. This finding provides direction for the type of aid the government or heritage agencies should roll out to safeguard these often–neglected custodian groups.

Table 4. Impact of Covid–19 on criterion (iii) of GTWHS's OUV

Following the MCO, several activities such as religious/cultural festivals and prayer congregation were curtailed. In your opinion, how have these restrictions impacted criterion (iii) (multi–cultural heritage)?	Frequency	Percentage
No impact.	27	13%
Practices of traditional prayer rites and rituals may phase out and gradually disappear.	96	46%
Supply for prayer requisites is negatively affected and may disappear.	75	36%
Supply for prayer requisites is negatively affected but will survive.	96	46%
Reduction in the business of traditional traders/artisans will put their businesses at risk of extinction.	116	56%
Loss of cultural and heritage tourism.	121	58%
No participation of the younger generation.	1	0%
No comment.	1	0%

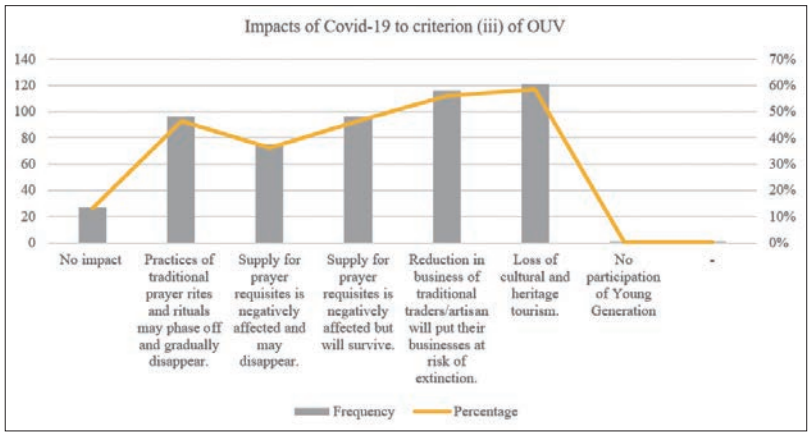

Figure 7. Impact of Covid–19 on criterion (iii) of the OUV

3–4 Impact of Covid–19 on the OUV Criterion (iv)

As shown in Table 5 and Figure 8, respondents were asked about the impact of Covid–19 on criterion (iv), which comprises George Town's shophouses and townhouses that showcase a blend of influences that developed a unique architecture, urbanscape, and culture that are not found in East and South Asia. In general, the findings indicate that there is less impact on criterion (iv) than on criteria (ii) and (iii). This is evident from the lower percentages of responses received to questions for this criterion (iv). The findings suggest that the majority (57%) indicated that the impacts of Covid–19 has caused the intention to restore heritage buildings to be put on hold, and the delay in maintaining such buildings may cause them to deteriorate. The survey also found that 53% thought that the periodic maintenance of heritage buildings taking a back seat during the Covid–19 pandemic has caused the conditions of buildings to deteriorate. In

general, the respondents agreed that building conditions deteriorated due to owners' decision to not spend money on building upkeep during the pandemic period.

The experts were asked this question during the interview session to seek further clarification. Data from the interviews with key informants explain this as follows:

> "I think periodic maintenance will take a back seat···that's true because if the hotels don't open and events don't happen, it is minimal maintenance you know, so it is really deteriorated. The intention to restore heritage buildings is put on hold causing building to deteriorate. Definitely."
>
> (Architect Planner, July 20, 2021)

> "Especially for those abandoned building, you know. They(authority) have to look for the owner (to decide) how they have to maintain, or they have to have some kind of laws to enforce and maintain these old heritage houses. So that our (heritage) core will be sustainable, I would say. If there is no law mandating maintenance, I think if the owner can save (on maintenance) then (they will) save, you know. That kind of mentality."
>
> (Batik trader in GTWHS, August 6, 2021)

The survey also found that another key impact (53%) is that the investment/demand for heritage properties has also reduced. A key informant explained this situation:

> "So, investment and demand for heritage shop houses have reduced. Yes. It had reduced. Nobody wants to take the risk now. Actually, there are quite a lot of things on sale now. You know··· people just don't know how long it is going to be··· the uncertainty is not giving people a lot of confidence to move on. They just want to wait and see."
>
> (Architect Planner, July 20, 2021)

This is followed by the impact of Covid–19 causing funding and sponsorship for conservation to become low priority (52%). This finding correlates with the lack of intention to restore heritage building where both of these inactions will be detrimental to the "health" of the heritage property. Interestingly, despite the drop in property prices, 53% stated that investment/demand for heritage shophouses has reduced, while only 13% agreed that investment/demand has increased. A key informant explains it this way:

"On George Town, now a lot of shop when you pass by you see they close down or they will put up the 'for sale' or 'for rent' sign. Things like that, right. So now I think the market is the buyers' market. It's not the sellers' market··· So, for property, I think it is shrinking also. I think for property, it has shrunk like at least I think 50% and above. So, I think property (market) is hit very hard."

(Batik trader in GTWHS, August 6, 2021)

Table 5. Impact of Covid–19 on criterion (iv) of the OUV

Following the MCO, how have these restrictions impacted criterion (iv) (heritage shop houses)?	Frequency	Percentage
No impact.	19	9%
Periodic maintenance of heritage buildings takes a back seat causing buildings to deteriorate.	110	53%
The intention to restore heritage buildings is put on hold causing buildings to deteriorate.	118	57%
Funding/sponsorship for conservation is now on low priority.	108	52%
Investment/ demand for heritage shophouses has reduced.	109	53%
Investment/ demand for heritage shophouses has increased.	27	13%
Rent an old house and renovate it.	1	0.5%
Still have some renovations.	1	0.5%
The heritage store cannot be sold as there is a partnership.	1	0.5%
It takes time to recover.	1	0.5%
Best time for renovation.	1	0.5%
The state legislature does not need to be changed.	1	0.5%
No comment.	1	0.5%

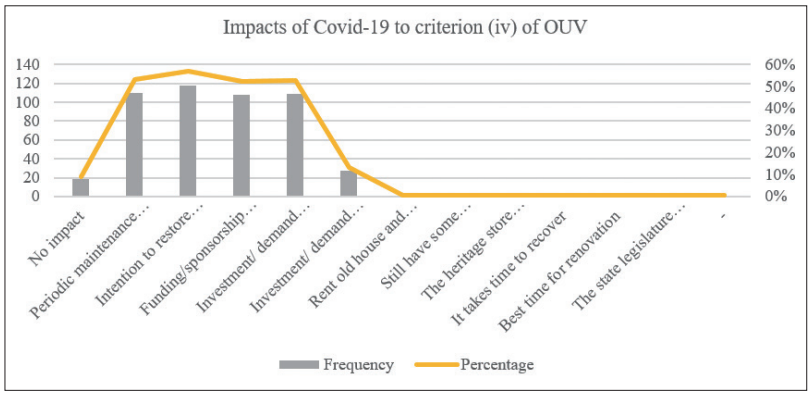

Figure 8. Impact of Covid–19 on criterion (iv) of the OUV

3–5 Magnitude of Covid–19's Impact on Criteria (ii), (iii) and (iv)

During the survey, a 5–point Likert scale was used to gauge the magnitude of Covid–19's impacts on criteria (ii), (iii), and (iv) of George Town's OUV. From Table 6, it is clear that the magnitude of impacts for the 3 criteria predominantly fall under the category of "big impact" with criterion (ii) being the highest at 52%, (iii) at 37% and (iv) at 32%.

Based on the findings, it is apparent that criteria (ii) and (iii) seem to be experiencing a bigger magnitude of Covid–19's impacts recording "big impact" and "enormous impact" when compared to criteria (iv). Figure 9 suggests that the strategies and interventions should be more targeted towards criteria (ii) and (iii).

Table 6. Magnitude of Covid–19 impact on criteria (ii), (iii), and (iv) of the OUV

MAGNITUDE (TOTAL)	CRITERION (ii)	CRITERION (iii)	CRITERION (iv)
No Impact (0%)	1%	12%	8%
Mild Impact (1 – 20%)	4%	9%	16%
Medium Impact (21 – 50%)	17%	22%	25%
Big Impact (51 – 80%)	52%	37%	32%
Enormous Impact (81 – 100%)	25%	20%	19%

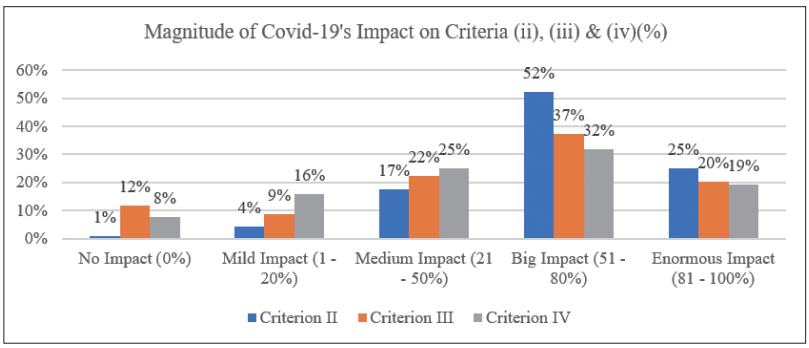

Figure 9. Percentage of the magnitude of Covid–19's impact on criteria (ii), (iii) and (iv)

One of the key informants provided insights into the reasons for the impact being big (51–80%) and not enormous (81–100%).

> "They may not be in the (81 to 100%) enormous impact category because there are still local people that want to go and 'bai–bai' [pray]. They want to worship. They still need to buy things from the shop. You know, at least they have some customer base to help them consume the products that they are selling. Last 4 months, I think the religious part is not so much impacted in the way because tourists even if they come, not necessary they will go to worship or they will just take pictures."
>
> (Batik trader in GTWHS, August 6, 2021)

3–6 Resilience and Sustainability Criteria for the GTWHS's OUV

At the end of the survey, respondents were asked to gauge how businesses, enterprises, or local communities could adapt to the Covid–19 pandemic and become resilient over time. The survey findings are illustrated in Table 7. The resilience and sustainability criteria were organized and grouped into 7 categories: a) new business model, b) new digital format, c) digital presence, d) government intervention, e) business orientation modification, f) cooperation with different parties, and g) others. The mean reading was tabulated for each of the 7 categories.

Table 7. Resilience and Sustainability Criteria

RESILIENCE AND SUSTAINABILITY CRITERIA		TOTAL	PERCENTAGE	MEAN
New Business Model	Design a new business model taking into consideration social distancing and health safety measures.	129	62.32%	129
New Digital Format	Design a new digital format and "go virtual" for businesses.	117	56.52%	105
	Design a new digital format and "go virtual" for cultural tourism.	93	44.93%	
Digital Presence	Enhance digital presence for traditional businesses.	118	57.00%	112
	Enhance digital presence for modern businesses.	106	51.21%	
Government Intervention	Need more government intervention(i.e., financial aid, training) for businesses.	129	62.32%	108
	Need more government intervention for communities.	125	60.39%	
	Adopt new criteria to allocate funds by the government/private sector.	70	33.82%	
Business Orientation Modification	Need to reskill and retool.	87	42.03%	70
	Diversify business into other areas.	82	39.61%	
	Downsize business.	41	19.81%	
Cooperation with Different Parties	Strengthen links with local communities to support small and local businesses.	109	52.66%	105
	Cooperate with other sectors to develop novel services to help each other.	102	49.28%	
	Private–Public–Civil Society Partnership to organize initiatives to support small businesses and local communities.	104	50.24%	
Others	Call it a day and close shop.	10	4.83%	3
	Forget about the OUV and lose the UNESCO WHS status	12	5.80%	
	Short video to spread the traditional arts and crafts.	1	0.48%	
	Need changes in the business	1	0.48%	
	Intervention according to the type of business, to help them get out from misery	1	0.48%	
	Need the assistance from the government very much, but don't know who to refer to	1	0.48%	
	Ever thought of quitting the business	1	0.48%	
	Teach the children to continue the business	1	0.48%	
	Skills Assistance from GTWHI	1	0.48%	

3–6–1 New Business Model

From the findings, the top 3 mean readings were for the new business model (mean=129), digital presence (mean=112), and government intervention (mean=108). When designing and implementing new business models, social distancing and health safety measures should be considered. As a majority of the respondents selected this criterion over the others, it indicates that standard operating procedures (SOPs) are now accepted as a part of daily activities and businesses are expected to follow the SOP laid out by the government. Anecdotal evidence shows that to adhere to the SOP of limiting customers in the shop, some businesses started accepting orders by telephone and through pickup apps by customers or organizing delivery for a fee. This reflects their ability to adapt and change according to the current environment.

3–6–2 Digital Presence

Within the category of "digital presence", enhancing it for traditional businesses recorded a frequency of 118, while doing so for modern businesses had a frequency of 106. While the migration of businesses to digital and online platforms/formats might be a viable immediate or long–term solution, the aspects of preparedness and efficiency in IT skills were highlighted, as illustrated by a local trader and the president of an ethnic group:

> "Yeah. I've actually tried a few online. But because I'm new into this, I just do live. Live on 'Facebook live' and all these because I'm new. For online business, you need to take time to build up your customer base. When you're online, nobody knows you and you depend on people to help you share. So actually, a bit tough. I have a few sessions··· I find it a bit hard because I don't have customer base. But I think it can be done, but it's just a bit tough."
>
> (Batik trader in GTWHS, August 6, 2021)

> "It is not about the money. Money is a necessity for development but counseling expertise from consultant··· For example, lets' take the 'songkok' (traditional Malay hat) shop, government/GTWHi can teach the shop owners how to do online business, prepare a platform for them to do business."
>
> (President, Indian Muslim Community Organization Malaysia, August 14, 2021)

An analyst from a local think tank also resonated with similar sentiments about traders' readiness and digital literacy in shifting and switching towards a digital format for their businesses:

> "So, this is the problem. It is very easy to say we want them to be rescued and retool and also move online. Some of the people cannot move online."
>
> (Analyst from think–tank, July 28, 2021)

Another key informant states that concerns about the stability of connectivity could deter people from using online transactions.

> "Online I think still not very popular. That's what I feel, I, myself also sometimes do not want to pay through online, worry that because of the internet services, the signal of the area and also the connectivity of the internet··· the services are actually very worrying. I, myself, also experience transaction (done online) but then it didn't catch by the system."
>
> (Property Surveyor, August 11, 2021)

Although the survey findings suggest the development of a digital presence, further findings from key informant interviews indicate that it will be challenging. This is because while it can be easily implemented by big businesses, it is difficult for small traditional businesses, especially if the owners are old and without young successors to take over. In summary, the factors mentioned by the key informants regarding digital presence are as follows:

a) Digital presence is difficult for small businesses to establish because they do not have an existing digital customer base to tap into. It is difficult to create a reasonable customer base within a short period, especially when they do not have the advantage of famous brand names or celebrities to promote their goods and services.
b) These businesses would need experts to help them migrate to and manage a digital platform.
c) The existence of these traditional businesses across generations without technology is one of the reasons for their OUV. Requiring businesses to suddenly pivot and embrace technology in their processes may not be possible.
d) The availability of good Internet infrastructure is important to ensure smooth online operations and instill confidence in people to make online transactions.

3–6–3 Government Intervention

Regarding the government intervention dimension, there are 3 resilience and sustainability criteria. The need for more government intervention (i.e., financial aid, training) for businesses scored the highest (129), followed by the need for more government intervention for communities (125), and the adoption of new criteria to allocate funds by the government/private sector (70).

