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Research Paper

A model of the adaptive reuse process of heritage buildings: Validation on four cases in the Netherlands

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Adaptive reuse (AR) of heritage buildings is a complex process involving many stakeholders with different ambitions. Recently, a theoretical model has been proposed to facilitate this process. However, the validation of this model and investigation of the nexus between process steps, methods/tools used by architects, and the effectiveness of projects are still lacking. This paper aims to validate the model by examining four AR projects in the Netherlands, considered effective as winners of a prestigious architectural prize. The research methods included literature reviews, case visits, and interviews with architects and other stakeholders. The model was refined, and methods/tools used by architects in the process steps were identified, highlighting their link with the effectiveness of results.

Keywords: adaptive reuse, heritage buildings, design model, design methods, built environment

1 Introduction

Adaptive reuse (AR) of existing buildings is becoming increasingly common, partly due to its alignment with sustainable development goals (Lewin & Goodman, 2013). A shift in attention and perception of the term "sustainability" is evident in the scientific literature, moving beyond merely enhancing the energy efficiency of new constructions to reusing the built environment (Abdulameer & Abbas, 2020). Additionally, there has been a rise in the number of papers discussing AR as a sustainable approach to the built environment in recent years (Arfa, Zijlstra, Lubelli, & Quist, 2022). In practice, the reuse of heritage buildings, not only as important relics from the past but

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also as sources of embodied energy contributing to a more sustainable environment, is increasing (Tam & Hao, 2019).

The AR of an existing building is complex (Kurul, 2007; Langston & Shen, 2007), and this complexity is heightened in the case of heritage buildings due to their cultural significance and the involvement of numerous stakeholders with diverse ambitions (Aigwi, Phipps, Ingham, & Filippova, 2021; Roos, 2007). Extensive research has investigated the role of different stakeholders within the AR process (e.g., Chatzi Rodopoulou, 2020; Misirlisoy & Günçe, 2016). However, despite architects playing a significant role in the AR process (Roos, 2007), there has been insufficient analysis of the process from their perspective.

In exploring the architectural profession, the broader field of design theories and previous research conducted in this area have been examined (e.g., studies by Darke (1979) and Bamford (2002)). According to these researchers, there are two main models for the design process from the perspective of architects: the "analysis-synthesis (A/S) model" and the "conjecture-analysis (C/A) model." The A/S model, developed in response to the tendency to systematize the design process, identifies four steps (Broadbent, 1966; Jones, 1970): a) briefing, b) analysis, c) synthesis, and d) evaluation. Some researchers have opposed this model, stating that "*There is no more rational procedure than the method of trial and error-of conjectures and refutations; of boldly proposing theories; of trying our best to show that these are erroneous; and of accepting them tentatively if our critical efforts are unsuccessful*" (Popper, 1972). This led to the initiation of the conjecture-synthesis model (Hillier, Musgrove, & O'Sullivan, 1972). The initiation of these models led to further research in the field of design processes to critique and propose modifications to the A/S and C/A models, resulting in the proposal that the process can also be a taxonomy of tasks and a combination of analysis, conjecture, and analysis (Bamford, 2002).

Regarding the AR of heritage buildings, which includes (re)design, the literature review reveals two main gaps despite the growing research on the AR process:

- The lack of validation of the existing AR process models from the perspective of architects in practice, to determine if and how the identified steps in the AR process are implemented.
- The lack of investigation into the nexus between the steps of existing AR models and the methods and tools used by architects, and the effectiveness of the AR project.

1.1 First gap in the process: the lack of systematic and validated models

Several theoretical models showing the different steps in the AR process are reported in the literature. However, most developed AR process models have not been validated in practice or have been validated considering a few steps of the process or only part of the stakeholders involved. For example, many models have been developed to identify the most appropriate functions for buildings, which is only one step in the AR process of heritage buildings. These models are Multi-Criteria Decision Making (MCDM) models, and some of them have been validated using AHP (Analytic Hierarchy Process) or ANP (Analytic Network Process) techniques (Balta (2022) and Vizzarri, Sangiorgio, Fatiguso, and Calderazzi (2021)). A few models addressed more steps of the process and attempted validation of the developed model through the investigation of effective AR projects and interviews with the engaged stakeholders. For example, Misirlisoy and Günçe (2016) developed a five-step model for the AR process, intended for use by all stakeholders involved in the AR process; however, the model does not consider the different groups of stakeholders and their roles and lacks validation in practice. Similarly, Van Hout (2021) developed a model based on a study of several effective cases in the Netherlands and interviews with stakeholders. While this model considers several steps of the AR process, the role of different stakeholders is not highlighted.

Few models and frameworks describing (part of) the AR process have focused on this process mainly from the perspective of architects (see Figure 1). Building on these models, the authors conducted a literature review of the field of AR in 2022 and subsequently proposed a theoretical model for the AR process of heritage buildings (Arfa, Zijlstra, et al., 2022). This model aims to cover all phases of an AR process, namely, pre-project, preparation, implementation, and post-completion, and seems comprehensive (see Figure 2). However, this theoretical model has not yet been validated in practice.

1.2 Second gap: criteria of effectiveness and the process

Next to the lack of validation of AR models, another gap in the literature on AR is the absence of a systematic analysis of the nexus between the AR process, including the methods and tools used by architects in the process, and the effectiveness of reuse projects. In 2018, and later modified in 2020, the European Quality Principles (EQP) were introduced by ICOMOS to guide all stakeholders involved in heritage conservation. One of the criteria for impactful interventions upon cultural heritage, as mentioned in this document, pertains to "Good governance" with a definition of *"The process is part of the success"* and includes points about "Good management, good performance, good stakeholder engagement, and good outcomes" (European Quality Principles for EU-funded Interventions with potential impact upon Cultural Heritage, 2020).

