

Javanese Limasan Architecture and 3D Modeling for the Revitalization of the Rumah Sandi Dukuh Heritage Site

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ABSTRACT	KEYWORDS
Rumah Sandi Dukuh is a Javanese <i>limasan</i> house in Kulon Progo, Yogyakarta, that served as an emergency post of the Dinas Code, Indonesia's wartime cryptography service, during the Second Dutch Military Aggression, and is now managed by Museum Sandi as an object presumed to be cultural heritage. Its revitalization programme had not been preceded by a systematic architectural study, leaving the building's historical form undocumented ahead of physical intervention. This study documents the identity, dimensions, and architectural style of Rumah Sandi Dukuh and produces a three-dimensional model as a technical reference for its revitalization. A qualitative case study carried out between September and December 2024 combined field observation and architectural measurement at the site, in-depth interviews with the museum officer responsible for the site and with a son of the original owner, and a literature study on heritage revitalization and Javanese vernacular architecture. Building-identity data were compiled on a Cultural Heritage Building Identity Sheet, and findings were triangulated across measurement and testimony before being modeled digitally. Rumah Sandi Dukuh, built before 1948, is found to be a <i>limasan apitan pengapit</i>, formed from two <i>limasan larwakan</i> units joined at the <i>emper</i> with a <i>talang air</i>, with a building area of 117 m² on a plot of 1,190 m². The resulting model, covering the building's ground floor, has been used by the Badan Siber dan Sandi Negara since November 2024 to guide the site's revitalization. The case shows how a small heritage institution can operationalize the documentation-before-designation principle of international conservation doctrine largely through manual methods.	3D modeling cultural heritage revitalization Javanese limasan architecture museum curatorship Rumah Sandi Dukuh  This is an open access article under the CC BY-SA 4.0 license.

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INTRODUCTION

Museum Sandi in Yogyakarta, the only cryptography museum in Indonesia, maintains a standing work programme within its Curator Assistant Division titled Rencana Revitalisasi Situs Rumah Sandi Dukuh (the Rumah Sandi Dukuh Revitalization Plan). Rumah Sandi Dukuh is a timber house in Dusun Dukuh, Purwoharjo, Samigaluh, Kulon Progo, originally owned by a resident named Mertosoetomo and built in the Javanese *limasan* style, a pyramidal-roofed vernacular house type; during the Second Dutch Military Aggression (Agresi Militer Belanda II) it functioned as an emergency post of the Dinas Code, the country's wartime cryptography service, relaying dispatches to General T. B. Simatupang at the Banaran headquarters. The building is today registered by Museum Sandi as an *objek diduga cagar budaya* (an object presumed to be cultural heritage), whose formal designation is still pending, and the revitalization programme aims to return its spatial layout, architectural elements, and materials to their historical condition.

Revitalization, in Rukayah's (2020) definition, is an effort to reanimate an area, precinct, or building whose social, cultural, or economic function has declined, through both physical and non-physical intervention, and for cultural heritage buildings specifically Widiyanto (2013a) sets out three guiding principles: restoring the arrangement of spatial function, reviving cultural values, and strengthening information about the heritage object. Indonesia's Law No. 11 of 2010 on Cultural Heritage (Republik Indonesia, 2010) further specifies that an object, building, or structure may be proposed as *cagar budaya* (cultural heritage property) once it is at least fifty years old, represents a distinct stylistic period, and holds special meaning for history, science, education, religion, or culture, while a site qualifies as *cagar budaya*, per Azizah et al. (2024) and Widiyanto (2013a), when it both preserves information about a past human activity or event and possesses at least one heritage element in the form of an object, building, or structure. Rumah Sandi Dukuh, built before 1948, meets the age threshold and is historically tied to a documented event, its wartime role in the Second Dutch Military Aggression, yet as an *objek diduga cagar budaya* it has not completed the verification and designation (*penetapan*) process the Law requires.

That documentation should precede, rather than follow, formal designation is not a claim unique to Indonesian regulation: it is a long-standing principle in international conservation doctrine. The Venice Charter's founding statement that historic monuments must be handed on in the full richness of their authenticity (ICOMOS, 1964) already implies that authenticity has to be established through record-keeping before an intervention can be judged faithful to it, and the Burra Charter makes this explicit by requiring that a place's cultural significance be understood and documented, typically through a statement of significance, before any conservation policy is set (Australia ICOMOS, 2013). Feilden (2003) goes further, treating a measured survey and historical research as the first practical steps of any conservation project, undertaken specifically so that later decisions about repair or reconstruction have something authoritative to be measured against. Read against this doctrine, Rumah Sandi Dukuh's undesignated status is not an obstacle to documentation but exactly the situation these charters anticipate: a place whose significance is locally understood but not yet formally recorded, for which documentation is the necessary first act of conservation rather than a bureaucratic prerequisite to it.