While the government intervened to assist impacted businesses and traders in the GTWHS during the pandemic, many informants felt that the government could have done more. Some extracts from the transcriptions are as follows:

> "You can't say that the government didn't help. There is government support, but insufficient, but then again··· at least better than nothing. We need more government intervention for all, especially financial aid and training."
>
> (Money Changer in GTWHS, August 19, 2021)

> "Actually, I hope the government can do something or the authorities could do something to help these kinds of people or the local."
>
> (All Clans Executive Secretary, July 22, 2021)

An interviewee commented on the lackadaisical role of George Town World Heritage Incorporate, which is the de facto custodian of the heritage site parked under the purview of the Penang State Government:

> "The first thing that I want to emphasize here is that the body responsible to oversee the interest of George Town historic city is George Town World Heritage Incorporated (GTWHI). I feel that in this respect they (GTWHI) have lost their role in assisting local communities in this area. They could have generated many ideas, but they have failed in executing their role in ensuring the resilience of GTWHS. Here I would like to say that I feel GTWHI has failed in helping the community, especially heritage businesses or heritage communities."
>
> (President, Indian Muslim Community Organization Malaysia, August 14, 2021)

> "The confidence in the government I think is not enough. The government needs to do something to have their confidence back into the market then only people will start to go out. People will still worry about this. The government needs to be ready to come out with the plan for the whole year on what are the programs to promote and enliven the area, mainly tourism."
>
> (Property Surveyor, August 11, 2021)

Besides more government intervention, the interviews also highlighted the need for private sector involvement in assisting impacted local traders and communities. Given that many of the historic properties in the GTWHS are privately owned, an interviewee who is a tenant–cum–trader has called for the "big landlords" to cooperate and partner with the government to assist impacted traders who have difficulties paying their monthly rents. Another interviewee concurred:

> "I think Penang government can do more. If they cooperate with the landlord. The big landlords."
>
> (Batik trader in GTWHS, August 6, 2021)

> "Maybe like I say the rental whether the private owner willing to help the trader. So, they can, let's say let them have six months no rent period for them to catch up their cash flow then maybe it will help. Everybody helps to make the economy come back again. It's not only the government, the private, the landowner must help to get this going."
>
> (Property Surveyor, August 11,2021)

In summary, the factors mentioned by the key informants regarding government intervention were as follows:

a) The custodians feel that the government should provide more assistance in the form of financial aid and training to help their businesses and activities adapt to the new environment brought about by the Covid–19 pandemic.
b) Government interventions to help communities are considered insufficient and have failed communities that face hardships during the Covid–19 pandemic.
c) The government is considered to be incapable of rallying cooperation from the private sector, especially the big landlords in the GTWHS, to help the custodians sustain during the pandemic. These findings also relate to the criteria for cooperation with different parties (M=105) as a resilience strategy.

The dimension of business orientation modification recorded the lowest mean of 70 indicating that the custodians are not willing to downsize their businesses, diversify into other business areas, or reskill and retool.

3–7 Existing Strategies by the GTWHS's World Heritage Manager

As the site manager of the GTWHS, George Town World Heritage Incorporated (GTWHI) has implemented some strategies with a funding allocation of RM1,000,000.00 from the Penang State Government. The program, called "George Town in the New Normal", started on July 8, 2020, until April 15, 2021. Its objective is to regenerate and assist Penang's cultural heritage sector, which has been impacted by Covid–19 to continue to survive in the new constrained environment. This project comprised 3 components: a) supporting local business, b) heritage repair, and c) heritage video.

As of November 24, 2021, the GTWHI website mentioned that it has assisted local businesses in digital marketing promotions to capture new customers via digital platforms. This strategy supports the survey finding of enhancing the digital presence of both traditional and modern businesses to ensure the sustainability and resilience of the OUV. However, only 142 local businesses have participated thus far, which is only about 4.7% of the 3,000 local businesses in the GTWHS. While the program has strategized to promote resilience in local businesses within the GTWHS, the outreach is considered to be very low. Thus, more robust strategies and solutions are required to safeguard the OUV of the GTWHS.

The second component of the abovementioned program targets criterion (iv) of the OUV, which refers to heritage buildings. The same website stated that it will provide a one–off financial reimbursement to a maximum of RM1,500 to qualified owners or tenants of heritage premises (Categories I and II as gazetted in the George Town Special Area Plan) within the GTWHS for minor repair and maintenance works on their heritage premises. This component of the program aided the repair of 253 buildings—only 5.0% of the 5013 buildings in the GTWHS (Special Area Plan George Town, 2016). Minor repairs include upgrading the electrical wiring, repainting the interior and exterior walls, removing vegetation from the facade, and termite treatment. This strategy—to provide grants to fund initiatives and technical assistance to building owners for restoration and repair works—is listed in Special Area Plan George Town, 2016 under Strategy D2, Action D2.1. Although this assistance is in place, the survey findings indicate that the intention to restore and undertake periodic maintenance is still on hold. This may cause deterioration of many existing heritage buildings, as the outreach of this component is very low. Consequently, criterion (iv) of the OUV could still be under threat.

The third component of this program is to assist cultural heritage practitioners to expand their customer base via digital platforms. The program will help them produce videos and promote them on GTWHI's website and other social media channels. To date, 159 videos comprising 59.55% of the cultural heritage practitioners were produced. This strategy, which uses technology to help safeguard criterion (iii) of George Town's OUV, has good outreach as it managed to cover more than half of the cultural heritage practitioners.

The abovementioned strategies have been quickly implemented by GTHWI to foster sustainability and resilience in safeguarding the OUV of the GTWHS during Covid–19. Although the outreach for component 3 is encouraging, the same cannot be said for components 1 and 2, where the outreach is still very low. This study suggests further strategies and solutions to complement the existing ones to reinforce the resilience of the cultural heritage of the GTWHS.

4. Strategies and Solutions

Based on the abovementioned analysis, 4 viable strategies and solutions were identified and proposed. These strategies and solutions are suggested to protect and safeguard the attributes of George Town's OUV.

First, the Covid–19 pandemic has accelerated the need for both consumers and producers to shift to digital business platforms. In the existing GTWHS strategies, the site manager (GTWHI) provides a digital platform to promote local businesses. Taking it further, the assistance should not stop at providing digital advertising but also ensure proper management of their digital businesses after launching the platform. The interview findings from this study indicated that most of the key informants agreed that the government has provided some help, but many also highlighted that the assistance is insufficient given that most traditional businesses lack the technological know–how to migrate to online business platforms and subsequently manage these platforms. In this sense, the government does not need to be the service provider but should be the facilitator in setting up "a common digital platform" for all heritage businesses. There should be a common platform that caters to businesses and cultural heritage practitioners' needs in the GTWHS.

Second, training is essential to help these businesses/custodians to manage and ensure the smooth running of the online aspects of the business. This will help alleviate the current issues and become a part of capacity building in sustaining the OUV of the GTWHS in the long term.

Third, for businesses that are very difficult to reskill and retool, the government could promote a "renaissance of heritage goods" to the local population. This is common in many parts of the world where the sustainability of the heritage economy is not solely dependent on foreign/outstation tourists but also on the domestic market and local population. It is even more critical now to devise a campaign to attract the younger generation to appreciate and consume heritage goods. To this end, marketing and branding consultants are required to advise and help with repackaging, promoting, and marketing heritage goods and services locally and internationally. For example, curating a hamper of heritage goods for festive seasons, gifts, and heritage discount vouchers to encourage sales are viable strategies to boost market demand for heritage goods and services.

Finally, the use of tax rebates incentivizes short–term solutions; the government could allow tax rebates on heritage goods to encourage more locals to purchase them. Special tax rebates may also be given to owners to restore and maintain their heritage properties to safeguard criterion (iv) of the GTWHS's OUV.

5. Conclusion

The effect of the Covid–19 pandemic is unprecedented, and no communities have been spared from its devastating effects. The government of Malaysia has imposed intermittent MCO's effectively from March 2020 to October 2021 depending on the severity of the Covid–19 cases reported across Malaysian states and cities. The economy of cities as well as the country in general are severely affected by the restrictions on economic activities imposed to curb the spread of Covid–19. However, a heritage site like George Town has an additional sphere to consider, which is the protection of its OUV. The privilege of being inscribed as a WHS is entirely due to the city's OUV, without which George Town would be like any other modern city. Protection of the GTWHS's OUV is particularly challenging due to the main attributes of its OUV are living heritage. Traditional businesses, heritage practitioners, daily cultural activities, religious events, and related downstream activities are all curtailed by the MCO. Over the last 2 years where there has been no demand for "heritage services and goods" of the GTWHS, what is the impact of Covid–19 on the GTWHS and its OUV? If living heritage activities are curtailed, will they survive or fade into non–existence? If heritage buildings are not maintained, will they fall into disrepair? Against this background, this research is conducted to ascertain

the impact of the Covid–19 pandemic on the OUV of the GTWHS. Additionally, the attributes that managed to thrive in this challenging climate will provide an insight into its resilience strategies. This learning of resilience strategies used by the custodians of OUV in the face of adversity will be synthesized to propose sustainable and resilient heritage policies to better manage the heritage site of the GTWHS.

The survey conducted in this research found that all 3 criteria ((ii), (iii), and (iv)) of the GTWHS's OUV have been significantly impacted by the Covid–19 pandemic. These findings indicate that the survival of traditional businesses is threatened by the severe reduction in customers/sales. The reduction in certain activities, such as cruise tourism, may also cause the demise of related businesses, such as the traditional trishaws or cruise tour agencies. The loss of cultural and heritage tourism is naturally very severe during the pandemic period. The curtailing of activities during the MCO not only causes empty streets and shuttered shops in the GTWHS, but more critically, threatens the lively existence of its living heritage. The key informants voiced concerns about the disappearance of traditional practices and the closing of related businesses. This also impacts tangible heritage, such as the heritage shophouses. Shuttering of shops means that there is no incentive to maintain these heritage properties. Thus, heritage properties may fall into disrepair due to postponed maintenance and repair.

Nevertheless, amidst the challenges of this pandemic, there are pockets of thriving traditional businesses. Some traditional businesses have managed to adopt technology to create an online presence to generate businesses. Support from local populations in utilizing heritage services and goods enables businesses, especially traditional food and sundry shops, to survive without tourist income. In terms of government help or intervention, the Penang State Government (through GTWHI) has implemented measures to safeguard criteria (ii), (iii), and (iv) in the program called "George Town in the New Normal." However, the custodians of the GTWHS's OUV found that assistance from the government was insufficient to build sustainability and resilience.

Learning from the Covid–19 pandemic, the survey indicated 3 key criteria to build resilience and sustainability: a) creating a new business model, b) enhancing the digital presence of businesses, and (c) increasing government intervention. The new business model now entails incorporating standard operating procedures (SOP) for walk–in customers to prevent the spread of diseases such as Covid–19 or other unknown viruses in the future. When

such SOPs are in place, activities can proceed as usual, which is important in safeguarding the GTWHS's OUV, especially criteria (ii) and (iii), which are its living heritage. The enhancement of digital presence works well for bigger and well–established traditional businesses where people trust their quality and are willing to buy from the online shop. However, for traditional smaller businesses, especially roadside stalls, which have been in existence for many years and some even generations, migration to online platforms is difficult for them to implement, and some will just give up and close down the business. Therefore, the research found that to build resilience for the custodians of GTWHS's OUV, the intervention from the government should not only entail financial or digital marketing assistance but also training in creating and managing digital business and presence. This need has been reiterated throughout the interviews by the key informants: training is needed by the custodians of OUV, and the government should investigate how such specialized training can be mobilized. Thus, resilient strategies and solutions that are fundamental to building resilience must not be superficial and only aim at short–term respite. Strategies must have follow–up intervention in terms of capacity building of custodians to build sustainability and resilience in the long run.

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Appendix A

Snapshot of the Google Form used in the survey

Survey on Outstanding Universal Value of George Town, Penang: Surviving Covid-19 在受新冠疫情影响下: 槟城乔治市的普世价值

The unprecedented and unpredicted Covid-19 pandemic has exposed and put to risk the resilience, survival, and sustainability of George Town's Outstanding Universal Value (OUV). This would necessitate a need to examine and comprehend the extent upon which the three (3) criteria of George Town's OUV are at risk or resilient enough to withstand the Covid-19 shock which is still unfolding. This study aims to examine what are the economic, socio-cultural and built-environment impacts that have manifested during Covid-19 pandemic on the three selection criteria (II, III, IV) of George Town's OUV.

[illegible]

This survey is part of a research project selected by the Korean National University of Cultural Heritage under the UNESCO Chair Research Grant. All information collected from this survey will be strictly used for academic purposes only and be kept confidential. All enquiries can be directed to Assoc. Prof. Sr Dr. Lim Yoke Mui (School of HBP, Universiti Sains Malaysia) and/or Assoc. Prof. TPr Dr. Khoo Suet Leng (School of Social Sciences, Universiti Sains Malaysia) at heritagespeak@gmail.com

[illegible]

We appreciate your time in answering this survey and be a part of the effort to help George Town World Heritage Site safeguard its OUV

[illegible]

*Required

PART A: BACKGROUND INFORMATION

1. 1) Are you a resident of George Town World Heritage Site? [illegible] *

Mark only one oval.

- Yes 是
- No 否

2. 2) Gender 性别 *

Mark only one oval.

- Female 女
- Male 男

3. 3) Age 年龄层 *

Mark only one oval.

- Below 18 yrs 18岁以下
- 19 - 30 yrs 19-30岁
- 31 - 40 yrs 31-40岁
- 41 - 50 yrs 41-50岁
- 51 - 60 yrs 51-60岁
- Above 60 yrs 超过60岁

4. 4) Ethnicity 种族 *

Mark only one oval.

- Malay 巫裔
- Chinese 华裔
- Indian 印裔
- Other:

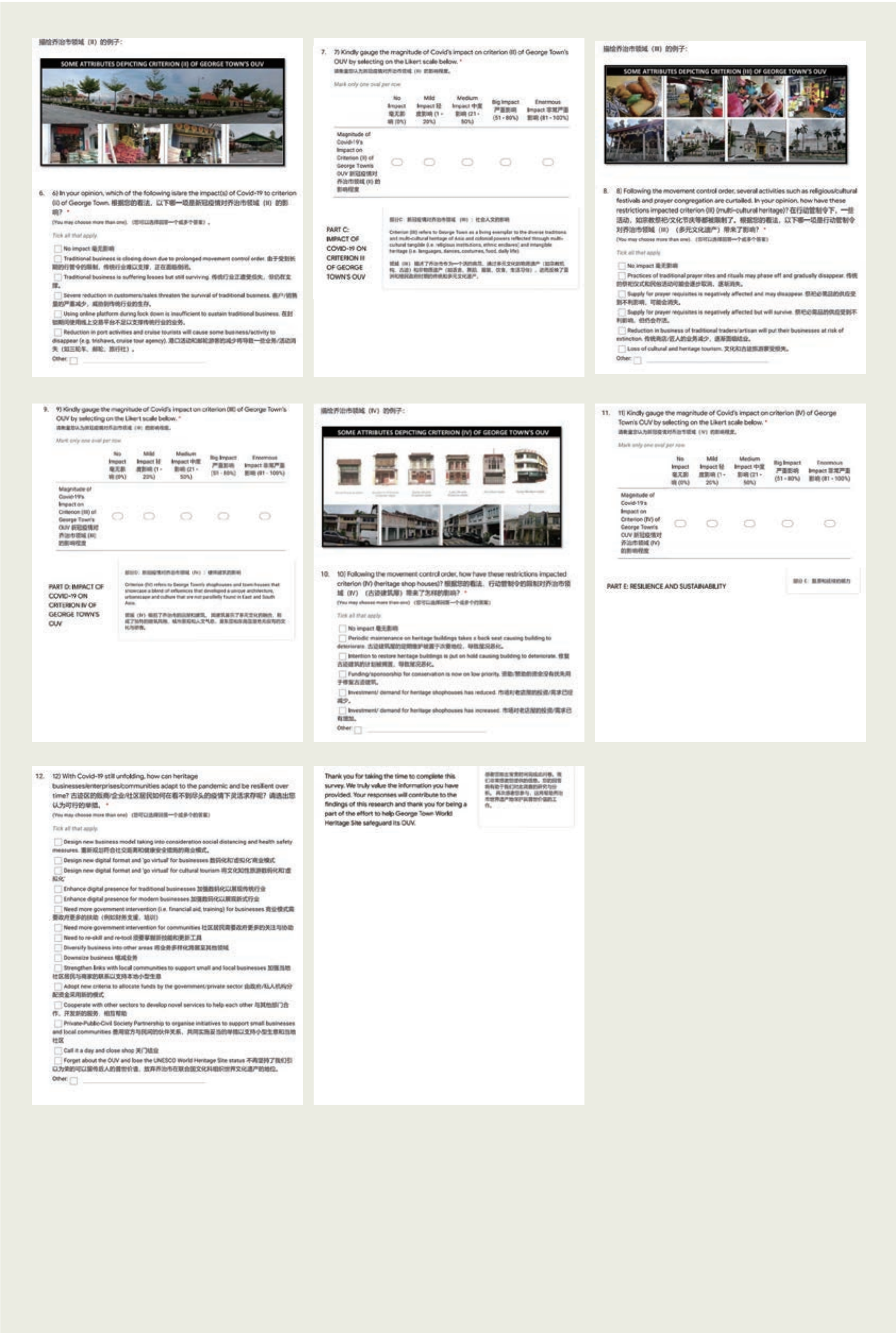
5. 5) Please choose the type of work you are attached to: [illegible] *

Mark only one oval.