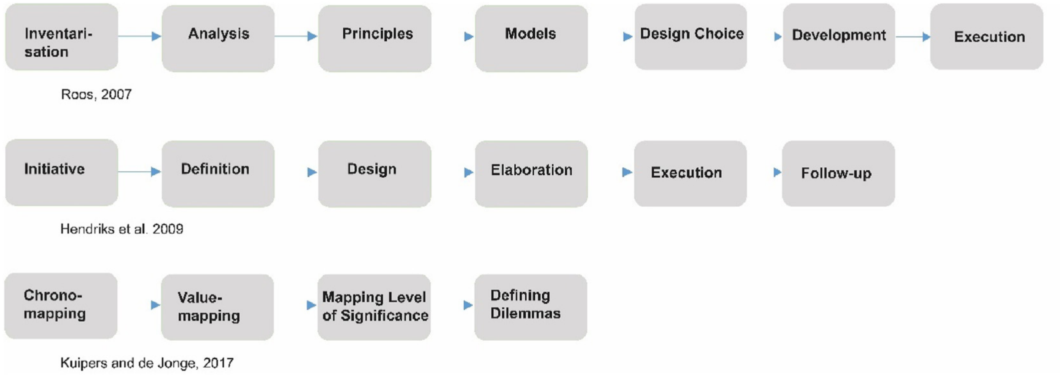

Figure 1 A collection of models and frameworks for AR process from the perspective of architects (Arfa, Zijlstra, et al. (2022))

Several publications investigated the mentioned criteria in the EQP document from different perspectives to make them applicable in practice. For example, the Leeuwarden Declaration on AR focused on the criteria of effectiveness and the process to ensure high-quality processes ("Leeuwarden Declaration, 2018"). Other authors identified the criteria of effectiveness in AR projects (Bosone, De Toro, Girard, Gravagnuolo, & Iodice, 2021). In 2022, Arfa et al. proposed a list of criteria based on a review of scientific literature and the jury reports of the NRP prize in the Netherlands (Arfa, Lubelli, Zijlstra, & Quist, 2022). However, in all cases, the investigation of the relationship between the process and the actual effectiveness of the AR project is lacking.

When considering the tools and methods used in the AR process, an overview of these methods, covering the entire process and their potential effects on the final result of AR projects, is still missing. Steps in this direction have been taken by Fava (2022), who specifically investigated bottom-up initiatives and citizen involvement in the AR process, aiming to add social values within the AR context.

To address the two gaps mentioned, this paper has two correlated aims:

1. To validate and refine the model proposed by the authors (presented in Figure 2) by analyzing the AR process in four effective AR projects, winners of the NRP Golden Phoenix prize in the Netherlands.

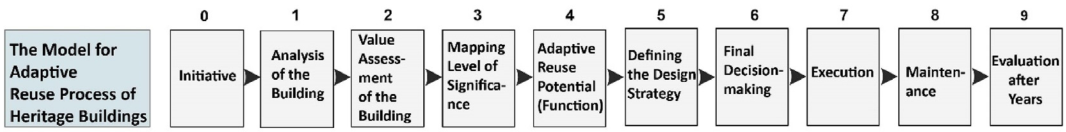

Figure 2 The theoretical model developed by Arfa, Zijlstra, et al. (2022)

2. To identify the nexus between the AR process and its actual effectiveness by analyzing the methods and tools used by architects and linking those to explicit statements in the NRP jury reports of the studied cases.

2 Material and methods

2.1 Selection of case studies

Various criteria were employed for selecting the AR projects discussed in this research:

- Location: The selected projects are situated in the Netherlands for several reasons:
  - The Netherlands is a prominent country in AR of heritage buildings (Veldpaus, Fava, & Brodowicz, 2019). Due to its dense population, there is a demand to repurpose existing vacant buildings, leveraging their inherent qualities to serve various community needs (Meurs & Steenhuis, 2017). In addition to this, in the Netherlands, heritage buildings are reused to be preserved in line with the approach of "conservation through transformation" (Janssen, Luiten, Renes, & Stegmeijer, 2017).
  - The authors are based in the Netherlands, facilitating easy access to visit the cases and interview relevant stakeholders.
- Effectiveness of AR projects: The cases were selected from the winners of the NRP[1] Golden Phoenix prize, a prestigious prize in the Netherlands, thereby ensuring their effectiveness.
- Change of function (adaptive reuse): The selected buildings have undergone significant changes in function and now serve public purposes, accommodating diverse groups of people.
- Monumental status: The chosen buildings are among the listed heritage buildings. It is recognized that the AR process for national, provincial, or municipal monuments is usually more complex compared to non-listed buildings.
- Located outside of G4 cities (Amsterdam, Rotterdam, Utrecht, and The Hague) ("Gemeentegrootte en stedelijkheid, n.d."): It was preferred that the selected cases be situated outside of these cities. This decision stems from the assumption that being located in these cities might positively influence case effectiveness, independent of the tools and methods employed by architects. Since this research aims to investigate the processes, methods, and tools utilized by architects, potentially leading to higher effectiveness, cases were chosen outside of these cities to mitigate any such positive impact.
- Availability of documents and willingness of the architects and other stakeholders to contribute to the research: The selected cases had ample documentation available, and their architects expressed willingness to contribute to this research.

These criteria led to the selection of four AR projects, which included the LocHal project in Tilburg, Energiehuis in Dordrecht, Blokhuispoort in Leeuwarden, and Fort van Hoofddorp in Hoofddrop.

2.2 Methods

A combination of qualitative methods was employed, including literature review, semi-structured interviews, and case visits. Published literature on the selected cases and documents provided by architectural firms were reviewed to gather background information for the case studies. Subsequently, the cases were visited to gain an impression of the project outcomes and their effectiveness.

In preparation for the case study research, a review of the literature focusing on case study research methods (e.g., Ying, 2018) was conducted. Case study research, particularly through interviews with architects, is a prevalent method for understanding (re)design processes (Darke, 1979; Roy, 1993). In this research, alongside visiting each case, architects responsible for the AR were interviewed to collect firsthand data about the process. The interviews were designed to address the following questions:

- Have the architects followed all the steps identified in the proposed theoretical model of AR (Figure 2)? If so, in what order?
- Which methods and tools did the architects utilize in the AR process?

Following the methodological approach proposed by Hennink, Hutter, and Bailey (2020), an interview protocol was developed. Questions were formulated (see Appendix 1), tested, and rehearsed in a pilot case. Subsequently, interviewees were selected, contacted, and interviewed.

Interviews carry the risk of bias, potentially reducing the reliability of collected data (Salazar, 1990). To address this risk, several strategies proposed by researchers in qualitative research methods (e.g., Hennink et al., 2020; Salazar, 1990) were implemented. These strategies included using open-ended questions, neutrally summarizing points mentioned by the interviewee, allocating similar timing to different questions, and utilizing probes during interviews.