On the architectural side, the Javanese *limasan*, named for its pyramidal (*limas*) roof of a truncated quadrilateral topped by four triangular planes (Novriyadi, 2023), is understood as a later, larger modification of the *joglo* form (Tohar et al., 2019) that, unlike the *joglo*, was historically accessible to ordinary households rather than the aristocracy (Idham, 2018). Idham's (2018) comparative survey of *joglo* and *limasan* houses across Central Java and Yogyakarta documents this typological diversity at the scale of regional comparison across many buildings, using a measurement system whose underlying logic Prijotomo (1995) sets

out in detail, while Prihatmaji et al.'s (2014) study of *joglo* houses damaged by the 2006 Yogyakarta earthquake demonstrates, from a structural-engineering perspective, how vulnerable this kind of unreinforced timber post-and-beam construction is to loss, whether from natural disaster, neglect, or an uninformed renovation. Taken together, this literature supplies both a classification framework for a building like Rumah Sandi Dukuh and a caution about how easily its distinguishing structural details could be erased if revitalization proceeds without first recording them. What remains comparatively rare in this literature, however, is a documented account of how field-level architectural and historical findings for one specific, still-undesignated heritage building are translated into a concrete spatial reference, such as a three-dimensional model, that a small managing institution can use directly to plan a physical intervention; existing sources set out either broad regional typologies or general revitalization principles, neither of which operates at the scale of a single case.

The managing institution in this case, Museum Sandi, is itself a *museum khusus* (special-interest museum): an institution whose collection is organized around a single discipline, in this case cryptography (Maryam & Puspitasari, 2021), and whose broader function, following Gray and McCall (2020) and Falk and Dierking (2013), extends beyond exhibiting objects to collecting, safeguarding, and interpreting material evidence of a community's past for present and future publics. Managing an off-site historic building such as Rumah Sandi Dukuh, whose wartime function is directly continuous with the museum's cryptographic subject matter, falls within that same custodial mandate even though the building sits outside the museum's main premises in Kotabaru. Internationally, three-dimensional digital documentation has become an increasingly common tool for exactly this kind of custodial work: Historic Building Information Modeling (HBIM), as first formalized by Murphy et al. (2009), integrates measured survey data with parametric building elements into a single reusable model, an approach subsequently extended to unmanned aerial vehicle photogrammetry and terrestrial laser scanning of monumental heritage (Ulvi, 2021) and, within Indonesia specifically, to close-range photogrammetric documentation of *cagar budaya* buildings (Prasetyo, 2018). What these approaches share, whatever the data-capture technology involved, is the aim of turning fragile or endangered physical evidence into a stable, reusable spatial record before that evidence is altered or lost.

The gap this study addresses is therefore not an absence of publications on either revitalization doctrine or Javanese vernacular architecture, but a deficiency in documented knowledge at the scale at which small institutions actually work: no published account follows a single undesignated vernacular building from field measurement and oral testimony through to a spatial model that its managing institution then uses to direct physical intervention. This article is the first to document that complete sequence for an *objek diduga cagar budaya* under museum management in Indonesia. It accordingly aims to document the historical identity and dimensions of Rumah Sandi Dukuh, to classify its architectural style within the Javanese *limasan* tradition, and to translate these findings into a three-dimensional model that Museum Sandi can use as a direct technical reference for the site's revitalization, showing concretely how a small, resource-constrained institution can put an established conservation principle into practice for a single vernacular building using largely manual methods rather than the equipment-intensive techniques the international HBIM and photogrammetry literature typically assumes.

METHOD

Research Design and Approach

This study used a qualitative case-study design (Yin, 2018), an approach well suited to research questions that ask how a real-world process unfolds within its own context rather than seeking a generalizable statistical pattern (Creswell & Poth, 2018). Two bodies of theory were brought

to bear, at different points in the work. Widiyanto's (2013a, 2013b) three principles of heritage revitalization and the documentation-first sequence of the Venice and Burra Charters (Australia ICOMOS, 2013; ICOMOS, 1964) framed the interpretation of the findings and are applied in the discussion below, while the typological literature on Javanese vernacular architecture (Idham, 2018; Prijotomo, 1995; Tohar et al., 2019; Wibowo et al., 1998) supplied the classificatory vocabulary applied to the measured and photographed evidence at the analysis stage. Rumah Sandi Dukuh was not selected through a comparative sampling process across multiple candidate sites; it was studied as a single, purposively chosen case because it was the subject of Museum Sandi's existing Rencana Revitalisasi Situs Rumah Sandi Dukuh work programme, which made the site and its documentation accessible in a way a randomly or comparatively sampled site would not have been. This is consistent with Yin's (2018) observation that case-study research often begins from exactly this kind of practical access rather than from a prior sampling frame, provided the resulting analysis is transparent about the case's boundaries: here, one building, one revitalization programme, and one four-month documentation period.