- New Cafe and Restaurant [illegible]
- Kopitiam/Traditional Cuisine Restaurant [illegible]
- Hawker Business [illegible]
- Prayer Paraphernalia Shop [illegible]
- Traditional Prayer Food Shop [illegible]
- Flower Seller [illegible]
- Money Changer [illegible]
- Jewellery/Gold Shop [illegible]
- Wholesaler [illegible]
- Repair Shop [illegible]
- Hairdressing/Barber [illegible]
- Souvenir Shop [illegible]
- Theme Museum [illegible]
- Government Agency [illegible]
- Academic Institution [illegible]
- Professional Services [illegible]
- Other:

PART B: IMPACT OF COVID-19 ON CRITERION II OF GEORGE TOWN'S OUV

[illegible]


SOME ATTRIBUTES DEPICTING CRITERION (II) OF GEORGE TOWN'S OUV

6. 6) In your opinion, which of the following is/are the impact(s) of Covid-19 to criterion (II) of George Town. *

(You may choose more than one).

Tick all that apply

- [ ] No impact 毫无影响
- [ ] Traditional business is closing down due to prolonged movement control order.
- [ ] Traditional business is suffering losses but still surviving.
- [ ] Severe reduction in customers/sales threaten the survival of traditional business.
- [ ] Using online platform during lock down is insufficient to sustain traditional business.
- [ ] Reduction in port activities and cruise tourists will cause some business/activity to disappear (e.g. trishaws, cruise tour agency).

Other: [ ]

7. 7) Kindly gauge the magnitude of Covid's impact on criterion (II) of George Town's OUV by selecting on the Likert scale below. *

	No Impact (0%)	Mild Impact (1 - 20%)	Medium Impact (21 - 50%)	Big Impact (51 - 80%)	Enormous Impact (81 - 100%)
Magnitude of Covid-19's Impact on Criterion (II) of George Town's OUV	◯	◯	◯	◯	◯

PART C: IMPACT OF COVID-19 ON CRITERION III OF GEORGE TOWN'S OUV

Criterion (III) refers to George Town as a living exemplar to the diverse traditions and multi-cultural heritage of Asia and colonial powers reflected through multi-cultural tangible (i.e. religious institutions, ethnic enclaves) and intangible heritage (i.e. languages, dances, costumes, food, daily life).

SOME ATTRIBUTES DEPICTING CRITERION (III) OF GEORGE TOWN'S OUV

8. 8) Following the movement control order, several activities such as religious/cultural festivals and prayer congregation are curtailed. In your opinion, how have these restrictions impacted criterion (III) (multi-cultural heritage)? *

(You may choose more than one).

Tick all that apply

- [ ] No impact 毫无影响
- [ ] Practices of traditional prayer rites and rituals may phase off and gradually disappear.
- [ ] Supply for prayer requisites is negatively affected and may disappear.
- [ ] Supply for prayer requisites is negatively affected but will survive.
- [ ] Reduction in business of traditional traders/artisan will put their businesses at risk of extinction.
- [ ] Loss of cultural and heritage tourism.

Other: [ ]

9. 9) Kindly gauge the magnitude of Covid's impact on criterion (III) of George Town's OUV by selecting on the Likert scale below. *

	No Impact (0%)	Mild Impact (1 - 20%)	Medium Impact (21 - 50%)	Big Impact (51 - 80%)	Enormous Impact (81 - 100%)
Magnitude of Covid-19's Impact on Criterion (III) of George Town's OUV	◯	◯	◯	◯	◯

PART D: IMPACT OF COVID-19 ON CRITERION IV OF GEORGE TOWN'S OUV

Criterion (IV) refers to George Town's shophouses and town houses that showcase a blend of influences that developed a unique architecture, urbanscape and culture that are not parallelly found in East and South Asia.

SOME ATTRIBUTES DEPICTING CRITERION (IV) OF GEORGE TOWN'S OUV

10. 10) Following the movement control order, how have these restrictions impacted criterion (IV) (heritage shop houses)? *

(You may choose more than one)

Tick all that apply

- [ ] No impact 毫无影响
- [ ] Periodic maintenance on heritage buildings takes a back seat causing building to deteriorate.
- [ ] Intention to restore heritage buildings is put on hold causing building to deteriorate.
- [ ] Funding/sponsorship for conservation is now on low priority.
- [ ] Investment/ demand for heritage shophouses has reduced.
- [ ] Investment/ demand for heritage shophouses has increased.

Other: [ ]

11. 11) Kindly gauge the magnitude of Covid's impact on criterion (IV) of George Town's OUV by selecting on the Likert scale below. *

	No Impact (0%)	Mild Impact (1 - 20%)	Medium Impact (21 - 50%)	Big Impact (51 - 80%)	Enormous Impact (81 - 100%)
Magnitude of Covid-19's Impact on Criterion (IV) of George Town's OUV	◯	◯	◯	◯	◯

PART E: RESILIENCE AND SUSTAINABILITY

12. 12) With Covid-19 still unfolding, how can heritage businesses/enterprises/communities adapt to the pandemic and be resilient over time? *

(You may choose more than one)

Tick all that apply

- [ ] Design new business model taking into consideration social distancing and health safety measures.
- [ ] Design new digital format and 'go virtual' for businesses
- [ ] Design new digital format and 'go virtual' for cultural tourism
- [ ] Enhance digital presence for traditional businesses
- [ ] Enhance digital presence for modern businesses
- [ ] Need more government intervention (i.e. financial aid, training) for businesses
- [ ] Need more government intervention for communities
- [ ] Need to re-skill and re-tool
- [ ] Diversify business into other areas
- [ ] Downsize business
- [ ] Strengthen links with local communities to support small and local businesses
- [ ] Adopt new criteria to allocate funds by the government/private sector
- [ ] Cooperate with other sectors to develop novel services to help each other
- [ ] Private-Public-Civil Society Partnership to organise initiatives to support small businesses and local communities
- [ ] Call it a day and close shop
- [ ] Forget about the OUV and lose the UNESCO World Heritage Site status

Other: [ ]

Thank you for taking the time to complete this survey. We truly value the information you have provided. Your responses will contribute to the findings of this research and thank you for being a part of the effort to help George Town World Heritage Site safeguard its OUV.

Trace Relationship between Revered River and Sacred Settlements Morphology in South India: Case of Kaveri River in Context of South Karnataka

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Abstract

The Kaveri river is recognized as one of the seven holy rivers in India. The Kaveri river basin is dotted with numerous sacred settlements that have a distinctive urban morphology. These settlements gave rise to historic towns because of their geographically strategic locations along the river. This study explores the unique relationship between the sacred river of Kaveri and its sacred settlements from a cause–and–effect perspective. This study examines the following settlements: Srirangapatnam, renowned for Ranganathaswamy temple, Tipu Sultan's Summer Palace, the Srirangapatnam Fort area, Lal Mahal palace; Somnathpura, renowned for Somnathpura Temple and Hole Narasimha Temple; Talakadu, renowned for Maraleshwara, Keertinaryaneshwara, and Vaidhyanatheswara temples; and Sivansamudra, known for the Barchukki waterfalls. These settlements have distinctive characteristics in the geographic and cultural contexts of South Karnataka. The study compares and contrasts the settlements' urban morphologies, identifies significant commonalities among them, and determines if they can be attributed to the river. This study, which is among the very few on this topic, is expected to help trace the causal relationships between rivers and settlements in southern India. The study also highlights the need to protect these sites under a regional policy that combines their identities into a single cohesive cultural landscape. The study's findings are expected to contribute to the development of policies designed to protect these settlements holistically, within a broader cultural and geographical context.

1. Introduction

India's geospatial history and civilizations have been inseparable from its river systems. The older cultures in the country have regarded rivers as sacred and built numerous traditions spanning from birth to death that conclude at the banks of rivers. Among the seven holy rivers of India, the Kaveri river is the southernmost. It originates on Brahmagiri Hill of the Western Ghats in Karnataka, a southwestern state, and flows in a southeasterly direction for 765 km through the states of Karnataka and Tamil Nadu, and then descends the Eastern Ghats in a series of great falls. The river divides into numerous distributaries before falling into the Bay of Bengal. The resulting delta is known as the "garden of southern India." (Vetrimurugan et al., 2014).

The Kaveri river basin is dotted with numerous sacred settlements, each with a distinctive plan morphology. There is a need to vitalize the cultural context within the historic settlements of Kaveri river, for holistic and sustainable protection of historic sites in these settlements. These historic towns emerged because of their geographically strategic locations along the river. This study examines the relationship between the revered river Kaveri and its prominent settlements in order to investigate the causal relationships between river course, geography, and settlement morphology.

Examining this relationship can help us understand how strategic settlements and their pilgrim festivals have aided in culture reinforcement. The grandeur of temples was a means of expressing the supremacy of dynasties and binding their histories with mythologies. Rituals and festivals were a means of mobilizing people around certain lunar dates in specific seasons and building routes around the river to foster trade and material exchange. The traditional approach to conserving the built heritage of sacred places usually focuses on rebuilding and protecting their monuments and sites.

1–1 Aim

This study investigates the unique relationships between river course, geography, and settlement morphology along the Kaveri river at the regional level in order to help revitalize the cultural context of the area's sacred settlements which foster investments in the protection of its historic monuments. This study examines the following settlements: Srirangapatnam, renowned for the Ranganathaswamy temple, Tipu Sultan's Summer Palace, the Srirangapatnam light and sound show, and Lal Mahal palace; Somnathpura, renowned for Somnathpura Temple and Hole Narasimha Temple; Talakadu renowned for Maraleshwara, Keertinaryaneshwara, and Vaidhyanatheswara temples; and Sivansamudra, known for the Barchukki waterfalls.

1–2 Objectives

This study has the following objectives:

- To study the distinctive character of the settlements listed above in the geographical and cultural contexts of south Karnataka.
- To compare between the settlements' morphologies.
- To contrast between the settlements' morphologies.
- To identify significant commonalities among the settlements and determine if they can be attributed to the river.
- To determine if the commonalities have a causal relationship with the geo–spatial features of the Kaveri river.
- To recommend strategies for reinforcing the identified cultural commonalities to protect the historic monuments and sites along the Kaveri as part of a broader cultural whole.

2. Geology and Geographical Characteristics of Region around River Kaveri

The Kaveri basin extends over an area of approximately 81,155 square km at an inclination from northwest to southeast. The basin is located between 1007N and 13°0'28"N and 75°0'28"E and 79°0'52"E (Clare and Oriole, 2009). The catchment of the river watershed lies in the states of Karnataka, Tamil Nadu, Kerala, and Union Territory of Pondicherry. The Kaveri Basin forms a part of the South Indian Shield, which preserves an early formed crust (〉 2500 Ma). Metamorphic and igneous rocks predominate throughout the basin, which mark major events of volcanism, plutonism, metamorphism, and sedimentation (Clare and Oriole, 2009)

The principal soil types are red soil in the Karnataka region and black soil in Tamil Nadu. Several rivers and streams originate in the Sahyadri Hills and confluence with Kaveri–Bhavani, Kapila, Lakshmana Tirtha, Hemavati, Ekadi, Harringi, and Kabini. Traditionally, the sites of the confluence and divergence of holy rivers are regarded as sacred in India, particularly among Hindus (Ivermee, 2021)

2–1 Climate of Kaveri River Basin

The climate of the Kaveri River Basin is dry except for the monsoon months. The mean daily maximum and minimum temperatures vary widely across the region. The mean daily maximum temperature ranges from 19.5° to 33.7° C, whereas the mean daily minimum varies from 9.1° to 25.2°C. Temperatures in the western areas, which are at high elevations, are warmest in March (28.5° C). Wind in the area is linked with the monsoons and thus mainly blows from the southwest and northwest during the southwest monsoons. Clouds are also

Figure 1. Geographic location of river Kaveri in South Indian Peninsula (source: author)

Figure 2. 2 Image of Kaveri in South Indian Peninsula (source: author)

associated with monsoon activity, with the skies being generally overcast during monsoons (Clare and Oriole, 2009).

2–2 Precipitation and Humidity

The western side of the catchment experiences the southwest monsoon from June to September, and the northeast monsoon from October to December falls on the eastern side. Rainfall during the rest of the period is insignificant. About 50% falls during the southwest monsoon, about 33 % falls in the northeast monsoon, roughly 10% falls in the pre–monsoon periods, and the rest falls in the winter months. There are more than 100 rainy days per year in the western part of the basin and 40 to 50 elsewhere in the region (Clare and Oriole, 2009).

3. Cultural Significance of River Kaveri

This river Kaveri is regarded by many as the *Dakshin Ganga*, the "Ganges of the South," and is revered in ancient Tamil literature. At the place of its origin, Talakaveri in Kodagu district, the river Kaveri is celebrated in the Kaveri Sankarmana festival because it is said to have sprung from the fountainhead in Talakaveri Temple. The Brahma Kundike (pot), the fountainhead of a pond located at the springing point of the river, is also celebrated as Theerthodbhava (the divinity of the appearance of this river) through ambulations, holy dips, and prayers.