To gain a comprehensive understanding of the architects' role within the selected projects and mitigate potential biases, interviews were also conducted with other stakeholders. A modified version of the questions (see Appendix 2) was used for these interviews. Stakeholders were selected based on either suggestions from architects or the authors' choice regarding the most involved stakeholders in the process.

It should be noted that this research adopted an inductive approach, drawing conclusions from case studies. While inductive reasoning typically lacks predetermined hypotheses, researchers still make implicit assumptions, as highlighted by Creswell (2009). In this research, it was assumed that observations accurately represent the studied phenomenon, implying the reliability and validity of collected data. Additionally, it was presumed that observed patterns are meaningful for theory development and that their interpretations reflect the true nature of the phenomenon. Implicit assumptions also exist regarding the generalizability of findings to other contexts or populations, as well as the relevance of the data collection context.

2.3 Analysis of collected data

The automatic transcription of recorded interviews was conducted using the Otter.ai tool and subsequently reviewed by the authors. Following this, the Atlas.ti tool was employed to support data analysis. To analyze the transcriptions of the interviews, three distinct groups of codes were created:

- Process steps codes: The questions were structured based on the theoretical model presented in Figure 2, aligning the content analysis with this model. Initially, all steps in the AR process mentioned by the architects were coded. Additionally, the questions included inquiries about the sequence of steps followed by the architect. Consequently, the order and interconnections between steps were analyzed. Based on the results, the authors drew a scheme for each case, illustrating the steps followed and the connections between them (see Section 3).
- Stakeholders codes: Segments of responses from interviewed stakeholders and architects, containing information on other stakeholders and their influence on the architects' role, were coded as "stakeholders." This code facilitated the development of conceptual schemes for each case in the results section, depicting the impact of other stakeholders on the architects' role.
- Methods and tools codes: At the end of each series of questions concerning a specific step in the AR process, when applicable, information about the methods and tools used by the architects was solicited. Responses to these questions were coded as "methods and tools."

Furthermore, the relationship between the AR process and the final effectiveness of the projects was further explored. This investigation was based on contextual analysis of the interviews and the effectiveness criteria outlined in the NRP jury reports of the winners, utilizing criteria and aspects identified and investigated by the authors previously (Arfa, Lubelli, et al., 2022). Effectiveness in AR projects was defined based on six criteria: "social value creation," "sublimation-architectural aspects," "sublimation-cultural aspects," "environmental sustainability," "economic value creation," and "innovation."

To ensure objectivity in evaluation, only the effectiveness criteria mentioned in the NRP reports of each case were considered. Consequently, the projects may have had additional positive impacts not mentioned in the NRP reports and thus not considered in this research. In compiling the results section of the paper, data collected from the literature on the cases and case visits were also utilized.

2.4 Terminology

Throughout the paper, certain terms are used repeatedly and may have varying interpretations. To maintain consistency, the following definitions have been adopted:

Adaptive reuse (AR): "The process of converting a building to a function that is significantly different from the original function" (Douglas, 2006).

Method: "*A particular way of doing something*" ("Cambridge Dictionary, n.d."). In this paper, the term refers to the specific way that architects act in the steps of the AR process.

Tool: "*Something that helps for doing a particular activity*" ("Cambridge Dictionary, n.d."). In this paper, the term indicates specific tools that architects utilize in various methods during the AR process.

Effectiveness: "*The ability to be successful and produce the intended results*" ("Cambridge Dictionary, n.d."). In this paper, the criteria of effectiveness in AR projects proposed by Arfa, Lubelli, et al., 2022 have been used to examine the relationship between the steps of the AR process and the project's effectiveness.

Stakeholders: The following terms are used to reference different groups of stakeholders (Aigwi et al., 2021):

- Users: The "user" stakeholder group is subdivided into three sub-groups
  - Original users, i.e., former tenants of a heritage building.
  - End-users, i.e., potential or future tenants of a reused heritage building.
  - Members of the community and passers-by.
- Producers: This group includes all participants involved in the preparation of an AR process, comprising various construction experts (e.g., architects, cultural history experts, environmental sustainability experts, etc.). These may vary for different projects.
- Investors: "Investors" in an AR process can be private owners of heritage buildings, funding agencies, governments, tenants, etc.
- Regulators: "Regulators" typically consist of government officials at the local and national levels whose role is to establish regulations and ensure

that "producers" strictly adhere to relevant regulatory procedures during the AR process. These regulations include building codes, health and safety regulations, heritage protection regulations, planning and zoning regulations, etc.

It should be noted that interviewees were either architects or other stakeholders from the groups of "investors" and "regulators," recognized and considered as the most influential stakeholders in the process. Therefore, whenever the text quotes "according to the interviewed stakeholders," it implies one of these two mentioned groups.

3 Results

In this section, the results of the data analysis are provided. The analysis includes a summary of the history of each selected case, followed by an analysis of the role of stakeholders and their influence on the architects' role during the AR process. Subsequently, the analysis provides an overview of the actual steps followed in the AR process, including the tools and methods employed, along with their possible effects mentioned in the NRP jury reports.

3.1 The LocHal project in Tilburg

3.1.1 A brief history of the LocHal

The LocHal (Locomotive Hall) is a former train workshop in the Spoorzone of the city of Tilburg in the Netherlands. This locomotive shed, dating back to 1932, was originally owned by the Dutch Railways and served as a facility for repairing defective locomotives. In 2010, the municipality of Tilburg acquired the hall from the NS (Dutch Railways). Plans were formulated in 2012 to repurpose the locomotive hall into the new Tilburg city campus. Subsequently, in 2015, the building was officially recognized as a municipal heritage site. The AR of the hall commenced in 2017, with a transformation period spanning two years. Ultimately, the building was repurposed into a center for art, culture, and community gatherings (see Figure 3), with the De Bibliotheek Midden-Brabant library being the largest user (Kok, n.d.).

3.1.2 Stakeholders in the adaptive reuse process of the building and their influence on the architects' role

The AR process of the LocHal was characterized by its complexity, owing to the involvement of various groups of architects, users, and other stakeholders, thus rendering it a participatory AR process. Figure 4 illustrates the stakeholders involved in the project and their respective roles, based on the collected data.