Site, Period, and Participants

The study was undertaken between September and December 2024, with Rumah Sandi Dukuh in Dusun Dukuh, Purwoharjo, Samigaluh, Kulon Progo, as its sole case. One full survey visit to the site was made, on 24 September 2024, during which the building was measured and photographed inside and out. Three informants were interviewed, each selected by role rather than by availability: the son of the building's original owner, Bapak Ngadiman, as the only surviving family source for the house's pre-designation history; the officer responsible for the site at Museum Sandi (*penanggung jawab*), Febianus Rudy Wijayanto, as the holder of the institution's working knowledge of the revitalization programme; and the museum's curator, Asnan Arifin, as the authority on the site's status within the museum's collection policy.

Data Collection

Four techniques were combined. First, field observation and measurement recorded the building's current condition, its principal dimensions, and photographic documentation of its exterior, interior, and structural elements. Second, in-depth interviews with the three informants named above recovered oral-historical information not available in written sources, in particular the account of the building's wartime function. Third, a literature study was conducted on cultural heritage regulation and revitalization theory and on Javanese vernacular, and particularly *limasan*, architecture, to provide the analytical framework for classifying the building. Fourth, the building's identity was formally documented on a Lembar Identitas Bangunan Cagar Budaya (Cultural Heritage Building Identity Sheet), the standard instrument used in Indonesia to register an *objek diduga cagar budaya*, which fixes name, type, address, dimensions, materials, ornament, period, and heritage status in a single record.

The workflow that carried these findings from field documentation to a finished model was organized using the four functions of management, planning, organizing, actuating, and controlling, or POAC (Rohman, 2017), which the Curator Assistant Division applied as its working framework for the revitalization-planning programme as a whole. Planning consisted of assigning a person in charge to each sub-task, scheduling the site survey and interviews, and setting out the *kajian* (written study) and modeling stages. Organizing distributed those sub-tasks among team members according to their individual competencies, as summarized in Table 1. Actuating was the execution of each stage in sequence: survey and interview, *kajian* writing, and 3D modeling, under the ongoing supervision of the division mentor and the site's person in charge. Controlling took the form of periodic review meetings, in which draft findings and the developing model were presented to the mentor and museum staff for

feedback before the next stage began, and a final review before the completed *kajian* and model were handed over to Museum Sandi's management.

Table 1. Division of responsibilities in the documentation-to-model workflow

Role in the documentation-to-model workflow	Person in charge
Division mentor (oversight and approval)	Irawan Haris Wibawa
Person in charge of the Rumah Sandi Dukuh site	Febianus Rudy Wijayanto
Head of the Curator Assistant Division team	Fasya Saysabila Hapsari
Person in charge of the site-history <i>kajian</i>	R. Nurzulhiyyah
Person in charge of the Javanese <i>limasan</i> architecture <i>kajian</i>	Avril Ailsa Suha Maharani
Person in charge of the combined architectural-style <i>kajian</i>	Avril Ailsa Suha Maharani
Person in charge of the 3D modeling output	Dedy Setiawan

Source: Curator Assistant Division work plan, Museum Sandi, 2024.

Data Validation and Analysis

Analysis proceeded in four steps, following the triangulation logic set out by Miles et al. (2014), in which findings from different sources are treated as provisional until they are checked against one another rather than simply combined. First, the raw material was sorted into three categories: historical claims about the building's wartime use, physical attributes recorded by measurement and photograph, and typological features nameable within the *limasan* literature. Second, each claim in the first category was checked against the second: the two distinct roof heights recorded at the front and the rear of the building, for instance, independently corroborated the interview description of the house as a composite of two joined roof volumes, rather than the measurement and the oral account simply being reported side by side. Where measurement and testimony agreed, a claim was treated as established; where a claim rested on interview data alone, it is reported in this article as attributed testimony rather than as a settled finding. Third, the corroborated physical attributes were matched against the subtypes described by Wibowo et al. (1998) to arrive at a single architectural classification. Fourth, these triangulated findings were compiled into a written *kajian* that served as the *acuan modul* (reference module) for the study's applied output, a three-dimensional digital model of the building.

Research Ethics and Positionality

No institutional review board governs student research of this kind at the author's faculty, so consent was secured directly and in person. Each informant was told the purpose of the documentation and its intended use by Museum Sandi before the interview began, and gave verbal consent to be recorded and named; permission to photograph the building and to publish those photographs was granted by Museum Sandi as the site's managing institution and by the owning family through Bapak Ngadiman. Nothing recorded at the site is ritually restricted or personally sensitive. Two conditions of the study's position warrant disclosure. First, because the historical account of Rumah Sandi Dukuh's wartime role rests on interview testimony rather than on archival military records, it is reported here as oral testimony corroborated by physical evidence where triangulation was possible, rather than as independently verified historical fact, consistent with Yin's (2018) guidance that case-study evidence should be reported at the level of certainty the underlying data actually supports; Bapak Ngadiman's account, in particular, could be dated only approximately, since he was recalling family history passed down to him rather than direct wartime experience of his own. Second, the documentation was collected and interpreted from inside the institution whose programme it describes, through the author's placement in the Curator Assistant Division,

which is a common condition in practitioner-based case-study research (Yin, 2018) but one that almost certainly shaped which structural and historical details were judged worth recording, in ways an external researcher without that institutional knowledge might have approached differently.