At the first drop of the river is Bhagamandala, the site of the First Sangam, near the Kanaka River and the mythical river Sujyothi. Bhagandeshwara, a Karavali–style Shiva temple, is considered sacred. There are shrines dedicated to Ishvara, Subramany, and Ganapati. Pilgrims travel long distances, a cultural practice since ancient times, to take a holy dip in the *triveni sangama* and offer

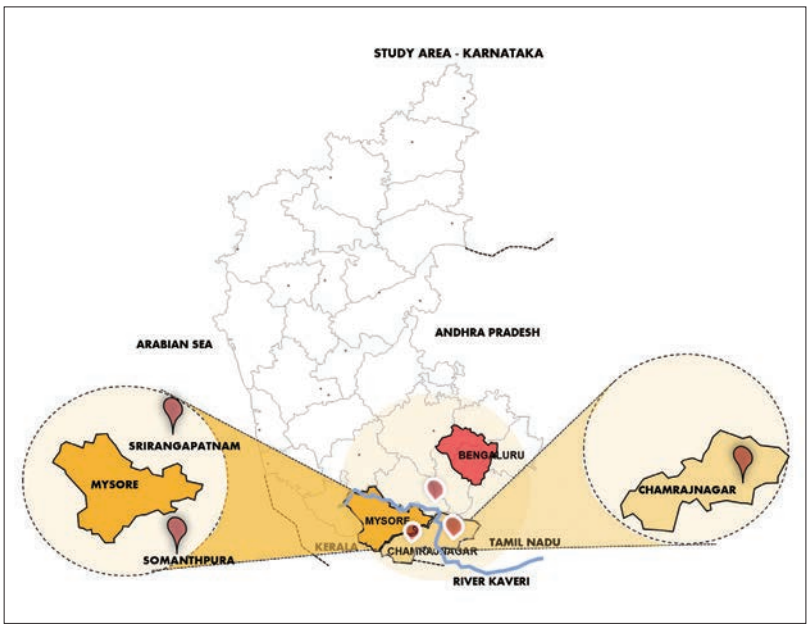


Figure 3. Geographical location of sacred settlements along river Kaveri

ambulations to their ancestors according to prescribed rituals. It has been a pilgrimage site since ancient times.

Somnathpur is a small and secluded Brahmin settlement on the banks of the Kaveri. This settlement has many pilgrim sites, including the Chennakeshava Temple, Talakad Panchalinga Temple, and Mudukuthore Mallikarjuna Temple. The Archaeological Survey of India declared it a heritage site.

The river, which diverges in south Karnataka, forms two distinctive sacred islands: Srirangapatnam and Sivasamudram. Srirangapattana has always been an important religious site; it is the place where it is believed the goddess Kaveri asked Ranganatha to come and stay. There are many ghats leading down to Kaveri (Clare and Oriole 2009).

At the sharp bend in the river lies Talakad, a settlement known for its sand dunes. These unique geographical features have mythological significance. The area is home to two pilgrimage sites, Vaidyeshvara Temple, where the Panchalinga festival is celebrated, and the mystical Kirtinarayana Temple, which is buried in sand.

The Kaveri river is revered as a gift from the gods. The river is believed to have a divine origin. Numerous oral folk traditions tell of how the cultures along the Kaveri have believed that the river has bestowed prosperity and salvation to countless people over the ages (Seshadri and Sundararaghavan, 2012, pp. 15). It is

believed that, as mentioned in Agni Puran, written between 300 and 1000 CE, Lord Vishnu blessed Kaveri, the daughter of King Kavera of Vidharbha, with the power to destroy the sins of men, after which the river flowed southward from the Sahyadri Hills.

The Puranas, the classical texts of Hinduism, have myriad narratives that complement each other in portraying the genesis of cultural landscapes. The significance of India's holy places (e.g., tirthas, holy rivers, and other sacred sites) is based on the sanctity of the cyclical pattern of death and rebirth as the ultimate truth of human life, the existence of divinity, and the possibility of breaking the chakra of the cycles of death and rebirth (moksha). The settlements and cultures along the Kaveri have long been sites of great sacred and temporal significance.

4. Methodology

Cultural landscapes are historically significant places that show evidence of human interaction with the physical environment. Their authenticity is measured in terms of historical integrity, defined as the presence and condition of physical characteristics remaining from the historical period (Birnbaum, 1994). The Kaveri river is central to the cultural landscape of south Karnataka due to its continuing cultural legacy.

The river course has given rise to settlements through divine attributions given to distinctive food cultures, festivals, garment styles, music, dance forms, and literature. This study seeks to develop an understanding of the historical context before undertaking the site study and analysis of selected historic towns. The site study is a ground–truth project aimed at developing satellite image–based spatial plans for the study areas. These spatial plans are then used to develop urban morphology drawings. The drawings are then analyzed to understand, compare, and contrast the features of the settlements that have a common cultural past.

5. An Approach to Understanding the Cultural Landscape of River Kaveri

5–1 Historical Context

The archeological site of Payampalli contains evidence of Stone Age habitations dating between 1500 and 300 BC (Seshadri and Sundararaghavan, 2012, p. 4). This region was inhabited by Neolithic cultures who practiced some type of agriculture. Evidence dating from between 1000 and 300 BC has also been discovered (Seshadri and Sundararaghavan, 2012, p. 5). Vedic and Brahmanic culture and beliefs are believed to have arrived in South India before Buddhism and Jainism, based on knowledge of Itihaas–puran, a tradition related to Rishi Agastya—who is, incidentally, central to the origin of the Kaveri River (Karashima 2014, p. 67). Kaveri Ashtakam is a stotram, recited in prayer for the Kaveri river, which is regarded as a divine blessing, personified as the beautiful young daughter of King Kavera. The verses of this hymn worship the auspicious, pure, benevolent Kaveri who is worshipped by gods and men alike. A verse from the hymn, as below, highlights how the river Kaveri was central to the belief system of south Indian cultures– across the section of hindu society:

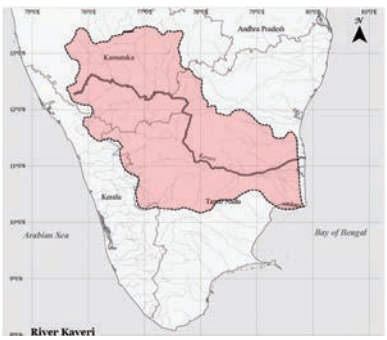


Figure 4. Kaveri River Basin area in southern India (source: author)

Devaalaya pooritha divyatriire
Samasta lokottama tiirtha muurdhe
Kashmiirabhooh kalpita choladeshe
Kaaveri mama prasiida

(from "Kaaveri Ashtakam"; the verses translate as "Your auspicious banks are crowded with the abodes of gods. Throughout the world, your holy places are the best. The beauty of Kashmir seems to pervade Chola because of you. O Kaveri! Shower your blessings on me" [Seshadri and Sundararaghavan, 2012. p. 184])

5–2 Study Area: Evaluating Integrity and Significance

An inscription in the cave dug by the Pallava king Mahendravarman 13 centuries ago reads as follows:

> Kaveri captivates the eye. She bears cool waters, and the meadows on her banks are like garlands on her neck. The great Lord Shiva himself has come down here to look at the beautiful Kaveri. Although he bears the Ganga on his head, Goddess Parvati (his wife) fears he might now want the Kaveri too! To avoid such entanglement, it is as if Parvati is sitting here beside Shiva and reminding him that Kaveri rightfully belongs to the Pallava Kings. (Seshadri and Sundararaghavan, 2012, p. 168)

The significance of Kaveri is deeply entwined with the mythology and historical accounts in which gods, kings, and people all revere the sacred river Kaveri. This belief system is common within the cultural boundary of the southern Karnataka and Kaveri Delta in Tamil Nadu.

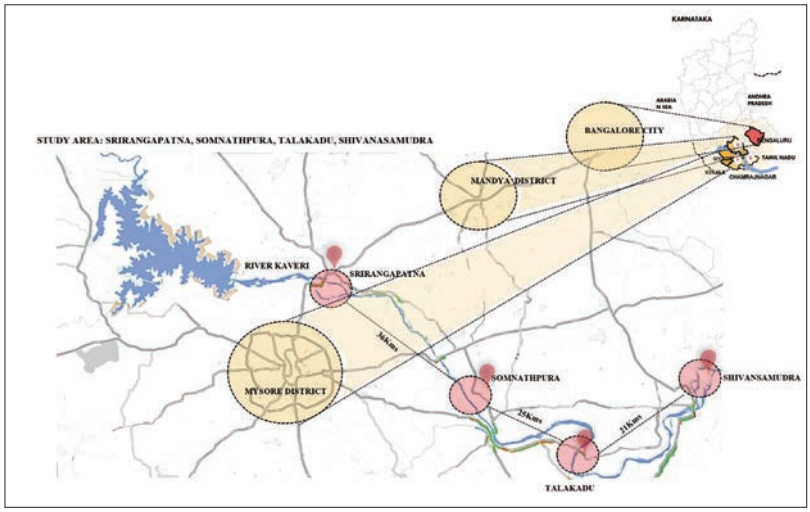


Figure 5. Spatial setting of identified settlements (Srirangapatna, Somnathpur, Talakadu, Shivanasamudra), with reference to river (source: author)

The selected study areas showcase this homogeneity in religion, practices, and physical manifestation in their temple complexes of historic significance. Demographic and religious data for the selected region reveal that most area residents practice the Hindu religion rooted in the Vedic–Brahminical system. This is a major factor in the cultural integrity of the study areas.

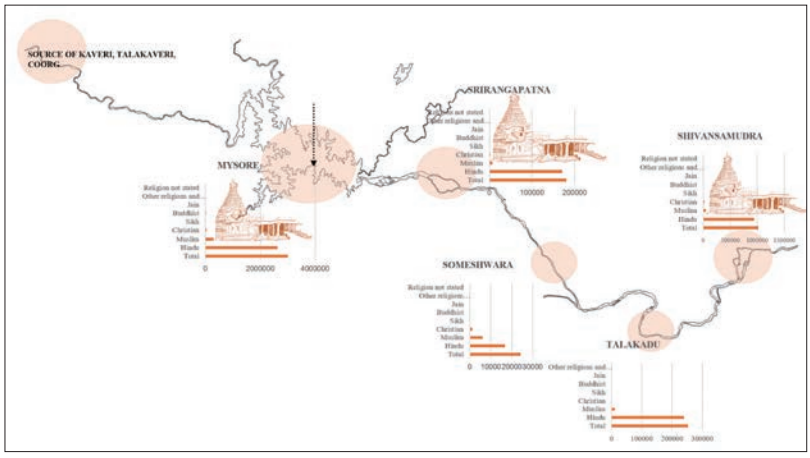


Figure 6. Demographic and religious profiles of identified settlements, showing that most residents follow the Vedic–Brahminical religion

The Kannada, Tamil, and Telugu languages are commonly spoken and understood in the study areas. These are pivotal in preserving the oral histories and belief systems that date back to the 4th century CE. Following the lunar calendar used in Hindu astrology, the various cultures have been integrated through festivals, harvest rituals, and pilgrimage seasons. The Srimad Bhagwat Gita says that those who drink the holy water of River Kaveri will become followers of Lord Krishna (Kannan, 2019, p. 4). The Kaveri river is integral to the 2,000–year–old tradition of Tamil literature, such as in Vuruthinkannanar, Seethalai Sathanar, Porunaratuppadai, Silappathikaram, Seethalaichathanar, Kamban, Sekkizhar, Thirungnana Sambandar, and Sree Villiputheurar, among many others.

5–3 Landscape Interpretation at the Regional and Settlement Scale

5–3–1 Temple complexes along River Kaveri as historic designed landscapes

Kannan claims that "It is believed that during the month of Thula (Ippasi) everyday one–half hours before sunrise the mighty three Shiva, Vishnu, & Brahma, nine hundred million gods and sixty eight thousand sages bathe in Kaveri" (2019, p. 3). This mythological relationship between river sacredness, Hindu gods, and sacred lunar months dates back about 2000 years. The numerous temples that were built along the Kaveri river manifest this cultural belief system and constitute the common origin of numerous historic sacred settlements that serve as famous pilgrimage sites. Important temples and pilgrimage sites along Kaveri include the following:

In Karnataka:

Thalai Kaveri, the origin of the river in Kodagu.

Athiarangam, an island (Srirangapattnam) encircled by the Bassima river and Poorra river; a holy site, Basmirangam, is at their confluence.

Anantha sayan, near waterfalls on the island of Shivasamudram; also the site of a statue of mother Kaveri.

Chamundeshwari Temple in Mysore.

Nanjankodu Srikandeshwaarer Temple south of Mysore.

Somanathpuram Kesava Temple, a temple so beautiful that the devas/gods wanted to take it to the heavens.

Panchalinga at Talakadu–Arkeshwara, Vaidyeswara Temple (a temple renowned for its healing powers), Pathaleshwara, Murudeswara, and Mudukuthore.

In Tamil Nadu

Thirunana (Barani) at the confluence of the Barani and Kaveri rivers.

Kodimada Sengunthur, a temple of Arthanareshwar.

Venjamkoodal, at the confluence of the Amravathi and Chitraru rivers.

Pashupathinathan Temple in Karuvur

Karumbarkuzhali and Rathinagiriswar temples in Kadambanthurai.

Tharungaraneshwar Temple, Thirupparayathurai, at the divergence of Vada Kaveri and Kaveri.

Anjalakshi Temple at Karkudi.

Panjavarneswarer Temple at Mukthiswaram.

Bhoologa Vaikundam, situated on an island.

Mudhuvaneshwari Temple, situated on hilly terrain.

Thirupoonthuruthi Temple complex, situated between Kaveri and Kudamurutti.

Thirukandiyur, a mythologically significant place where Shiva beheaded Brahma.

Tanjore, a temple built by the Chola kings; it is an Archeological Survey of India [ASI] monument.

Thenkudi, an island formed between Vennaru and Vettaru, both sub rivers of Kaveri.

The temples listed above were all patronized by kings and were hotspots of cultural development. Forms of dance, literature, and music such as Carnatic music were developed in these institutions. The settlements that developed around these temples and temple complexes still exist today, and many—such as Srirangapattnam, Shivasamudran, Talakadu, and Tanjore—are recognized for their historic significance.

5–3–2 Talakadu as Historic Site

Talakadu is a historic site recognized and protected by the Archeological Survey of India. It is unique and is known for its sand dunes, which have gradually been deposited on the inner bend of River Kaveri. This geographical event forced migration outwards. The site is regarded as cursed based on oral history. In the 7th century, queen Rangamma traveled to meet her husband in Talakadu, where he was battling with the king of Mysore. She arrived to find that her husband had been killed and threw herself into the Kaveri while laying several curses: that Talakadu would be buried in sand, that the river in which she jumped would become a whirlpool, and that the Mysore dynasty would end for lack of an heir (Seshadri and Sundararaghavan, 2012). Talakadu had an important presence in the rich agricultural region of Kaveri and was a significant trade route between Karnataka and the plains of Tamil Nadu. It has a unique place in the historic settlements of Kaveri.

5–3–3 River Kaveri as an Ethnographic Landscape

The roots and belief systems of many people, particularly the Kodavas, are deeply entwined with the story of River Kaveri. Many communities trace their origins to mythological narratives involving the Kaveri's history. The river is the source of water and therefore food to the region. The river is thus pivotal to the agricultural and animal husbandry practices of the region. The Karnataka region has been primarily inhabited by agrarian cultures. The region's numerous river islands, sacred sites, unique food resources, and cultural resources such as Carnatic music all contribute to the ethnographic landscape character of River Kaveri.

At Talakaveri, in the southwest corner of Karnataka, the Kaveri, the Ganges of the South, is born high up in the green Brahmagiri Mountain at an elevation of 1,340 m above sea level (Clare and Oriole, 2009). Between October and November, depending on the calculation of local astrologers, the Kaveri bubbles up in rebirth. At this time, the Kodagu region welcomes thousands of devotees who are undertaking a pilgrimage to the holy bath in the tank built near the origin of the holy river Kaveri. Srirangapattana is another important religious site on the sacred island and is the place where the goddess Kaveri requested Lord Ranganatha to manifest. The area features the Sri Ranganatha Temple, and ghats leading down into the Kaveri can be found everywhere.