The project commenced with a European tender, wherein the architects asserted that their winning design struck a balance between affordability for

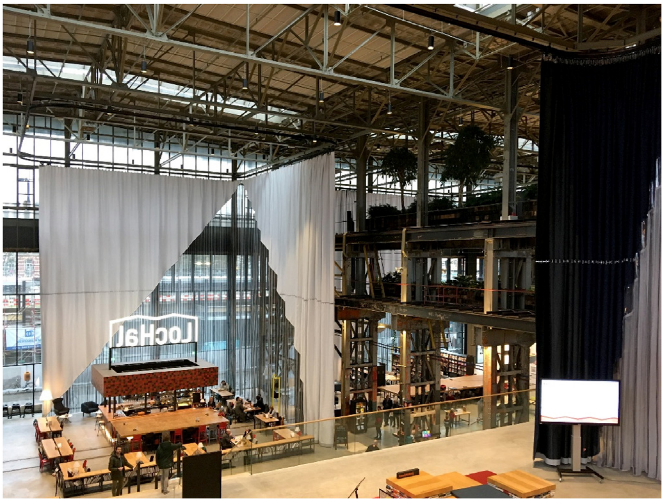

Figure 3 Interior of the main open space (library, café, etc.) of LocHal in Tilburg (Quist, 2020)

stakeholders and the added value it would bring to the community. Throughout the AR process, the municipality actively participated in monthly meetings with the architects, spanning from Steps 0 to 1 and Steps 3 to 6. Regulators were engaged in the early steps (Steps 0 to 4) as well as later steps (Steps 5 and 6) and were influential on the architects' strategies (see Figure 4). Nevertheless, the architects made concerted efforts to reconcile the demands of investors and regulators with their own design proposals.

Various groups of producers were involved in the project, such as ARUP company for contributing to the improvement of the building's energy efficiency and environmental sustainability. Discussions with the original users played a pivotal role in recognizing the intrinsic values of the building. According to one architect, "It's not just about the historic values but also the social values related to the space and function."

3.1.3 The AR process and the used methods and tools in the AR process of the LocHal project

The Braaksma & Roos office conducted the heritage analysis, sourcing data from NS archives in Tilburg and Amsterdam. Collaborating with cultural-historical experts, the architects assessed the building's value and mapped the significance of its elements to decide which parts to keep and which parts to modify.

The AR of the building, as recognized by NRP jury reports, showcased specific cultural sublimation effects. These effects included "respect for history, authenticity, and materials," as well as "preservation of heritage building characteristics" ("LocHal, 2019"). The positive outcomes may be attributed to

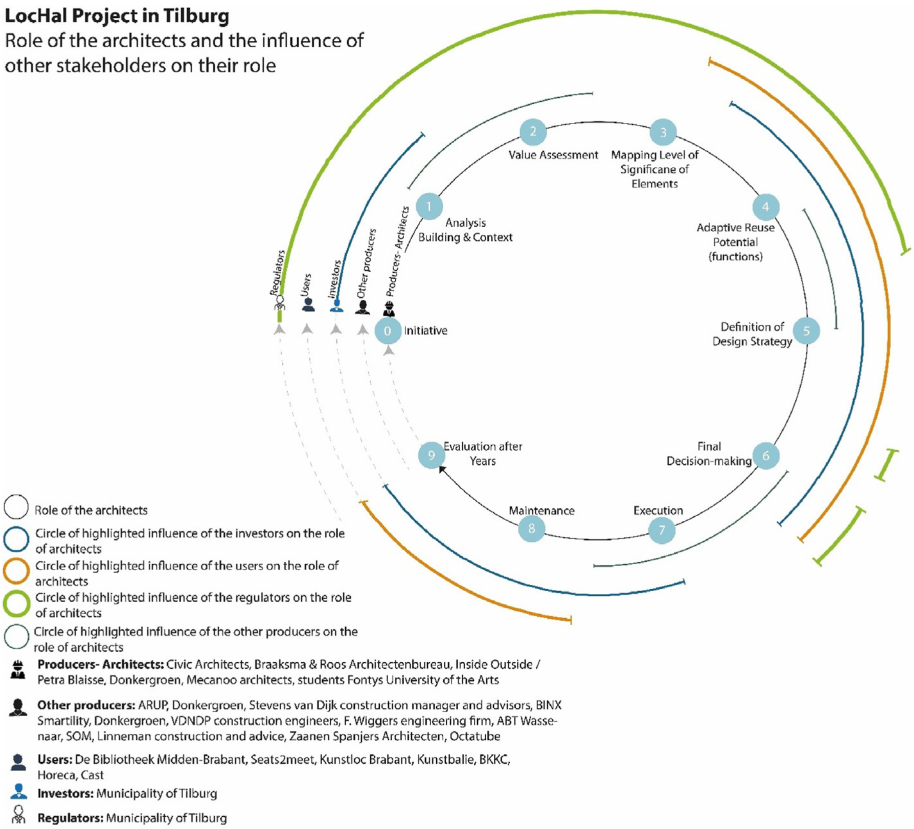

Figure 4 The involvement of the architect and other stakeholders in the AR process

meticulous data collection from various archives, site analysis, and regular building visits during Steps 1 to 5.

Following the preliminary steps, architects engaged end-users in multiple meetings to understand their needs. Involving end-users throughout the process, architects presented diverse sketches, 3D models, and renders for feedback.

In defining the design strategy (Step 5), interviews revealed several key approaches employed by the architects:

- Maintaining the building's originality and spatial qualities while enhancing its attributes.
- Upgrading previous technologies used in the heritage building.
- Facilitating open dialogs with end-users, to incorporate their input judiciously.
- Employing innovative strategies rather than traditional approaches, such as constructing closed boxes within the heritage building.

- Enhancing connectivity within the building and prioritizing occupants' well-being and interior climate quality.
- Adopting a continuous and cyclical approach to the reuse process, exemplified by their developed model (Figure 5) based on Nota Belvedere ("Nota Belvedere, 1999").

Furthermore, positive impacts noted by the NRP jury included the "creation of multifunctional spaces," "clear orientations in the new design," "creation of a pleasant atmosphere," and "effective preservation through contemporary additions" ("LocHal, 2019"). These architectural impacts were influenced not only by methods and tools but also by the design strategy employed. Thorough spatial analysis, multiple visits, and observation of other effective AR projects of industrial heritage buildings contributed to the development of an effective interior landscape focused on users' needs.