RESULT AND DISCUSSION

Historical Background and Site Identity of Rumah Sandi Dukuh

Rumah Sandi Dukuh is a modest house built in a traditional Javanese architectural style, originally belonging to Bapak Mertosoetomo, a resident of Dusun Dukuh. Museum Sandi's curator described the site as a relic of the struggle of Indonesia's heroes to defend the country's independence, situated in Dusun Dukuh, Purwoharjo, Samigaluh, Kulon Progo (A. Arifin, personal communication, 24 September 2024). Its wartime role was described in more detail by the officer responsible for the site, who recounted that the house served as the emergency headquarters of the Dinas Code during the Second Military Aggression, becoming a centre of cryptographic activity and a checkpoint for *sandimen* (cipher operators) sending messages to T. B. Simatupang at the Banaran headquarters (F. R. Wijayanto, personal communication, 24 September 2024). The building's core identity data, compiled on its Lembar Identitas Bangunan Cagar Budaya, are summarized in Table 2.

Table 2. Cultural heritage identity of Rumah Sandi Dukuh

Attribute	Description
Name of <i>objek diduga cagar budaya</i>	Rumah Sandi Dukuh
Type	House (<i>rumah</i>)
Nature	Profane
Address	Dusun Dukuh, Desa Purwoharjo, Kecamatan Samigaluh, Kabupaten Kulon Progo, D.I. Yogyakarta
Dimensions	Length 14.35 m; width 9 m; height of front section 4.16 m; height of rear section 4.58 m
Building area	117 m ²
Land area	1,190 m ²
Primary materials	Wood and bamboo, combined with stone, marble, and reinforced concrete
Ornament	Geometric (<i>tumpal motif</i>)
Year of construction	Before 1948
Historical period	Independence era (<i>kemerdekaan</i>)
Heritage status	<i>Objek diduga cagar budaya</i> ; not yet formally designated (<i>belum ditetapkan</i>)

Source: Lembar Identitas Bangunan Cagar Budaya compiled by the author, 24 September 2024.

As Table 2 shows, the building predates 1948 and is classified under the independence-era period, corresponding to its documented use during the Second Dutch Military Aggression of 1948–1949, when Dutch forces occupied Yogyakarta and much of the Republic's civilian and military leadership was forced into the surrounding countryside. Rumah Sandi Dukuh's location in the hills of Samigaluh, away from the main roads under Dutch control, is consistent with the account of the house serving as an emergency post rather than a fixed headquarters, though the precise operational reasoning behind the choice of this particular site is not

documented beyond the interviews conducted for this study and would benefit from further archival verification. Its heritage status remains that of an *objek diduga cagar budaya* rather than a formally designated *cagar budaya*, which is consistent with Widiyanto's (2013a) observation that designation follows, rather than precedes, the documentation of a site's historical and physical information, and with the Burra Charter's (Australia ICOMOS, 2013) requirement that significance be documented before conservation policy is set, discussed further below.

Javanese Limasan Architecture as a Reference Framework

The *limasan* is one of the principal traditional house forms of Java, distinguished from the *joglo* by its simpler ornamentation and, historically, by its wider accessibility: while the *joglo* was largely confined to the aristocracy, the *limasan* was the form more commonly built by ordinary Javanese households (Idham, 2018). Structurally, Javanese textual sources describe the *limasan* as a modification of the *joglo*, developed by enlarging the *joglo*'s length and width (Tohar et al., 2019), and the *limasan*'s components are understood to respond to and represent the natural, social, and cultural conditions of its immediate environment. This combination of formal simplicity and environmental responsiveness makes the *limasan* category a suitable frame for classifying a modest, functionally adapted building such as Rumah Sandi Dukuh, which was a private dwelling before it was pressed into wartime service.

This typological placement also carries a practical warning. Prihatmaji et al.'s (2014) documentation of *joglo* houses damaged in the 2006 Yogyakarta earthquake found that the timber post-and-beam systems characteristic of both *joglo* and *limasan* construction concentrate structural resistance in a small number of load-bearing junctions, precisely the kind of connection visible at the *ander* (king post) in Rumah Sandi Dukuh's interior (Figure 2), such that damage or unrecorded alteration to those junctions can compromise a building's structural logic in ways that are not obvious from its exterior. Measuring and recording those junctions before any physical work begins, following the traditional measurement conventions (*petungan*) that Prijotomo (1995) sets out for Javanese architecture, is accordingly not simply a matter of historical completeness but a practical safeguard against a revitalization team unintentionally altering a structurally significant detail while restoring a cosmetic one.