The word *pushkaran* means "worship of the sacred river." There are 12 rivers where the Maha Pushkaram or Pushkaralu are celebrated, with each river getting its turn every 12 years. Several *homams* and *yajnas* are conducted

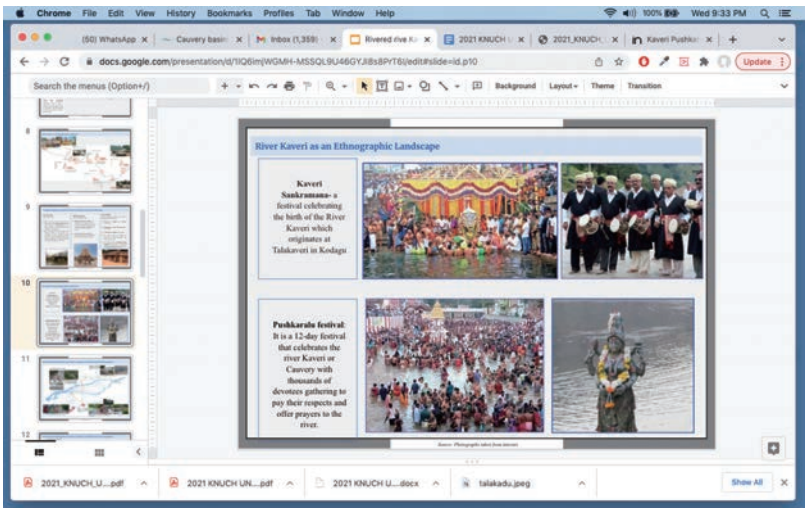


Figure 7. Cultural practices of communities worshiping the Kaveri river (image source: Internet)

throughout the 12–day period of Maha Pushkaram. Kaveri Pushkaralu and Cauveri Maha Pushkaram are large festivals for farmers and devotees in South India (Merala, 2017). Maha Pushkaram is a 12–day festival that celebrates the river Kaveri, with thousands of devotees gathering to pay their respects and offer prayers to the river. Most of these devotees depend on agriculture for a living and therefore pray for good rains and crops during the Kaveri Pushkaralu festival (Merala, 2017).

Srirangam hosts around 20,000 festival devotees, who arrive from the neighboring states of Andhra Pradesh and Telangana. Mayiladuthurai is another popular pilgrimage site for the Kaveri Pushkaralu celebration and sacred holy dips, which are a major part of prayer rituals. Apart from these popular sites, locals and devotees also visit several Tamil ghats along the Kaveri river to celebrate the Kaveri Maha Pushkaram. These periodic festivals reinforce cultural continuity and serve as a setting for integration, along with deeply sacred pilgrimages.

6. Settlement Morphology Characteristics in Region around River Kaveri

Van Oers has observed that the concept of "historic urban landscape," as adopted and promoted in recent years through UNESCO and supported by the International Council on Monuments and Sites (ICOMOS), is an attempt to articulate an overarching tool for the holistic management of historic cities, from the protection of their visual image through to the conservation of their historic built environment and its enhancement via appropriate contemporary intervention, enabling the continuity of the socio–cultural human activities that constitute an indispensable component of its sense (or spirit) of place (Oliveira, 2016).

In the United Kingdom, conservation approaches consider settings larger than individual sites from two principal perspectives: One considers the site's architectural and historic interest and streetscape (or townscape, arguably a misnomer); in the other, the protective system is fragmented and only identifies individual listed buildings and conservation areas. No policies or guidance is provided for historic cities as a whole, and there is no perception that any are needed (Rodwell, 2007b, 2008b). These works are referred to bring out the perspective that conservation of historic sites is an incomplete effort. The site, its setting, its vitality and relevance all are integral to any approach that aims to conserve the heritage in a holistic manner.

The settlements along River Kaveri need to be understood as part of a broader cultural heritage, the urban morphology of which can reveal a deeper

understanding of a common past and collective legacy. The following four settlements were studied to determine their morphology and spatial plans and to compare and contrast their characteristics from historical and cultural perspectives.

6–1 Srirangapatna

6–1–1 Settlement Morphology Study

Srirangapatna is 18 km away from Mysore district, an island city surrounded by the Kaveri river. The historical site dates back to the 9th–century Rangnathswamy Temple, which is worshipped by Vaishnavas, participants in a Hindu pilgrimage that begins at Adi Ranga at Srirangapatna or Madhya Ranga at Shivanasamudra and ends at Antya Ranga at Srirangam (Tamil Nadu State), running along the river Kaveri.

The fort built around the city by Hyder Ali and Tippu Sultan in the 17th century, remains of the fort wall, the Tippu Sultan summer palace, Lal Mahal Palace, and Tipu's death site (the British killed Tippu in the Battle of Srirangapatna) can all be seen. This place has religious and historical significance for both Hindus and Muslims.

Figure 8. Landmark and land use map, Srirangapatna (source: author)

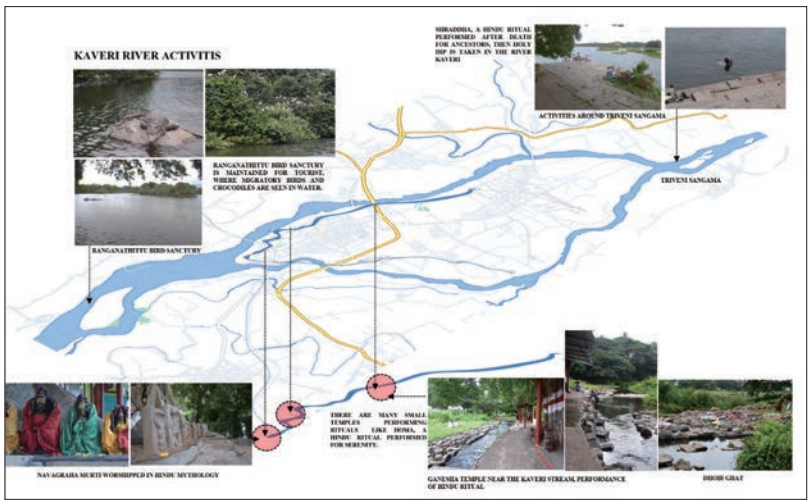


Figure 9. Kaveri river activity, Srirangapatna (source: author)

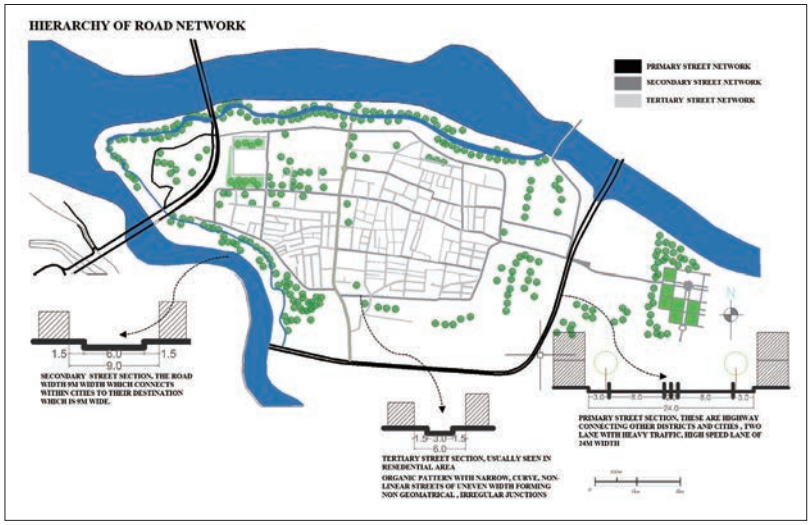


Figure 10. Hierarchy of road network, Srirangapatna (source: author)

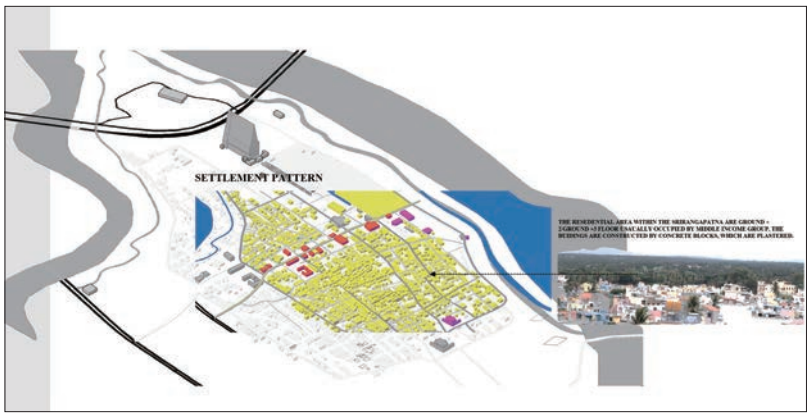


Figure 11. Settlement pattern, Srirangapatna (source: author)

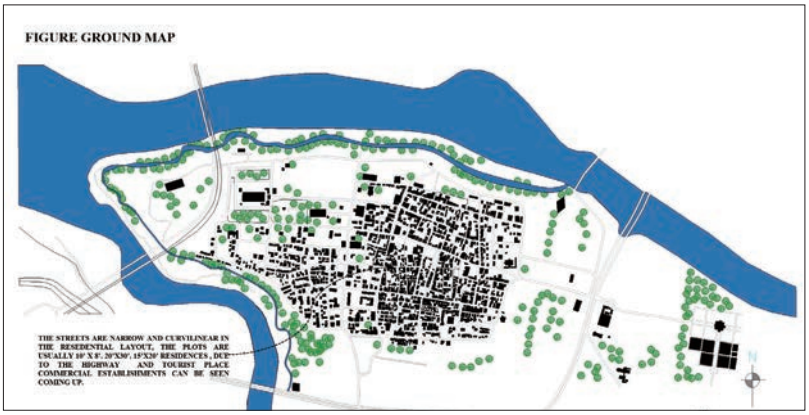


Figure 12. Figure ground map, Srirangapatna (source: author)

6–2 Somnathpur

Somnathpur is an important historic settlement known for its beautiful Hoysala temples. The great sculptor Jakkanachari is credited with these masterpieces (Jankiraman, 2002). Somnathpur is situated in south Karnataka, and is about 35 km away from Mysore city. Chennakeshava Temple is the most famous of the area's historic temple nad is known to have been built by the Hoysala commander Somnath in 1268 AD. The temple was built in soapstone. The Archaeological Survey of India has recognized it as a Heritage Site.

6–2–1 Settlement Morphology Study:

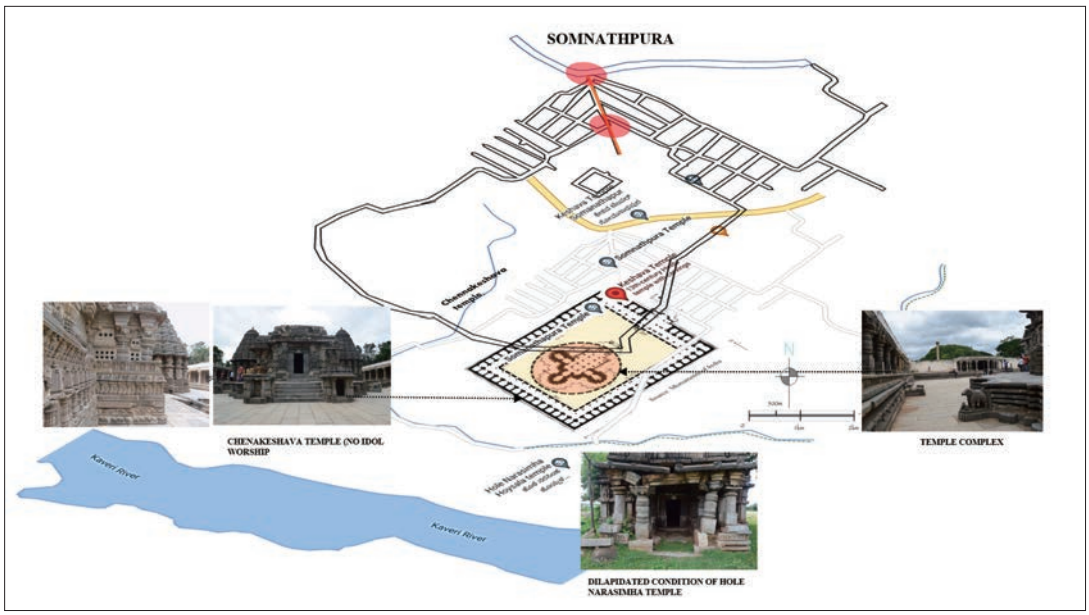


Figure 13. Chena Keshava Temple and road network, Somnathpura (source: author)

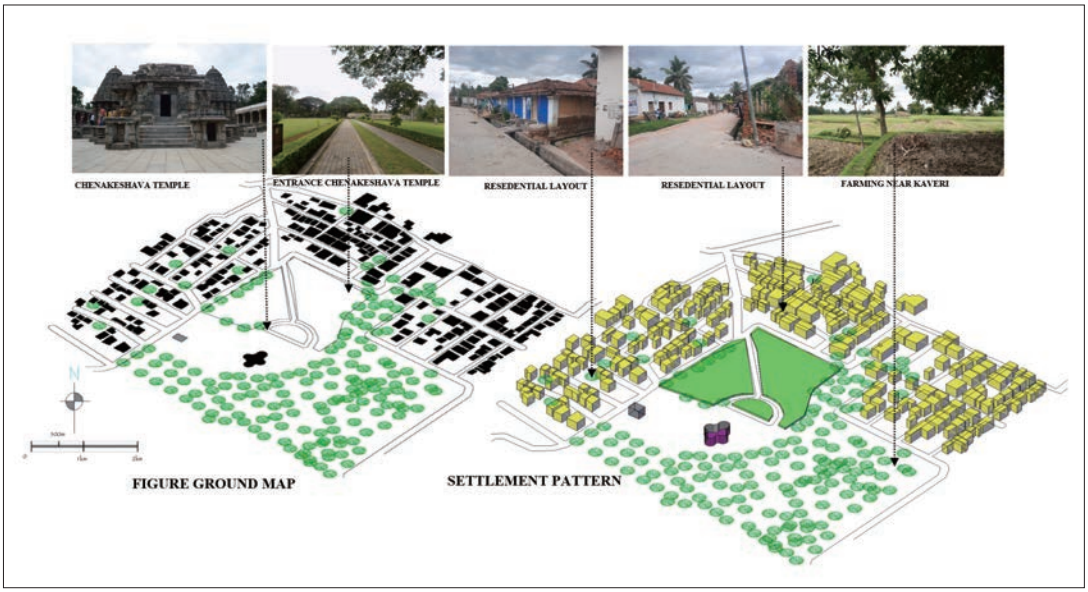


Figure 14. Ground and settlement pattern, Somnathpura (source: author)

6–3 Talakadu

Talakadu is situated approximately 45 km away from Mysore City and 185 km from Bangalore in southern Karnataka. Talakadu is a historic site of archaeological importance. It is known as a spiritual pilgrimage center and boasts unique scenic beauty owing to its riverine sandy banks. It is an ancient town and home to monuments protected under the ASI, such as Kirti Narayan Temple.

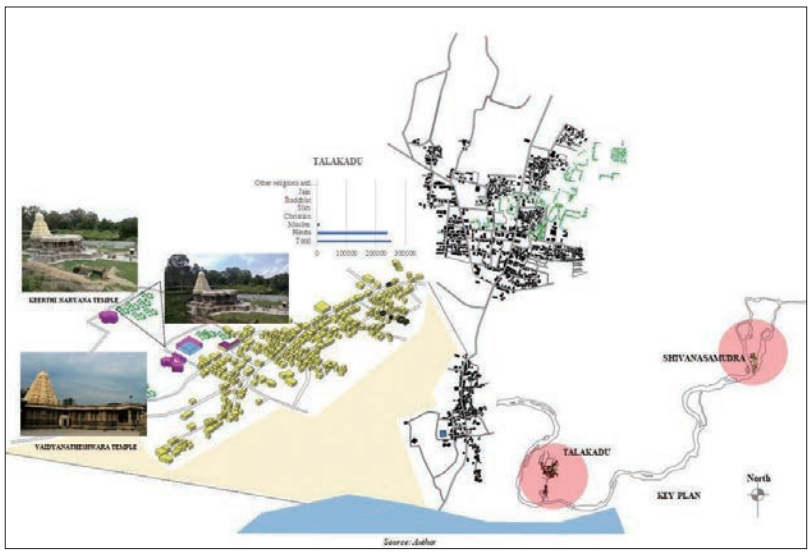


Figure 15. Settlement morphology and spatial setting, Talakadu (source: author)

Due to the historical account of the “triple curse” on Talakad, nearly 30 temples are believed to be submerged in sand, which is said to have forced people to migrate away (Jankiraman, 2002) The Talakad Panchalinga Temple is a popular place for pilgrims. Dedicated to Lord Shiva, this temple is known for the Pathaleshwara Shivalinga, which is red during the morning, black at noon, and white in the evening. The Mudukuthore Mallikarjuna Temple is another important site.