The interviewed architects and stakeholders reported they had regular meetings with various stakeholders. They mentioned that the positive attitude of the stakeholders made the final decision-making (Step 6) rather smoother than what was expected. That being said, according to the architects, "final decision-making" was the point where some new challenges arose and it was the point that a further check on the previous steps was needed. For example, one of the stakeholders was not satisfied with their place entrance design in the LocHal building. Thus, the architects needed to recheck the previous steps and reach to a consensus with the stakeholders before execution.

According to the architect, execution (Step 7) was generally successful, attributed to the contractor's flexibility and eagerness to establish their company's reputation through the project, despite challenges and disagreements. Architects remained involved post-completion to address design modifications if

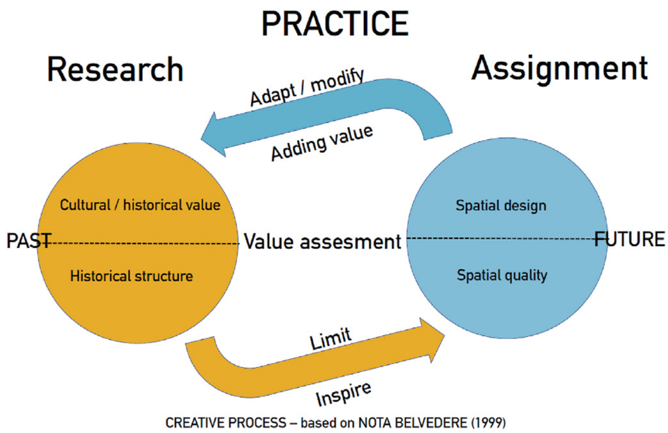

Figure 5 The creative process applied by the architects (Graeven, 2019)

needed (Step 8), such as altering a door design to address indoor climate issues several months after execution.

Architects mentioned the "evaluation after years" (Step 9) as an important step in which architects learn to reflect on their projects and draw lessons for future projects. Systematic analysis by architects involved regular visits to LocHal, brief conversations with end-users and tenants, and gathering feedback. Although interviewees expressed overall satisfaction with the outcome (the interview was conducted in 2022), one critique centered on the interior design, suggesting a desire for a more industrial and contextually connected esthetic: "*The interior design is fine, but we would have liked something that was really more industrial and more connected to the building. It's a typical interior design that you see in every library and building.*"

The NRP jury report highlighted a wide range of aspects provided by the AR of this building, including various benefits such as "strengthening community attachment" and "creating an inclusive environment" ("LocHal, 2019"). Original and end-users played crucial roles throughout Steps 1 to 9. Architects involved original users in Steps 1 and 2 to gather their ideas about the building and its potential positive or negative aspects. Subsequently, architects engaged with end-users in Steps 4 to 7 for further discussions regarding their needs. Finally, they monitored the building and community satisfaction in Step 9.

The architects from the Braaksma & Roos office provided positive feedback on the theoretical model (Figure 2), acknowledging its insightfulness and accuracy regarding the sequence of steps. However, they highlighted the complexity of certain steps beyond the simplistic depiction of straightforward arrows. They noted that some steps contained inner loops, complicating the process. They emphasized that "final decision-making" introduced new challenges, particularly involving stakeholders, necessitating a revaluation of previous steps (Steps 1, 2, and 3) and impacting subsequent ones (Steps 4 and 5). They advocated for a more participatory approach, involving a wide array of stakeholders, including users, from the outset to mitigate challenges. Nevertheless, they acknowledged that even with increased participation, the steps leading to execution (Step 7) remained non-linear.

The codification of interview transcripts provided insights into the actual steps followed in the AR of the LocHal project (Figure 6), reaffirming the complexity and iterative nature of the process described by the architects.

3.2 Energiehuis Project in Dordrecht

3.2.1 A brief history of the Energiehuis

The Energiehuis, situated in Dordrecht, the Netherlands, is a former power station dating back to 1910. Originally constructed in three phases, the

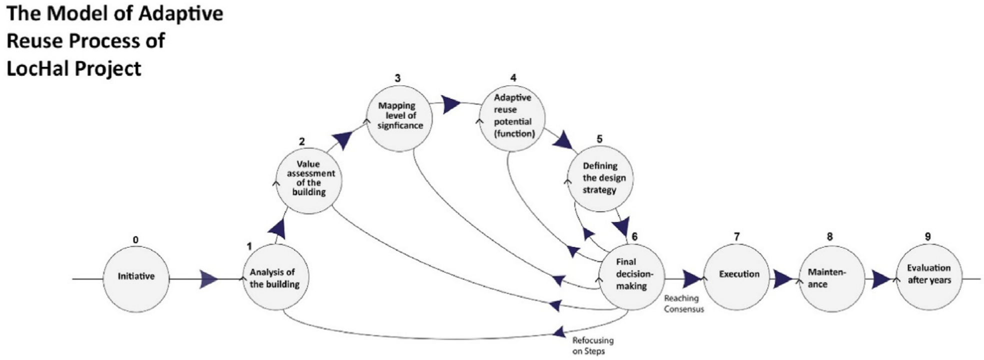

Figure 6 The AR process of the LocHal, based on the analysis of the process and the interviews with stakeholders

Energiehuis comprises six machine and boiler halls, making it a significant industrial heritage building. With the inauguration of a modern energy plant in 1960, the Energiehuis ceased to serve its primary function as a power station. In 2011, the AR project of this building commenced. By 2013, the Energiehuis had been transformed into a vibrant cultural center, serving as a stage, production house, rehearsal space, and educational and meeting venue for both amateurs and professionals, including young makers and producers. The municipality of Dordrecht had the vision to swiftly transform the Energiehuis into a prominent regional cultural and recreational attraction. Following its AR, the Energiehuis was officially listed as a municipal monument. According to a stakeholder interviewed, this listing occurred post-project completion to mitigate potential limitations arising from its historical significance (Chatzi Rodopoulou, 2020; "Energiehuis, Dordrecht, n.d."). Figure 7 illustrates the building's appearance post-AR.

3.2.2 Stakeholders in the adaptive reuse process of the building and their influence on the architects' role

Figure 8 outlines the stakeholders involved in the project and their respective roles, based on the collected data. The municipality of Dordrecht initially aimed to establish a new theater for the city but faced opposition from certain political factions regarding the AR of the building. However, through persuasion and consensus-building, the municipality proceeded with a tender process, ultimately selecting the TenBrasWestinga firm to lead the design.