Architectural Classification: Rumah Sandi Dukuh as Limasan Apitan Pengapit

Combining the field measurements, the interview data, and the literature on *limasan* typology, this study classifies Rumah Sandi Dukuh as a *limasan apitan pengapit*, a subtype formed by joining two *limasan lawakan* units, each built around its own *ander*, at their *emper* (verandah) and fitted with a *talang air* (rain gutter) at the join (Wibowo et al., 1998, p. 48). This composite form is visible in the building's current, pre-revitalization condition (Figure 1), where the two roof volumes and their shared verandah line remain legible despite the deterioration of the structure's cladding and floor. The building's interior further shows the timber post-and-beam system characteristic of the *limasan*'s structural logic (Figure 2), with the *ander* and its supporting columns still standing and providing the principal reference points used for the subsequent 3D reconstruction.



Figure 1. Rumah Sandi Dukuh prior to revitalization, exterior view

Photograph by the author, Dusun Dukuh, Samigaluh, Kulon Progo, 24 September 2024. Reproduced by permission of Museum Sandi.



Figure 2. Interior structural elements of Rumah Sandi Dukuh, showing timber columns and roof framing
Photograph by the author, Dusun Dukuh, Samigaluh, Kulon Progo, 24 September 2024. Reproduced by permission of Museum Sandi.

Beyond the *ander* itself, the *limasan* roof frame documented at the site follows the layered structural vocabulary described by Wibowo et al. (1998): a horizontal ring beam (*blandar*) carried on the main columns (*saka*), diagonal rafters (*usuk*) rising from the *blandar* to the ridge assembly, and a covering of clay roof tiles laid over a lath structure, with the paired-unit *apitan pengapit* form doubling this system across the shared *emper*. Measured against the building-identity data in Table 2, the roof's two distinct height points, 4.16 m at the front section and 4.58 m at the rear, correspond to the two joined *limasan latwakan* volumes rather than to a single unified roof plane, a detail that the field measurement made legible but that would not have been recoverable from oral testimony or archival photographs alone. Documenting this structural detail before revitalization began was necessary precisely because it is the kind of information that is difficult to reconstruct once cladding, flooring, or roofing members have been replaced.

Building Materials and Their Implications for Restoration

The material inventory recorded on the building-identity sheet (Table 2) lists wood and bamboo as the primary structural materials, combined with stone, marble, and reinforced concrete, and this mixture is itself analytically informative rather than merely descriptive. Timber and bamboo are the materials of the building's original vernacular construction: the *saka*, *blandar*, *ander*, and *usuk* are all timber members, while bamboo appears in the woven wall panels (*gedhek*) visible in the interior documentation (Figure 2). Stone and reinforced concrete, by contrast, are almost certainly later additions; the concrete plinth and the partial masonry visible along the base of the exterior in Figure 1 are not features of a pre-1948 rural *limasan*,

and their presence indicates that the building has undergone at least one round of undocumented repair since its wartime use. Distinguishing original fabric from later intervention in this way matters directly for revitalization planning, because the Venice Charter's requirement that later additions be respected unless they detract from the building's significance (ICOMOS, 1964) can only be applied if a project knows which elements are original and which are not.

The condition of the timber elements also bears on the urgency of documentation. Prihatmaji et al. (2014) note that the structural performance of Javanese timber houses depends heavily on the integrity of their jointed connections, which in tropical conditions are vulnerable to moisture ingress, insect damage, and progressive loosening, processes that, unlike sudden earthquake damage, occur slowly enough to go unnoticed until a member fails. The deterioration visible in Rumah Sandi Dukuh's cladding and flooring at the time of survey (Figures 1 and 2) suggests the building was already some distance into that process. This gives the documentation undertaken here a preservation value independent of its use as a revitalization reference: even if the physical revitalization had not proceeded, the measured record and 3D model would constitute a durable account of a structure whose original fabric may not survive indefinitely, which is precisely the rationale Murphy et al. (2009) and Prasetyo (2018) offer for digital heritage documentation more generally.