6–4 Shivasamudram

Shivasamudra, an island settlement, is situated where the river Kaveri descends sharply to 75 meters, in two beautiful waterfalls into rocky gorges, in the Mandya district of South Karnataka. Shivasamudram is the second largest waterfall in India. It has twin falls, Gaganachukki and Bharachukki, within a distance of 1 km. Kaveri splashes into majestic falls, one of which is Shivasamudram. Asia’s first hydroelectric project was established in 1905. Power was drawn from this power project to the Kolar Gold Fields near Bangalore to run the gold mines. Shivasamudram Island is about three miles long and three quarters of a mile wide. There are four temples and a dargah. The main temples are the Someshwara Temple and the Ranganatha Temple.

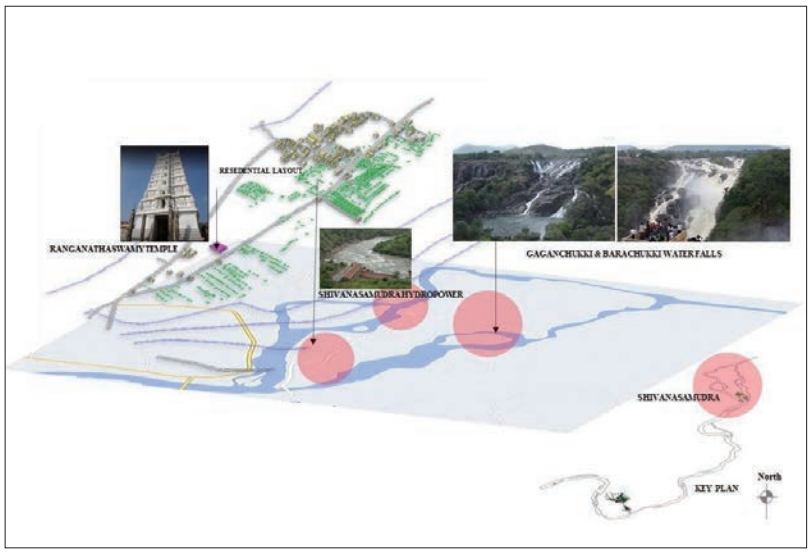
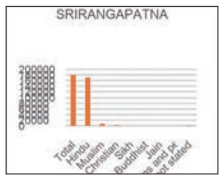
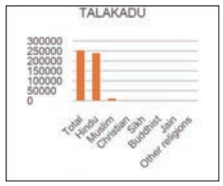
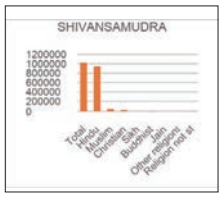


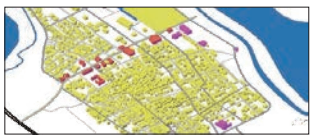
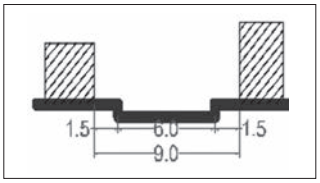
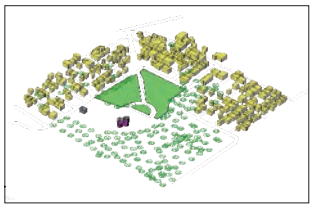
Figure 16. Settlement morphology and spatial setting of Shivasamudran

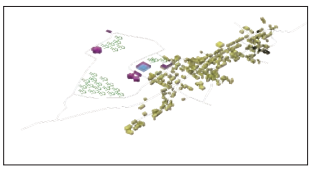
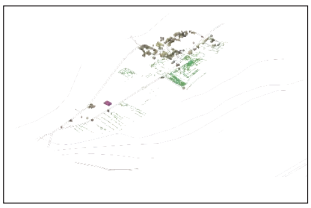
(source: author)

7. Comparative Analysis

Sl no	Sacredscape	Year of Historic Event	Religion	Religious Belief/ Mythology
1	Srirangapattanam		 According to the 2011 Census of Karnataka, most of the population is Hindu. 	The Hindu pilgrimage has cultural significance; it starts from Ranganatha Temple (known as "Adiranga") on the banks of River Kaveri. Srirangapattnam's island geography offered a strategic military advantage; the capital of Tippu Sultan contributed to another layer of urban development.
	Ranganathswamy Temple	984 CE, renovation during the Hoysala regime in the 12th century.		
	Sriranga fort	The fort was built during the Vijayanagar empire in the 15th century to offer protection from invaders		
	Tippu Sultan Palace	The summer palace was built during the 18th century.		
2	Somnathpura	The temple was built in the 13th century during the Hoysala regime. 	 According to the 2011 Census of Karnataka, most of the population is Hindu.	The Hoysala style of architecture is specific to the region of Karnataka; the temple complex has intricate, detailed carving on the façade, narrating the stories of "Mahabharata" and "Ramayana" Puranas.
	Someshwara Temple			
	Hole Narasimha temple			
3	Talakadu Maraleshwara Temple	It was ruled by Mysore raja in the 17th century	 According to the 2011 Census of Karnataka most of the population is Hindu.	Queen Alamellama laid a curse on the Wadiyar raja family, who had conquered the Srirangapatna. She threw away her jewels, laid the curse, and drowned in the Kaveri River. Hence, the temples were covered in sand and were opened for pooja every 12 years. It has been restored by the ASI and can offer pooja every day. The Vaidyanatheshwara Temple is believed to be able to cure any ailment.
	Keertinarayanaswamy Temple			
	Vaidyanatheshwara Temple			

Sl no	Sacredscape	Year of Historic Event	Religion	Religious Belief/ Mythology
4	Shivanasamudra Ranganatha Swamy Temple Bharachukki & Gaganachukki waterfalls	The temple complex was renovated during the 12th century by Hoysalas.	According to the 2011 Census of Karnataka 2011, most of the population is Hindu. 	The pil**grimage starting from Adi Ranga, Madhyaranga (Ranganathaswamy Temple in hivanasam**udra) is a sacred journey that ends in Antya ranga in Srirangam (Tamil Nadu state). The twin waterfalls formed by the river Kaveri fall from an altitude of 100 m. A holy bath is taken in the river by rishis before performing the "Sandhya Vandana" Vedic ritual.

Sl No	Architecture & Planning	Road Network/Temple Street	Observations
1	Srirangapatnam: The settlement pattern features irregular, small plots with low–rise residential buildings; most of those who settled in and around the temple complex performed temple activities. 	The secondary narrow streets were mostly meant for walking. Temple streets have been widened, and small commercial establishments sell pooja items and artefacts. 	Cultures that revere Kaveri have existed continuously since ancient times and are associated with Hindu gods and their blessings. There is a cause–and–effect relationship between the area's cultural activities and its roads and built environment.
2	Somnathpur: It has low–rise residential plots, with farming lands around the banks of the river Kaveri; its landscape and activities are rural. 	The narrow streets within the rural area and the landscape maintained by the ASI inside the temple complex allow pedestrian–friendly settlement with greenery all around.	The ASI has protected only the Someshwara Temple. More attention should be paid to the ruined sites around the temple, like the Hole Narasimha temple complex.

Sl No	Architecture & Planning	Road Network/Temple Street	Observations
3	Talakadu: A three–temple complex is near the banks of the river Kaveri, in the sandy area. The city has many small temples devoted to Shiva and a rural landscape, with typical low–rise pitched roof buildings. 	The tour around the three–temple complex runs along a pedestrian sand path, making the journey difficult. After ASI protection was obtained, a dedicated pathway with a shaded area was built.	The periodic festival attracts thousands of people, while the mythology and beliefs of Hinduism (e.g., that Vaidyanatheshwara Temple cures ailments) and the sandy area attract tourists from across the globe.
4	Shivanasamudra: It is a tranquil rural settlement with low–rise residential development. 	All the sites in the study area chosen along the banks of River Kaveri have narrow streets and rural landscapes.	The twin waterfalls, which fall from an altitude of 100 m, the rural landscape, and Hindu mythology attract tourists from across the globe. The Madhyaranga Temple, part of a pilgrimage across the banks of the river, makes this a sacred place.

8. Conclusion

A comparison between the selected settlements reveals that they are similar in terms of the following attributes: scale of settlement, demographics (particularly religious communities), historic temples and pilgrimage centers, cultural narratives, mythological origins, practices, geographies, and the astrological alignments of sacred seasons. Most of the communities in these settlements show a deep reverence for the areas' temple complexes, many of which are disused or protected monuments, along with riverside ambulation practices. Understanding the value of cultural factors and the importance people attach to these attributes can help us revive and protect cultural treasures beyond the boundaries of the Kaveri region.

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Traditional Use of Lacquer in Cambodia

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Abstract

This research attempts to understand the history of the traditional use of lacquers in Cambodia by focusing on the characteristics of Khmer lacquers, lacquer specialization, and lacquers as authentic material for cultural heritage conservation. The information gained from reviewing lacquer research literature, examining ancient lacquer remains, reviewing old epigraphy, and conducting ethnographic surveys enriches our knowledge of lacquer and its traditional use in Cambodia. Natural lacquer sap is tapped yearly from two lacquer tree species growing in Cambodia: *Gluta usitata* and *Gluta laccifera*. The knowledge of using a lacquer can be traced back to a very remote period. The first historical record of lacquer work dates back to the 10th century, when King Jayavarman V (AD 968–1001) established a royal corporation of *khmuk*, a mixture of lacquer with I leaves, for use in use the holy chamber of worship, supervised by a chief of khmuk and some members under a royal directive, and supported by domestic products and land revenues. The post–Angkorian lacquer sculptors used benzoin gum, dammar resin, clay, ash of rice husks, sand, and other sediments to mix with the lacquer to make a lacquer–based mortar. This lacquer mixture was used to mold, coat, and repair Buddha statues and other sculptures before applying cinnabar/vermillion, mercury, and gilding. The queen mother of a 16th century king in Cambodia sacrificed her holy hair bun and burned it to make a sacred *khmuk* for the erection of Angkor Wat's Buddha statues. This sacrifice was obviously not for technical purposes, but rather from a pure heart of devotion and respect given to the Buddha and Buddhism. The tradition of harvesting lacquer sap and using it for the fabrication of artistic and daily objects still exists among rural communities in Cambodia, but it has significantly declined because the time, labor, and resources consumed for lacquer work do not provide a good

living income. Based on several tests, lacquer is considered an authentic and perfect traditional material for conserving stone sculptures coated with lacquer and polychromes in Cambodia. The first attempt to use natural lacquers in stone conservation work in Angkor was made during the conservation of the statue of Ta Reach at Angkor Wat in 2005 and the post–Angkorian Buddha statues in the central shrine of Pre Rup in 2020. Although this preliminary research has enriched our knowledge of the history of the traditional use of lacquers in Cambodia, further scientific research on the ancient composition of lacquer and lacquer mixtures from various historical and cultural contexts needs to be considered in the future.

1. Introduction

Lacquer, or mrāk to give it its local name, is generally known to almost all Cambodian people because the tradition of using lacquer to make artistic, decorative, ritual, and daily life objects is still practiced. However, most Cambodians do not know the history of lacquer work and hardly recognize the lacquer tree (local name, *kreul*), or the traditional practice of harvesting lacquer sap and using its resin. The tradition of tapping lacquer trees and using lacquers to produce crafted objects faces a great decline because the income obtained from selling traditional lacquered objects does not compensate for the cost of producing lacquer work. Only a few households in the villages of Trea and Pralay in Kampong Thom province, central Cambodia, continue to practice their traditional lacquer work. Most cultural heritage conservators in Cambodia are not familiar with this precious and valuable material and do not know when lacquer was used, what are the constituent components of lacquer and lacquer mortar, and how these materials are applied in traditional craft and architecture. The remains of various types of lacquer and lacquer mortar are found in the 16th–17th century sculpture in Angkor and elsewhere in Cambodia, either used in production or restoration. However, no investigation has been conducted thus far on these traditional materials.

This research attempts to collect all relevant information that can help us understand the history of traditional lacquer use in Cambodia by focusing on three major themes: characteristics of Khmer lacquer, Lacquer specialization in ancient times, and Lacquer as authentic material for cultural heritage conservation. In the section on the characteristics of Khmer lacquer, a number of subthemes will be examined – lacquer trees, lacquer sap harvesting, lacquer sap, and lacquer in medicinal use–are examined. The section on lacquer specialization will present various pieces of information and evidence on Angkorian royal lacquer corporations, the use of lacquers in Angkorian and post–Angkorian times, and sacred lacquers in religious and ritual contexts. Lacquer as authentic material for cultural heritage conservation is also preliminarily documented and applied for the first time in Angkor. The methodology adopted for this research includes 1) reviewing the epigraphical records of Angkorian times: eleven inscriptions are identified that record lacquer–related work and royal lacquer corporations during the reign of King Jayavarman V; 2) investigating ancient lacquer and lacquer–based mortar remains left on the walls of Angkorian temples and sculptures; 3) conducting an ethnographic survey on lacquer sap harvesting and lacquer craftmanship at Trea villager in Kampong Thom province, central Cambodia; and 4) conducting a lacquer–related literature review.

2. Characteristics of Khmer Lacquer

When reviewing published articles on lacquer species in Southeast Asia, we could differentiate some basic characteristics of Khmer lacquer from other lacquer species in Asia by examining lacquer tree species, lacquer sap, techniques of lacquer sap harvesting, and other parts of lacquer trees that have been used in traditional medicine by local villagers.

2–1 Lacquer Trees

More than 73 genera and 600 species of lacquer trees worldwide are classified into the Toxicodendron genus of the family Anacardiaceae. Most of them grow in the subtropical environment of Southeast Asia, and a few grow in the evergreen forest of East Asia [1]. Two botanical species of lacquer trees are recognized in Cambodia: *Gluta usitata* (Wall.) Ding Hou [1, 9] and *Gluta laccifera* (Pierre.) Ding Hou [9, 2]. These two species also grow widely in Myanmar, Laos Thailand and Vietnam [9, 2]. *Gluta usitata* (Wall.) Ding Hou grows in a deciduous dipterocarp forest [1, 2, 3, 4, 9] at an altitude of 100m to 1000m above sea level and to a height of 5–25m [3, 4], whereas *Gluta laccifera* (Pierre.) Ding Hou grows densely on quaternary sedimentary rock and alluvial sandy plains in Cambodia [5, 6], at an altitude of 10 to 600m [7] and to a height of 18m [3] to 25 or 30m [8]. A recent survey conducted in Kampong Thom province showed that from 2014, less than five trees were counted within a plot of 30 x 80m, and the 50–60cm diameter at breast height (DBH) trees were cut for timber [6] (Figure 1).