Investors consistently supported the process, playing a facilitative role. The responsible authority within the municipality effectively guided proceedings throughout.

Regulators, instrumental in the project's initiation and decision-making step, demonstrated a commitment to realizing the project as a source of pride for Dordrecht. They actively supported its accomplishment.

Figure 7 Interior of the main corridor of Energiehuis Project in Dordrecht (2022)

Producers, including engineering companies (see Figure 8), engaged at various steps of the process, displaying flexibility in adjusting plans to accommodate changes driven by budget constraints. Motivated by the project's scale, they remained committed to its success.

Following their successful bid, architects conducted meetings with end-users to ascertain their requirements. However, subsequent budget cuts necessitated modifications to the design schemes. The architects' adaptability in response to these changes proved pivotal in sustaining the project's momentum.

3.2.3 The AR process and the used methods and tools in the AR process of the Energiehuis project

The selected architecture firm was invited by the municipality of Dordrecht to participate in the tender process. Upon winning the tender, the architects diligently proceeded through each step, including extensive data collection, notably involving original users.

End-users' input regarding their requirements was solicited in Step 4. During the meetings with end-users, the architects employed various tools, such as 3D renders, to articulate ideas effectively.

As highlighted in the NRP jury report, some positive impacts of the AR project included "clear orientations in the new design," "increased functionality of the heritage building," and "effective preservation through contemporary additions" ("Cultuurcentrum Energiehuis, 2014"). The architects prioritized recognizing and enhancing the architectural values of the building, employing architectural tools such as sketching and capturing photos for understanding

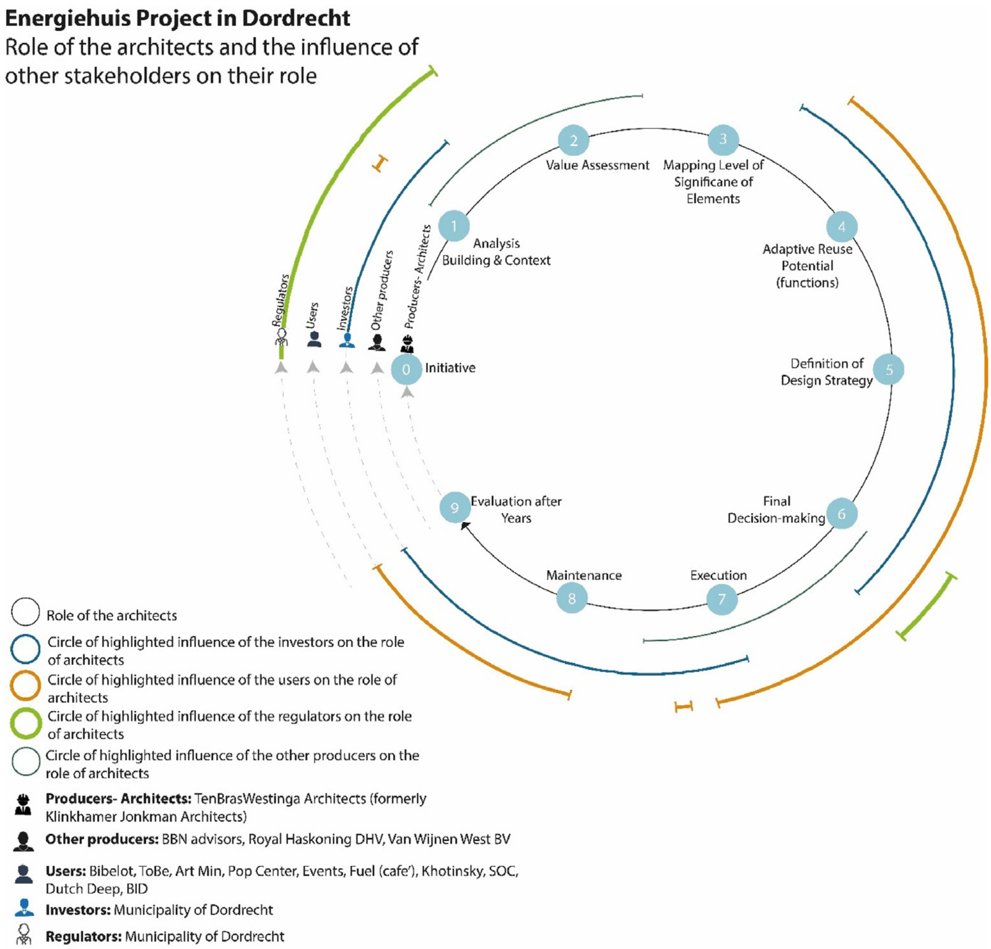

Figure 8 Role of the architects and the influence of other stakeholders on their role based on the analysis of the collected data

the space and 3D renders to facilitate discussions with producers regarding potential interventions.

Analysis of interviews revealed several design strategies applied by the architects in Step 5:

- Showing the scars of the heritage building instead of fully covering them with plasters.
- Making old and new parts of the building visible.
- Preserving the authenticity of the building.

According to the interviewees, close collaboration between architects, regulators, and investors facilitated smooth decision-making in Step 6. However, issues arose during cost calculation, necessitating a reduction of built area, and prompting architects to revisit previous steps for modifications.

In Step 7, mediation by architects resolved conflicts between regulators (who were investors as well) and one group of producers regarding deadlines. The exemplary cooperation among stakeholders highlighted in the NRP jury report ("Cultuurcentrum Energiehuis, 2014"), may have been influenced by their common goal, as was understood during the interviews, to elevate Dordrecht.

The NRP jury report highlighted several positive aspects, including the Energiehuis serving as a "vibrant cultural, educational, and social center that meets the needs of residents and others." It also noted the "significant positive impact on the surrounding area" ("Cultuurcentrum Energiehuis, 2014"). The involvement of original and end-users at various steps raised awareness about the project and its values. Furthermore, the engagement of local producers, such as construction companies, likely increased community attention to the building. Architects remain actively involved in aftercare (Step 8), intervening when changes are necessary. According to the interviewees, they do no visit the project regularly (Step 9), but only if a change is needed.