Conservation Doctrine and the Case for Documentation-First Practice

The approach taken here, producing a documented *kajian* and a 3D model before any physical intervention on Rumah Sandi Dukuh begins, sits squarely within the documentation-first tradition of international conservation doctrine introduced above. The Venice Charter's insistence that restoration must stop at the point where conjecture begins (ICOMOS, 1964) presupposes that a project has enough documented evidence to distinguish a conjectural reconstruction from a substantiated one; without the measurements, photographs, and oral testimony compiled in this study, a future revitalization team would have had no such basis for that distinction at Rumah Sandi Dukuh. The Burra Charter's process, understand significance, develop policy, then manage the place in line with that policy (Australia ICOMOS, 2013), maps closely onto the sequence followed here: the historical and architectural *kajian* correspond to establishing significance, the resulting 3D model functions as the spatial expression of a conservation policy of returning the building to its documented form, and the site's continued undesignated status means the formal management stage is still pending. Feilden's (2003) treatment of measured survey and historical research as the first practical steps of any conservation project is, in this sense, exactly what the *kajian* and building-identity sheet accomplish for Rumah Sandi Dukuh, notwithstanding that neither charter was written with a small regional museum's internal documentation workflow in mind, since both assume access to conservation professionals and resources that a small *kajian* team, working with hand tools and interview notes rather than laser scanners, did not have.

From Field Documentation to a 3D Model as Revitalization Reference

The *kajian* on Rumah Sandi Dukuh's history and the *kajian* on its *limasan* architecture were combined into a single reference module used to guide a three-dimensional digital reconstruction of the building, following the same basic logic Murphy et al. (2009) describe for Historic Building Information Modeling: survey and historical data are compiled first, and only then mapped onto a spatial model, rather than the model being built ahead of the documentation it is meant to represent. Unlike the laser-scanning and photogrammetric pipelines Murphy et al. (2009), Ulvi (2021), and Prasetyo (2018) describe, the Rumah Sandi Dukuh model was built manually from the measured dimensions in Table 2, the interview testimony, and the site photographs in Figures 1 and 2, without point-cloud or photogrammetric data capture, a lower-technology approach consistent with what a small

division without dedicated surveying equipment could realistically carry out. Every element visible in the field observation, the interview data, and the literature study was translated into the model in detail, so that the building's original form could be represented as accurately as the available evidence allowed (Figures 3 and 4).



Figure 3. Three-dimensional model of Rumah Sandi Dukuh, exterior view
Model by the Curator Assistant Division, Museum Sandi, 2024. Reproduced by permission of Museum Sandi.



Figure 4. Three-dimensional model of Rumah Sandi Dukuh, interior view
Model by the Curator Assistant Division, Museum Sandi, 2024. Reproduced by permission of Museum Sandi.

Because of time constraints and a shortage of personnel with 3D-modeling skills, the scope of the model was narrowed partway through the work from the whole of Museum Sandi's premises to the ground floor of Rumah Sandi Dukuh alone, a limitation the division flagged internally as a point for improvement in future documentation cycles. Within that narrowed scope, the model was completed, reviewed internally by Museum Sandi's Curator Assistant Division, and handed over to the site's management together with the underlying *kajian* documents. The Badan Siber dan Sandi Negara, which manages Museum Sandi (Badan Siber dan Sandi Negara, 2023), has used this model and its supporting documentation as a reference for Rumah Sandi Dukuh's physical revitalization since November 2024.

Museum Sandi's Institutional Role as Steward of an Off-Site Heritage Building

That Museum Sandi, a *museum khusus* built around a single collection theme, has taken on responsibility for a domestic building several hours from its own premises illustrates a broader point about how specialized museums manage heritage in Indonesia: their custodial mandate is defined by subject matter rather than by physical location. Rumah Sandi Dukuh's value to Museum Sandi does not rest on its architecture alone but on its documented role as a wartime node of the Dinas Code network, which makes it a physical extension of the same cryptographic history the museum's indoor collection already narrates (Badan Siber dan Sandi Negara, 2023). Under Gray and McCall's (2020) broader account of the museum's role, collecting, safeguarding, and interpreting material evidence for present and future publics, and Falk and Dierking's (2013) description of museums as institutions whose value depends on the meaning visitors and communities attach to what is preserved, this positions the revitalization programme not as a detour from the museum's core work but as a direct extension of it, carried out through the same curatorial competencies, *kajian*, registration, and

interpretation, that the Curator Assistant Division applies to indoor collection items. Assigning the site's documentation to curatorial staff working under a named mentor and site person in charge (Table 1), rather than to an external conservation contractor, further shows how a small institution can extend its stewardship to an off-site building without a dedicated conservation department, by embedding that work within its existing curatorial structure.

Organizing and Coordinating the Documentation-to-Model Workflow

The division of responsibilities in Table 1 shows a workflow with clearly separated but interdependent roles: historical and architectural *kajian* were assigned to different individuals so that documentary and stylistic analysis could proceed in parallel, while a single person in charge for the 3D model ensured that the two *kajian* were reconciled into one consistent spatial output. Coordination between these roles ran through the division mentor and the site's person in charge, both of whom reviewed draft findings at each stage before the next stage began, the controlling function of the POAC cycle described in the Method section. This structure meant that factual claims entering the model, such as the building's classification as a *limasan apitan pengapit* or its recorded dimensions, had passed through at least two levels of review, peer-level cross-checking between the history and architecture *kajian* and supervisory review by the mentor and site officer, before being built into the 3D reconstruction. The same structure, however, made the workflow sensitive to the availability of modeling-specific skills: because only one team member held primary responsibility for 3D modeling, the eventual narrowing of the model's scope to the ground floor tracked that single point of capacity more than it tracked any gap in the underlying *kajian*, which had been completed for the building as a whole.