Figure 1. Lacquer trees growing on a sandy alluvial plain in the rice field of Trea village, Stong District, Kampong Thom province, central Cambodia (Author 2021)

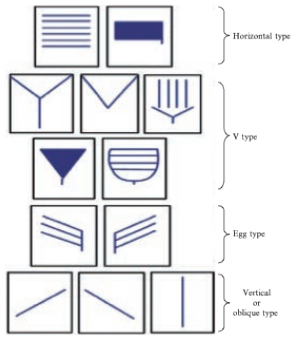

Figure 2. Various types of incisions adopted for tapping lacquer sap [1]

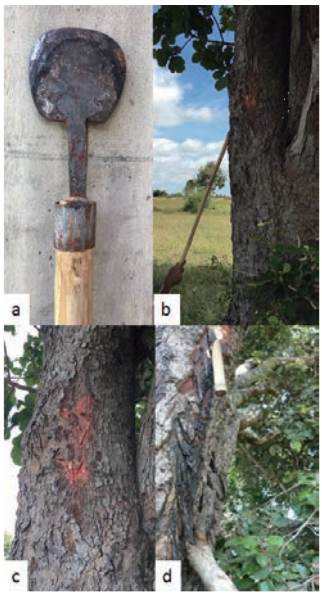

Figure 3. a. A spatula–shaped tool with sharp edges for cutting and opening the barks for inserting the collecting bamboo tubes (Author Sept. 2021). b. Cutting the bark of a lacquer tree (Author Sept. 2021). c. barks cut into a V–shaped type (Author Sept.2021). d. collecting sap by inserting the bamboo tube into the cut bark ([2])

2–2 Lacquer sap harvesting

Several factors affect the quality and quantity of lacquer sap harvested. These conditions include meteorological conditions, growth environment, tree species, tree age, harvest season, and tapping techniques. During extended periods of sunshine and high temperatures, the lacquer yield increases and reduces with an intensification of rainfall, low temperatures and shorter periods of sunshine [1]. Generally, a lacquer tree can yield its sap after five years of growth if the bark thickness grows quickly. However, for species whose bark thickness develops slowly, it takes up to 10 years growth [1]. According to Rong Lu and Tetsuo Miyakoshi, the harvesting of lacquer sap is usually carried out three times a year [1]. The first collection is from mid–June to early July, when the harvested lacquer sap contains a lot of water and has a high viscosity. The second is from mid–July to late August, when the life activity of a lacquer tree is healthy, sap secretion is strong, yield is high, and quality is good. The third is from early September to early October, during which time the temperature decreases, and transpiration weakens the laticiferous canal cell activity, decreasing the secretion. The lacquer collected at this time has a light color and low lipid concentration [1]. Various tapping techniques have been recorded. Horizontal incision is recognized as popular in Japan; oblique and vertical incisions are mostly practiced in Myanmar and Thailand, while in Cambodia, China, Myanmar, and Vietnam, egg–type incisions and V–shaped incisions are the most popular tapping techniques (Figure 2). The Cambodian lacquer tappers of Trea and Pralay villages use an iron spatula–shaped incising tool to incise the

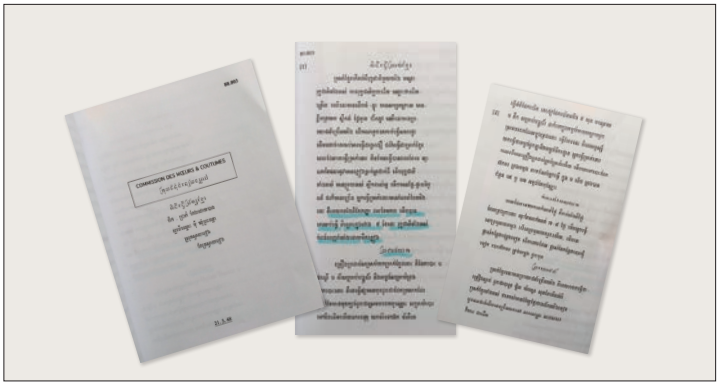

Figure 4. The ethnographic record of Mr Chik Prak, describing a lacquer sap tapping process in 1948 [24]

lacquer bark into a V–shaped cut and insert it to collect the sap [2] (Figure 3).

In Cambodia, lacquer sap harvesting techniques are diverse and differ from one region to another or from one generation to another. An old ethnographic record written in Khmer, dating back to 1948 (Figure 4), is the oldest piece of literature on lacquer harvesting I encountered during my documentary research, and it is worth summarizing as follows:

> "Pithi Thveu Mrāk Khmae," a ritual for the fabrication of Khmer lacquer. The harvesting of lacquer sap is not possible in all seasons. The best season is from September to January, when the growing activity of the lacquer trees is strong, with healthy and mature leaves and fruits. The yield is high, and the sap quality is particularly good. The tools for collecting the sap are an iron tool with a curved incising edge to cut the tree bark, a ladder, a gutter, and a bamboo tube. The tapping starts by cutting the tree bark with the incising tool, inserting the gutter into the incised area, and then connecting the bamboo tube to the gutter. Usually, approximately 15 to 17 tubes are used to collect the sap, over 7 to 8 days after the tappers come to collect the sap, and then are moved to tap again in other new locations on the tree' [24].

2–3 Lacquer Sap

It has been reported that lacquer is the only self–catalyzing natural polymer, and no organic solvent evaporates (only water) during the drying process. Therefore, because of this self–drying system, a natural lacquer is a precious coating material with solvent–free and high–solid–content components [1]. When the bark of a lacquer tree is mechanically injured, its milky white sap comes out of the tree, and a few minutes later, the sap becomes dark brown to black after oxidation [1, 2] (Figure 5). Skin contact can cause severe dermatitis in some people due to its catechols [2, 4, 10]. Lacquer sap contains 60%–70% catechol derivatives, 20%–30% water, 4%–10% plant gum, 3%–5% glycoproteins, and 1.5 to 2% of enzyme laccase [12]. Thitsiol is the main component of lacquer sap tapped from both species. The sap sampled from Cambodia does not contain C_{10} phenyl catechol, whereas the sap from Myanmar contains both C_{10} and C_{12} phenyl catechols [2]. In general, additives and solvents are added to the lacquer to prolong its fluidity and improve its workable state. The best lacquer is black, but if the water content in the lacquer reaches 30%–45%, the lacquer sap has a brown, yellow or red color [2].

Figure 5. lacquer sap exudes from the injured bark of a lacquer tree at Trea Village, Kampong Thom province (Author, Sept. 2021)

It has been reported that thitsiol lacquer is more viscous than other lacquers; therefore, other wood oils or plant oils are added to the lacquer [2]. Other oils, such as peanut or tung oil, are also used when making a colored

lacquer, especially when vermillion is used [2]. Contemporary lacquer workers or artists add ashes from burned old cloth, palm or banana leaves [14, 25, 26], rice husk ash, talcum [2], petrol, red iron, titanium, sandstone powder, and resin of Ficus benjamina [26, 30] to the natural lacquer to make a variety of lacquer pastes for different purposes.

3. Lacquer Specializations

Lacquer is widely used in the chemical and petrochemical industries, shipbuilding, and crafts [1]. Therefore, it is evident that its utilitarian diversity requires various specific skills in its application for different purposes. This section presents various pieces of information on lacquer works since ancient times in Cambodia.

3–1 Angkor Royal Lacquer Corporation

When reviewing old Khmer epigraphy, we come across a strikingly important record of the establishment of a royal corporation of lacquer. At this stage of the research, we identified a number of old Khmer inscriptions: K.168 [31], K. 868 [32], K. 175 [33], K.444 [34], K.814 [35], K.1152 [36], K.1198 [37], K.465 [15], K.715 [14], and K.302, K.303 of IMA2&3 [13] *mentioning khmuk*[1] related stories. Among these inscriptions, one inscription (K.168) mentions a person named *gho khmuk* [31], five inscriptions (K.175, K. 444, K. 868, K. 1152, K. 814) tells us that King Jayavarman V (AD 968–1001) established a new "*varna*" or corporation of *khmuk* professionals attached to the chamber of cult "*kralā arcanā*" of the royal palace [37], one inscription (K.1198) reports that a group of persons were ordered by King Suryavarman I in AD 1014 to enter into the service of *khmuk* of the chamber of the cult [37] and the other four inscriptions (K.456, K.715 and K.302, K303 of IMA2&3) are not related to the Angkorian *khmuk* corporation but to the repair of broken Buddha statues at Bakheng and Udong by a monk [15], the sacrifice of her holy hair bun by the queen mother of a 16th century Khmer king to make *kmuk*[2] [13] for the erection of the Buddha statues at Angkor Wat, and the sacrifice of a noble man's hairs, eyebrows and chest hairs to make kmuk for the construction of a Buddha statue [14].

Here are the old Khmer inscriptions that mention the royal corporation of khmuk during the reign of Jayavarman V: K.444A:16[3] (AD 974); K.868A:9–10 (AD 974): ··· *duk mūla khmuk vrah kralā 'arccana 20 mūla karmmāntara 20*··· (··· to appoint a chief [and] twenty *khmuk* of the holy chamber of worship [and] a chief [and] twenty members of the Karmmāntara Order[4] ···) [16].

1 "*Khmuk*", in modern Khmer, is a mixture of lacquer with burned banana leaves or cloth; It also means to paint with this mixture, but also to be smashed to little pieces; crushed, pulverized, broken. It is a black undercoating applied to images before gilding; it could be also the artisan who applies this undercoating [17].

2 This word is written as "*khmuk*" in the 10th and 11th centuries and today, and as "Kmuk" in the 16th century.

3 K.444A:16 presented here indicates the inscription numbered K.444, face A, line 16.

4 "*Karmmāntara*", a Sanskrit word, is meant: a varna or clerical order responsible for funeral rites [17].

K.444A:17–9; K.868A:10–1: ⋯ *phle sruk sre bhūmyākara leṅ siddhi jā varna neh ta vyar nā khmuk vrah kralā 'arccana nu karmmantāra* ⋯ (⋯ the produce of the *sruk*, the rice land, [and] land revenues in full title as members of these two corporations, the parent departments (*nā*) of the *khmuk* of the holy chamber of worship, and members of the Karmmāntara Order) [16].

K.444A:21–3; K.868A:13–4: ⋯ *phle'anvaya neh nā khmuk vrah kralā 'arccana nu karmmāntara yāvat vrah candrāditya mān dau* (⋯ the yield [accruing] from these sources shall be for (*nā*) the *khmuk* of the holy chamber of worship and members of the Karmmāntara Order for as long as the sacred moon and sun shall shine) [16].

K.444A:24–5; K.868A:15: ⋯ *khloñ khmuk vrah kralā 'arccana nu khloñ karmmāntara* ⋯ (⋯ the chief of the *khmuk* of the holy chamber of worship and the chief of members of the Karmmāntara Order ⋯) [16].

K.1152B:6 (AD 977): ⋯ *pandval vrah śāsana [ta] steṅṅ khmuk vrah kralā 'arccana* ⋯ (⋯ to issue a royal directive to the *steṅ* of the *khmuk* of the holy chamber of worship ⋯) [16].

K.814A:66–8 (AD 1004): *steṅ 'añ 'ācāryya homa ta khmuk vrah kriya* [= *kralā*] *'arccana* ⋯ (The *steṅ 'añ* the instructor of sacrifice, a *khmuk* of the holy chamber of worship ⋯) [16]

We have seen that the royal corporation of the *khmuk* of the holy chamber of worship is managed by a chief and 20 khmuk professionals assigned by the king, working under a royal directive and supported by domestic produce, rice land, and land–revenues. It is presumed that this royal corporation might have been composed of a group of lacquer specialists working on fabricating lacquered accessories for the holy chamber of worship of the royal palace.

3–2 Lacquer as Coating Material

Lacquer is a fascinating coating material used in human life for thousands of years [1]. Based on the results of recent investigations on lacquer remains of the Buddha statues of Pre Rup [18], the wooden Buddha from the Angkor Conservation [17], the Buddha statues at the "Gallery of a Thousands Buddha" of Angkor Wat, and the polychrome remains on the bas–reliefs of Angkor Wat [23], in combination with observations of the pre–Angkorian Buddha statue from Wat Kampong Luong during a restoration intervention at the stone conservation workshop of the National Museum of Cambodia [20], we have verified that lacquer was used as an undercoat on stone statues and carvings before applying other polychromes and gilding. This information is compatible with the records of the 16th–century inscriptions from the Angkor region [13, 14, 15, 16]. We have

learned from these epigraphical records some technical words such as "*khmuk*" (10th century) [16], "*kmuk*," a mixture of lacquer with additives, "*hingulā*," cinnabar/vermillion, "*pāratt*," mercuric sulphide (16th century) [15], "*pit māṣ*," gilding (17th century) [14], that indicate a technical process starting from coating with a lacquer mixture or "*kmuk*," then applying cinnabar/vermillion, and gilding or decorating ornaments. The same technical process has also been applied to wooden statues [17].

In some sections of the bas reliefs of Angkor, especially on the historical panel of King Suryavarman II, some lacquer remains are still visible. The bas reliefs were coated with black lacquer layers beneath the red and gilded layers (Figure 6). These lacquer remains have been provisionally dated back to the 12th century, whereas other polychromes containing no lacquer might have dated from the 16th century onward [23].

Another example that clearly shows several layers of lacquer coatings made in different periods on the same sculpture is the Buddha statue of Wat Kampong

Figure 6. a & b. Black traces left in carved motifs are the remains of black lacquers overcoated by red polychrome gilded, Southwestern bas–reliefs–gallery of Angkor; c. lacquer overcoated with red polychrome Vishnu statue, 3rd floor, southern gallery, Angkor Wat, d. lacquer and polychrome gilded of a Buddha statue from the Gallery of Thousands Buddha, Angkor Wat (Author, Oct. 2021)

Figure 7. a. The appearance of the Buddha statue after the first partial restoration in 2000, b. Sectioning of successive coated layers revealed after de–restoration, c. Schematic stratigraphy of four phases of coated layers: Phase I (16th century) and II (19th century) are very fine, less than 1mm, Phase III (20th century) is very thick, 3mm to 1cm, and Phase IV is the new synthetic painting (Photos of [21])

Figure 8. a. A mask of the monkey dancer, made of paper and lacquer, b. Trays and betel boxes made from palm tree's branches and coated with lacquer of a lacquer craftsman from Trea village (Author, 2021)

Luong from Angkor Borei, Southern Cambodia. This 7th–century pre–Angkorian statue is made of sandstone in the Phnom Da style. The statue underwent several modifications in the past, and it was difficult to recognize its original appearance and state of conservation [20]. In 2000, the studio of stone restoration at the National Museum of Cambodia initiated a de–restoration (Figure 7a and 7b). The stratigraphy of successive coated layers revealed a thick complex coating composed of four coating phases, as shown in the schematic stratigraphy (Figure 7c). The first phase consists of a black lacquer coating that is directly applied to the stone surface; the red lacquer, the gilded layer (yellow), dated to the 15th–16th centuries or AD 1415–1515, the second and third are thicker, probably dated to the 19th century; and the fourth is the new synthetic painting [20].

It is not known when it ceased, but the tradition of using lacquer in stone and wooden architecture, conservation, restoration, and other construction domains in Cambodia is no longer practiced. This is perhaps because the collecting of the lacquer is a manual rather than a mechanical operation. Added to this is the possibility of lacquer allergy, and the fact that lacquer trees grow in remote and inconvenient areas, and lacquer sap is expensive [1]. An ethnographic record from 1948 reports that lacquer is traditionally used to coat and make bowls for Buddhist monks [25], water bowls, betel boxes, and so on, as well as to coat the manuscripts and pillars of pagodas or as drawing material [24]. This tradition continues, even though it is facing a significant decline, among local lacquer communities, especially in Trea and Pralay villages, Kampong Thom province, central Cambodia (Figure 8b) [26], and among modern lacquer artists who produce art objects [11], especially the masks of dancers of the Monkeys or "*khol*" theatre (Figure 8a) [28].