The main architect evaluated the theoretical model (Figure 2) as helpful for future assignments but suggested renaming Step 8 from "maintenance" to "aftercare," emphasizing that maintenance is mainly technical but the architects' responsibilities involve adapting the previous design and providing ongoing care for the project. He found the model too simplified, noting that all steps from analysis (Step 1) to final decision-making (Step 6) involved inner loops. According to him, in Step 6, budget constraints necessitated a reduction in construction areas, requiring a revaluation from Steps 1 to 4. Additionally, issues arose in Step 4 regarding the location of a business within the building, prompting a reconsideration of Steps 1 to 4 to reach a consensus with the end-users. Figure 9 outlines the AR process of the Energiehuis based on interviews and collected data.

3.3 Blokhuispoort in Leeuwarden

3.3.1 A brief history of the Blokhuispoort

The Blokhuispoort is a historic complex in Leeuwarden that formerly served as a detention center until December 2007. Due to its inability to meet modern safety standards, the complex ceased its correctional operations. Built in 1877, the complex sits on a site with a prison history dating back to the 16th century, featuring 180 cells. It holds the status of a listed national monument. Following the closure, the complex underwent AR, acquiring various new functions. Since 2015, ownership has been held by BOEi (Organization for the Restoration and Adaptive Reuse of Cultural Heritage in the Netherlands),

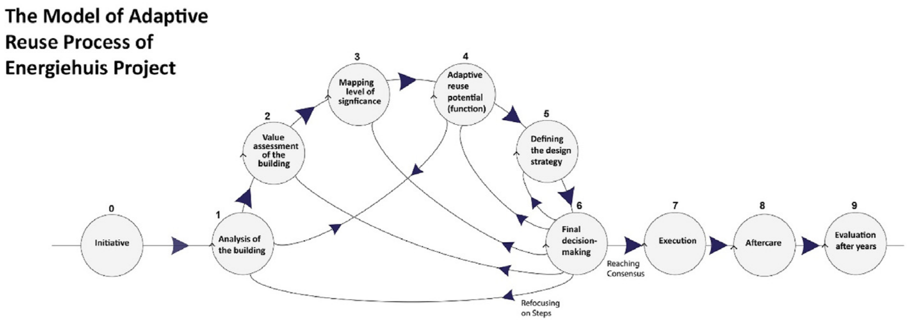

Figure 9 The AR process of the Energiehuis, based on the analysis of the process and the interviews with stakeholders

with support from the municipality of Leeuwarden and the province of Friesland. In 2018, coinciding with Leeuwarden's designation as the European Capital of Culture, the Blokhuispoort became a focal point for cultural activities, serving as a vibrant hub for the city. Within the complex, visitors can explore the library (Figure 10), offices for start-ups, attend concerts, enjoy catering facilities, and even host events.

3.3.2 Stakeholders in the adaptive reuse process of the building and their influence on the architects' role

Figure 11 delineates the stakeholders involved in the project and their respective roles, based on the collected data. Investors included BOEi, the Municipality of Leeuwarden, and the Province of Friesland. BOEi was tasked by the municipality to lead the reuse project. The municipality of Leeuwarden, acting as both regulator and investor, aimed to relocate the city's library to the Blokhuispoort. TWA architecture firm joined the AR process between Steps 0 and 1. Different groups of producers were involved in the project. For example, cultural-historian experts influenced the architects' decisions

Figure 10 Interior of the library of the Blokhuispoort Project in Leeuwarden (2021)

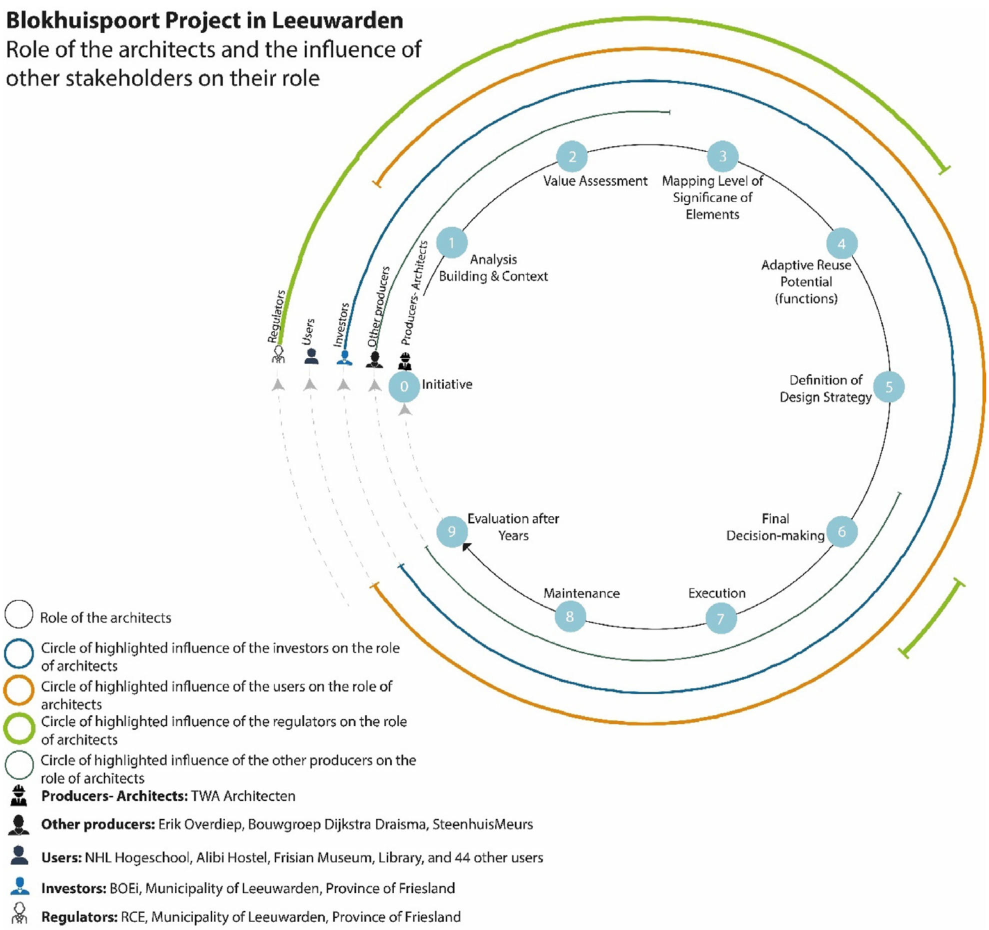

Figure 11 Role of the architects and the influence of other stakeholders on their role based on the analysis of the collected data

from Steps 1 to 4, offering insights without restricting design strategies. The primary user, the Library of Leeuwarden, initially resisted relocation but eventually agreed after persuasion from regulators and investors. Several meetings were held with tenants, original users, and architects to address concerns and progress with the project.