Rumah Sandi Dukuh in Comparative Perspective: Small-Scale Heritage Revitalization in Indonesia

Rumah Sandi Dukuh's revitalization differs in scale and intent from the adaptive-reuse projects most often documented in the Indonesian heritage literature, which tend to involve converting urban colonial-era commercial buildings into cafés, boutique hotels, or retail space. Rumah Sandi Dukuh's revitalization follows a different logic: the building is not being adapted to a new use but restored toward its documented historical condition as a private house that briefly served a specific wartime function, and its intended audience is not primarily commercial foot traffic but visitors to a museum-managed heritage site.

The comparison is nonetheless useful because it clarifies what is, and is not, generalizable from this study. The documentation-then-modeling workflow developed here for a single rural timber house is unlikely to transfer directly to the very different technical and regulatory demands of adapting a masonry urban shophouse to commercial use. The underlying principle, however, that a small institution can produce a usable revitalization reference through low-technology documentation rather than by commissioning specialist survey services, plausibly extends to other small, non-monumental heritage buildings that under-resourced institutions across Indonesia are responsible for, whether or not those buildings are eventually adapted to a new function or, as here, restored toward their historical form.

A further difference concerns how the two kinds of project sustain themselves after the intervention. Adaptive-reuse projects of the Kayutangan type generate revenue from the new commercial function, which in turn funds ongoing maintenance; a restored house museum in a rural district has no comparable income stream and depends on its managing institution's continuing budget commitment. This asymmetry has a documentation implication that the adaptive-reuse literature does not need to address: for a site like Rumah Sandi Dukuh, the *kajian* and 3D model may need to serve not only the immediate revitalization but also any future maintenance or repair cycle carried out years later, possibly by different personnel, with no continuously funded conservation team in place to hold the knowledge institutionally.

Producing documentation that is legible to a future reader who was not present at the survey, rather than working notes intelligible only to their authors, is therefore a substantive requirement for this class of site rather than an administrative formality, and is one reason the building-identity sheet and the written *kajian* retain value alongside the visually more immediate 3D model.

Interpretive Potential of the Model Beyond Revitalization

Although the 3D model was produced as a technical reference for physical revitalization, its usefulness is not exhausted by that function. Falk and Dierking (2013) argue that a museum's value rests substantially on the meaning visitors construct from what they encounter, which for a site like Rumah Sandi Dukuh is complicated by two practical obstacles: the building sits several hours from Museum Sandi's main premises in Kotabaru, and its wartime significance is not self-evident from its appearance, since a modest rural *limasan* looks much like any other unless a visitor already knows what happened inside it. A spatial model that reconstructs the building's documented historical configuration offers a way to address both obstacles, whether displayed at the museum itself for visitors who will never travel to Samigaluh, or used on site to show what the building looked like in the period that gives it its significance.

This interpretive potential is, however, contingent on the model's current limitations being addressed. In its present ground-floor-only form, the model reconstructs the building's spatial envelope but not the roof structure whose *apitan pengapit* configuration is the basis of the architectural classification advanced in this study, which means the model cannot presently illustrate the very feature the accompanying *kajian* identifies as most architecturally distinctive. Extending the model upward would serve interpretation and architectural documentation simultaneously. Any interpretive use would also require a decision the present documentation does not settle: whether to represent the building as recorded in 2024, with its accumulated later repairs, or as reconstructed for the wartime period, and if the latter, how to signal to viewers which elements are documented and which are inferred, a question the Venice Charter's caution about conjectural restoration (ICOMOS, 1964) raises for digital reconstruction just as much as for physical intervention.

Implications for the Revitalization of Undesignated Heritage Sites

Read against Widiyanto's (2013a) three principles of heritage revitalization, the process documented here operationalizes each principle before formal designation is secured rather than after it: the building-identity sheet and historical *kajian* strengthen documented information, the architectural classification supports the revival of cultural value by clarifying which formal elements should be restored, and the 3D model operationalizes the restoration of spatial function by giving Museum Sandi and the Badan Siber dan Sandi Negara a shared reference for the intended layout. The reduction of the model's scope to the ground floor is itself an instructive finding rather than only a limitation: it shows that documentation-to-revitalization workflows for small, resource-constrained heritage institutions are as much a function of available time and modeling expertise as of architectural or historical complexity, a constraint that general revitalization guidelines (Widiyanto, 2013a, 2013b) and international conservation charters (Australia ICOMOS, 2013; ICOMOS, 1964) do not address directly, since both bodies of doctrine assume access to professional conservation capacity that a small regional museum may not have. Compared with the photogrammetry- and laser-scan-based documentation surveyed by Murphy et al. (2009), Prasetyo (2018), and Ulvi (2021), the manually modeled approach used here required far less specialized equipment but was correspondingly more labour-intensive per square metre modeled, which is consistent with why scope, rather than accuracy, was the parameter that had to give way under time pressure. For sites like Rumah Sandi Dukuh, whose significance is well attested historically but whose *cagar budaya* status remains administratively pending, combining ethnographic

documentation with even a partial digital model appears sufficient to give a managing institution a working basis for revitalization.