3–3 Absence of Lacquer in Polychrome of Brick Temples

A preliminary research report was compiled on anicent paintings and polychromic remains in ancient Khmer brick temples in Cambodia. An inventory of 105 brick towers of 19 temples from the 9th to 10th centuries, was made, and 43 towers were confirmed to have paintings and polychromic remains in situ on the interior walls (Figure 9) [21]. The scientific analysis of the pigments from these paintings and polychromic remains revealed that the black pigments are aluminum silicates with manganese and iron oxides as coloring components. Kaolin clay pigments and cinnabar were also used to make white paint and red layers, respectively [21]. To detect distinctive components of the binding medium, the research team used the Fourier transform infrared spectroscopy (FT–IR) technique to analyze the samples, and it was confirmed that the intensely strong peak at 1694 cm^{-1} was assigned to carboxylic acid, which is highly likely to match the spectrum of kauri copal gum, but not that of lacquer [21]. Therefore, lacquer has not yet been confirmed as having been used either in painting or polychrome remains of ancient Khmer brick temples.

Figure 9. Floral decorative designs of light orange, red and black colors, interior south wall of Prea Ko temple, 9th century (Photo of [23])

3–4 Absence of Lacquer in Other Polychromic Remains of Angkor Wat

It is doubtful that lacquer was extensively used to coat, to mold, and to repair the Buddhas and other statues in the 16th century in Cambodia, but it was not present in other polychromes of Angkor Wat, especially the polychrome remains found in the cruciform gallery and corner pavilions of Angkor Wat. Two scientific

Figure 10. a & b. Pillars, beams, corniches, door frames, pilasters and vaults of the cruciform gallery painted in red, black and white colors, Angkor Wat (Author, 2021)

studies on the polychrome remains of these locations in Angkor Wat were conducted in the past [22, 23]. The results of the analysis revealed that red iron oxide, black pigment (12th century), red lead, cinnabar, white ochre (16th century) [23], white lead, iron hydroxide, lead oxide, and carbon black [22] were used to paint the interior wall surface, columns, corniches, door frames, beams, and half–vaults of the cruciform gallery of Angkor Wat. Therefore, the use of a lacquer to coat the interior surface and other architectural elements of the cruciform gallery and corner pavilions of Angkor Wat has not yet been confirmed.

Figure 11. A post–Angkorian Buddha statue of Pre Rup: After cleaning off the dirt and debris, various types of lacquer mortars are exposed. Four types of lacquer mortars are recognized – lacquer mortar for gluing, for filling, for shaping or molding, and for coating (Author, 2020)

3–5 Lacquer as Gluing, Refilling, Molding Material

Apart from being used as a coating material, lacquer mixed with other organic and inorganic additives to make a lacquer–based mortar is used to glue broken stones, refill the gaps or void areas on the stone, and mold or shape the statues. The lacquer mortar used to shape the Buddha statues of Pre Rup contains thitsiol, dammar resin, bone, and sediment, whereas benzoin gum, sand, and sediments are mixed with lacquer for gluing ornaments and stone [18] (Figure 11). Other examples include the post–Angkorian Buddha statues and other divine statues at the "Gallery of a thousand Buddhas" of Angkor Wat and other temples in Cambodia (Figure 12).

Figure 12. a. the upper section of the legs is made of lime mortar and covered by lacquer mortar; b. the front of the statue's body is shaped in lacquer mortar; c. the statue's ornament and skirt are molded in lacquer mortar; d. the statue's arm is made of wood coated with lacquer and polychrome connected by the stone body by lacquer mortar. Three statues (a, b, d) are housed in the 1000 Buddha Gallery, and the Vishnu statue (c.) in the 3rd southern gallery (Author 2021)

3–6 Sacred Lacquer

Two remarkable epigraphical records of the post–Angkorian period mention the sacrifice of human hairs to make a sacred lacquer "*kmuk*." The first inscription (K. 303) from lines 18 to 21 (Figure 13) recounts that Mahākalyānavattī Çrīsujātā, the Queen Mother of the 16th century Khmer King, Jayachetha I, within her pure royal heart of devotion and respect to the Buddha and Buddhism, shaved her head and received a ritual ablution, *muddhābhisek*. The shaved hairs were burned into ash then mixed with lacquer resin to make "*kmuk*" for the

erection of the Buddha statues of the central shrine of Angkor Wat [13, 29].

Another inscription (K.715) from the mountain of Kulen in the northern region of Angkor (Figure 14) says a noble man named Māhākosal came to venerate the Grand Buddha of the site, sacrificed his hair, eyebrows, and chest hairs, burned and boiled them to make a lacquer "*kmuk*" for the repair of the Grand Buddha statue of the site [14].

The religious act of abandoning the hair bun of the queen mother, and of the hairs, eyebrows and chest hairs of the noble man, is not obviously related to the technical aspect of lacquer "*kmuk*" for the repair or erection of the Buddha statues but rather to the sacrifice and devotion to the Buddha and Buddhism in particular.

4. Lacquer as an Authentic Material for Cultural Heritage Conservation

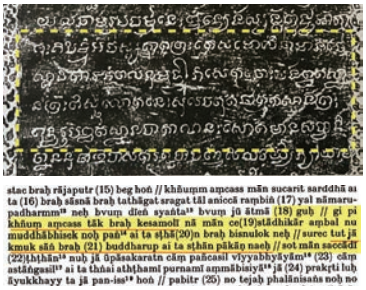

Figure 13. Inscription of K.303 of Angkor Wat, from lines 18 to 21mentioning the sacrifice of the saint chignon of the queen mother in the 16th century to make "*kmuk*" (Photo, [39], Transliteration of [14])

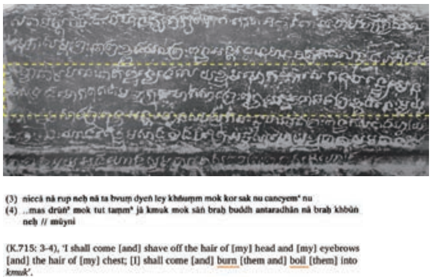

Figure 14. K.715 recounting the sacrifice of head hairs, eyebrows and chest hairs to make "*kmuk*" for the repair of the Grand Buddha of Phnum Kulen in 16th century (Photo and transliteration, [15], translation, [28])

Recent investigations of traditional materials have revealed that lacquer is among the traditional materials used in ancient Cambodia in the field of plastic arts. Lacquer remains either in lacquer finishes, lacquer adhesive, or lacquer mortar, allowing us to understand its physical and compositional attributes, and its involvement with human life from other sociocultural aspects. Modern experts or conservators of cultural heritage, in general, still concentrate on using industrial products, materials, and modern technology, as they believe that those materials are strong, safe, and durable. However, they have not studied the consequences of the weakness or adverse impacts of these materials after their introduction into ancient structures or materials. An attempt to use natural lacquer and other materials combined with lacquer for the conservation and

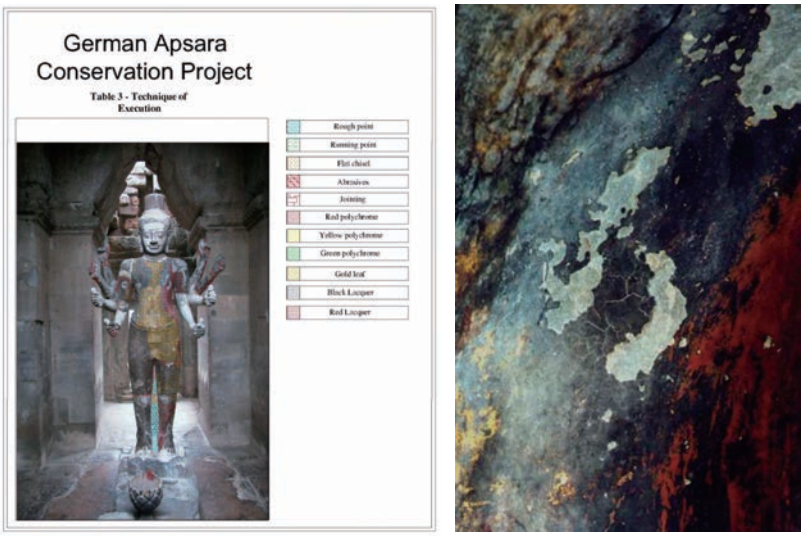

Figure 15. The mapping of degrees of preservation conditions of the polychromy of the statue before intervention (Photo on the left), and the scaling and cracks of polychromy and lacquer layers (Photo on the right) (Photo of [20])

restoration of traditional lacquered objects, especially stone sculptures partially made of or coated with lacquer, has not been widely considered in Cambodia.

The first trial of using a natural lacquer was when the Vishnu statue or Ta Reap of Angkor Wat was restored in 2005. After several tests, it was observed that the natural lacquer was perfect for sealing or gluing small cracks or lacunae more than half a millimeter in thickness, but it was too viscous to infiltrate into smaller cracks. Therefore, a mixed method was adopted by using about 5% Paraloid B72 to inject into the finer scales to adhere them, and then using a lacquer to seal or fill the cracks [19] (Figure 14).

Figure 16. Two post–Angkorian Buddha statues of Pre Rup ready for lacquer conservation intervention (SUC, 2020)

The second successful challenge was in the conservation and restoration project of the post–Angkorian Buddha statues at Pre Rup temple in Angkor in 2020, carried out by a Cambodian conservation team under the technical instruction and supervision of a lacquer conservation specialist from Stocker Studio in Siem Reap province, Cambodia. After several tests, the lacquer conservation work started with the following main procedures: 1) Using the raw lacquer containing 80% resin and 20% water mixed with petrol to cover the gaps (95 g raw lacquer and 5 g petrol). 2) Applying the well–mixed liquid with a brush onto the repaired surface, then

coating the areas filled by the solution of raw lacquer and petrol with a refined lacquer using a brush and drying for 3 to 5 days. 3) Sanding the refined lacquer with 240–320 grain sized sandpaper and cleaning off the dust. 4) preparing the surface to receive pigments by applying a lacquer mortar (60%–70% sandstone dust of the appropriate color tone identical to that of the original colors of the statues, mixed with 40% of raw lacquer) onto the pigments–received areas, and keeping it dry between 5 and 10 days. 5) Sanding the surface and applying a mixture of red iron oxide powder with the sap of *Chrey Krem* (*Ficus benjamina*) for adhesiveness to obtain the color. White titanium pigment was also used to obtain a smoky color tone [30] (Figure 16 and 17).

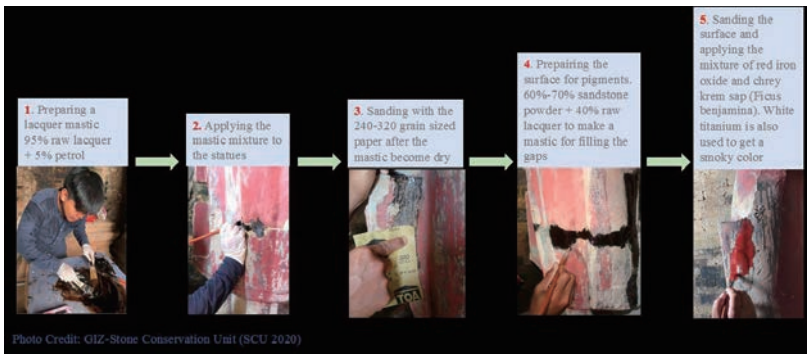

Figure 17. Summary of the major steps of lacquer conservation and restoration intervention adopted for the post–Angkorian Buddha statues at Pre Rup temple in Angkor. The work was executed by the young professional Stone Conservation Unit under the instruction and supervision of the technical coordinators of GIZ and of the lacquer master of Stocker Studio, Siem Reap [31].

5. Initial Conclusions

Lacquer research in Cambodia is still underdeveloped compared to other Asian countries. This preliminary research is just a starting point to collect general information or evidence that we had encountered through a lacquer–related literature review, a study of lacquer remains, reading epigraphical records, and conducting ethnographic research. The results obtained at this stage of research allowed us to draw the following initial conclusions:

Lacquer might have been used in Cambodia in remote history, even though there is no archaeological evidence. However, lacquer trees growing in Cambodia on the sandy and alluvial plains within deciduous dipterocarp forests have already suggested their presence in geobotanic history in this part of the world. The interaction between lacquer and human life is obvious when humans realize and understand the important values and advantages of lacquer trees and lacquer saps in their lives. The knowledge obtained from the study of ancient

polychrome and lacquer mortar components remaining on the pre–Angkorian Buddha statue of Wat Kampong Luong, the survey of lacquer remains on the 12th century bas–reliefs of Angkor Wat, the conservation documentation, and scientific analysis of lacquer remains of the post–Angkorian Buddha statues in the central brick shrine of Pre Rup in Angkor, the study of lacquer work–related epigraphical records in combination with the ethnographic survey at the lacquer crafts village of Trea in Kampong Thom province, all allowed us to understand not only the history of traditional lacquer work but also the diversity of lacquer in its social, cultural, religious values and in its nature as a traditional and authentic material for cultural heritage conservation in Cambodia.

Early historical records of lacquer work in Cambodia were found in the 10th century Angkorian inscriptions when King Jayavarman V (AD 968–1001) established his royal corporation of lacquer for the holy chamber of worship, but the tradition of using lacquer was probably older than that. As seen in this research, lacquer has multiple functions, including coating, gluing, refilling, molding, and decorating material in the domain of traditional lacquer crafts, and has the capacity to receive a large variety of organic and inorganic additives to improve its fluidity and workability in conformity with the technical requirements of the masters of lacquer work.

The sacrifice of the hair bun of the Queen Mother of the 16th century Khmer king (K. 303) and the abandonment of the hair, eyebrows and chest hair of a noble man in the 16th century (K.715) to make "kmuk," obviously not for the technical purpose but rather for the pure heart of respectful devotion for the Buddha and Buddhism. Lacquer and lacquer mortar were well developed from the 15th to 18th centuries in Cambodia and primarily used to repair broken statues and to decorate or to make religious sculptures and other art objects. As a traditionally authentic material, lacquer has been successfully introduced into stone conservation works in Angkor even though more scientific research on ancient compositional attributes of lacquer found in various historical and cultural contexts needs to be considered in the future. The tradition of using lacquer in modern architecture, especially in modern religious buildings, is no longer practiced. This is perhaps because the lacquer is expensive since collecting lacquer sap is a manual rather than a mechanical operation taking time, energy, and financial resources. In addition, the tradition of harvesting and making traditional lacquer crafts continues in restricted and remote areas in Cambodia. The lacquer workshops seen today produce lacquered art objects for

commercial purposes, and the teaching of lacquer arts is conducted only at the Secondary School of Fine Arts. Further scientific research on traditional lacquer in Cambodia requires academic consideration; replanting lacquer trees should be encouraged, and revitalizing all kinds of traditional lacquer works is highly appreciated for Cambodia.

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Abbreviations

Acta Phytotax. Geobot. : Acta Phytotaxonomica et Geobotanica
APSARA: Authority of the Protection and Management of Angkor and the Region of Siem Reap
BEFEO: Bulletin de l'École Française d'Extrême–Orient
CKS: Center for Khmer Studies
EFEO: École Française d'Extrême–Orient
IC: Inscription du Cambodge
ICC–Angkor: International Coordination Committee for the Safeguarding and Development of the Historic Site of Angkor
IMA: Inscriptions Modernes d'Angkor
Nat. Hist. Bull. Siam Soc: Natural History Bulletin of the Siam Society
NIC: Nouvelles Inscriptions du Cambodge
RUFA: Royal University of Fine Arts
SCU: Stone Conservation Unit
UDAYA: Journal of Khmer Studies

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