Limitations of the Evidence

Three limitations bound the claims made here. The first is evidentiary: the wartime history rests on interview testimony and has not been cross-checked against military or state archives, which means the account of Rumah Sandi Dukuh's operational role, while consistent across informants and compatible with the building's physical evidence, should be treated as well-supported oral testimony rather than as archivally established fact. Locating Dinas Code correspondence or Republican military records from the 1948–1949 period that reference the Dukuh post would materially strengthen the case for the site's significance, and would also supply the kind of documentary evidence the designation process is likely to require. The second is technical: the model covers the ground floor only, is built from manual measurement rather than point-cloud capture, and therefore carries dimensional tolerances that were not formally quantified during the survey, a gap that a subsequent photogrammetric survey of the type Prasetyo (2018) describes could close at relatively modest cost, since close-range photogrammetry requires a camera and processing software rather than a laser scanner. The third concerns the scope of the case itself: this study documents one building, and its conclusions about how small institutions can operationalize documentation-first conservation describe what proved workable at Rumah Sandi Dukuh rather than what would prove workable across the wider population of small heritage sites in similar administrative positions.

CONCLUSION

Rumah Sandi Dukuh is a *limasan apitan pengapit* of the independence era, formed from two *limasan lawakan* units joined at the *emper* and fitted with a *talang air* at the join, occupying 117 m² on a plot of 1,190 m², and it served as an emergency post of the Dinas Code during the Second Dutch Military Aggression. That classification rests on physical evidence rather than testimony alone: the two roof heights recorded at the front and the rear of the building establish the paired-volume form independently of what the informants recalled, and the stone and concrete elements recorded alongside the original timber and bamboo establish that the house has been repaired at least once since its wartime use. The three-dimensional model built from this record has guided the site's physical revitalization under the Badan Siber dan Sandi Negara since November 2024.

The contribution of the study is to show what documentation-first conservation looks like when it is carried out by a small institution on a building that has no formal heritage status. The measured record, the identity sheet, and the model together did the work that international doctrine assigns to professional survey: they fixed what was original, what was added, and what would be conjectural, before any physical intervention could blur the distinction. For museums and communities holding vernacular buildings in comparable administrative limbo, this indicates that designation need not be waited for, and specialist survey equipment need not be acquired, before a defensible revitalization reference can be produced; hand measurement, photography, structured interviews, and a modeling workstation are sufficient to meet the standard that matters, which is that later decisions can be checked against a record made earlier.

The study is bounded by one site, one four-month documentation period, and a model that covers the ground floor only, and its historical account rests on oral testimony that has not been confirmed against military or state archives. Three lines of further work follow directly. Archival research on Dinas Code and Republican military records from 1948 and 1949 would convert the wartime account from corroborated testimony into documented fact and

strengthen the designation dossier. A photogrammetric resurvey and the extension of the model to the roof structure would both quantify the dimensional tolerances left open here and allow the model to display the *apitan pengapit* configuration that is the building's most distinctive architectural feature. A comparative study of several small, undesignated sites under different managing institutions would then establish whether the workflow described here generalizes beyond the single case in which it was developed.

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Conflict of interest. The author carried out the documentation reported here as a member of the Curator Assistant Division of Museum Sandi, the institution managing the site, and this position is disclosed and discussed in the Method section. The author declares no financial or other competing interest.

Ethical approval and informed consent. No institutional review board with jurisdiction over research of this kind operates at the author's faculty; informed consent was therefore obtained directly. All informants were told the purpose and intended use of the documentation before interview and gave verbal consent to be interviewed and named. Consent to photograph the building and to publish the photographs reproduced here was granted by Museum Sandi as the managing institution and by the owning family. No identifiable persons appear in the figures.

Data availability. The field notes, measurement records, interview transcripts, the completed Lembar Identitas Bangunan Cagar Budaya, and the three-dimensional model files underlying this article are held by the Curator Assistant Division of Museum Sandi, Yogyakarta, and may be consulted on reasonable request to the museum, subject to its institutional access procedures.

Use of generative artificial intelligence. A generative artificial intelligence assistant was used for language editing and for formatting the manuscript to the journal template. It was not used to generate data, analysis, interpretation, or references. The author reviewed all output and takes full responsibility for the content of this article.

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