3.3.3 The AR process and the used methods and tools in the AR process of the Blokhuispoort project

The municipality invited the architect to conduct a feasibility study for the complex. Together with stakeholders from RCE,[2] they determined that a library and hostel would be suitable for the site. Due to project urgency, many steps were simultaneously undertaken. Step 1 involved analyzing the building and its context, leading to a conclusion that maximizing public accessibility was crucial. in the NRP jury report. According to the NRP jury report, increasing accessibility is one of the positive effects of the project ("Blokhuispoort, 2018").

The interviewed architect criticized the tool proposed by RCE (Hendriks & Van der Hoeve, 2009) for mapping the level of significance (Step 3). This tool has three colors, including blue, green, and yellow, for categorizing the historic values of the heritage buildings. According to the architect, *"Green is a little bit important and yellow is not important. If you take care of the blue parts, you can remove the other parts; but I did not use this tool as there are social and collective values in those yellow parts as well."*

According to the interviewed architect and stakeholder, Step 4 (adaptive reuse potential (function)) was not conducted in a systematic order after Step 3. However, the NRP jury report has highlighted "finding an appropriate use to secure the future of the heritage building" as a significant aspect of architectural sublimation in this AR project. Moreover, in the same report, the chosen function has been appreciated for "housing smaller businesses and workshops spaces for creative businesses," which has led to the positive effect of economic value creation. Moreover, a notable outcome mentioned in the NRP jury report was "strengthening the local community's attachment to the site" ("Blokhuispoort, 2018"). The data analysis showed that it was achieved through the involvement of original users in Steps 1 and 2 and regular meetings with end-users from Step 4 to the end.

Several design strategies (Step 5) could be identified from the analysis of the interviews:

- Adding a new chapter to the history of the building.
- Applying a unified style to the interior and exterior design of the entire complex.
- Combining technical solutions with improved functionality and well-being.

These design strategies might have led to the sublimation-cultural effects highlighted in the NRP jury report as "telling the history of the building by using digital and innovative technologies" and "preservation of the unity of the heritage building" ("Blokhuispoort, 2018").

Triweekly meetings facilitated smooth decision-making (Step 6), with a focus on completing essential parts due to budget constraints.

During the execution of plans (Step 7) the architect played an active role, overseeing quality and accuracy on-site. Despite smooth progress, high costs necessitated prioritizing essential areas like the library, delaying others. According to the architect, BOEi's management of the process, particularly in execution, proved invaluable. The interviewees emphasized the positive effect of the extensive experience of BOEi and their team in managing the execution, contracts, and hiring professional producers in this step.

Monitoring and maintenance (Step 8) are handled by BOEi, with the architect being consulted if a change in function and design is needed.

Evaluation of the project (Step 9) lacks a systematic approach and primarily relies on feedback from various committees (e.g., NRP prize) and stakeholders (such as architects and producers). This feedback is collected through visits to the buildings and unstructured interviews with end-users. Notably, the library within this complex (dbieb) was awarded the best library in the Netherlands in 2019 (Petra Starink, 2019).

The architect interviewed acknowledged the potential utility of the theoretical model (Figure 2) for the AR process. However, he underscored that the implementation of the process for Blokhuispoort was not as systematic as depicted in the figure, primarily due to time constraints. He remarked, "*There was no time to go through the process step by step; sometimes we had to do a brief analysis [Step 1] and then immediately develop a design strategy [Step 5]*." Nevertheless, the analysis of the collected data indicated that all the steps were still incorporated into the process. Various steps were concurrently underway in different parts of the complex. For instance, while architects were finalizing design strategies (Step 5) for a part of the complex, other parts were at the analysis step (Step 1). This approach sometimes necessitated adjustments to the architect's strategies for other parts (as indicated by the arrow from Step 6 to Step 5). This highlights the pragmatic nature of the reuse process, with steps occasionally conducted in reverse order (Steps 1 to 6 and sometimes Steps 6 to 5, 4, 3, 2, 1). Analysis of responses from interviewed architects and stakeholders, along with transcript codification, elucidated the steps of the process (Figure 12).

3.4 Fort van Hoofddorp in Hoofddorp

3.4.1 A brief history of the Fort van Hoofddorp

Fort van Hoofddorp, situated in the province of North Holland, is a municipal monument dating back to 1904. As a part of Stelling van Amsterdam defense line, it was designated as a UNESCO World Heritage site in 1996. The fort served various functions over the years. Initially utilized as a fortification, it later housed a local shooting club and briefly functioned as a music school. In 2010, two private individuals spearheaded an initiative for its AR, proposing its transformation to the municipality. Securing financial backing for the project proved challenging, resulting in a prolonged process. Finally, in 2020, the building was unveiled to the public as a multifunctional cultural center (Figure 13), featuring educational, recreational, and event spaces, alongside a theater ("Fort van Hoofddorp, n.d.").

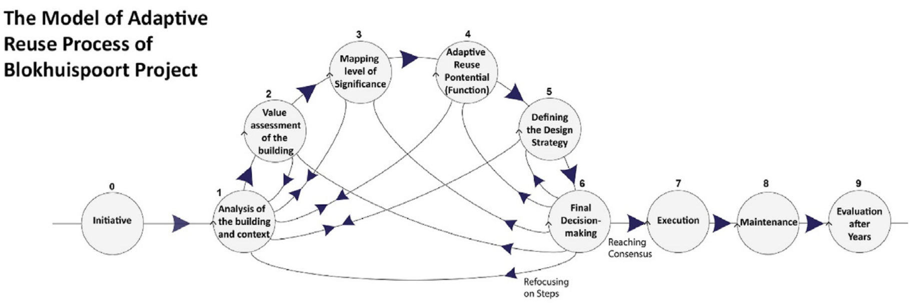

Figure 12 The AR process of Blokhuispoort, based on the analysis of the process and the interviews with stakeholders

3.4.2 Stakeholders in the adaptive reuse process of the building and their influence on the architects' role

Figure 14 illustrates the key stakeholders involved in the AR process of Fort van Hoofddorp, based on the collected data. The project was initiated by two private individuals, one of whom also served as the project's architect. However, it took eight years to secure adequate financial support for the project's realization.

Regulators played a supportive role by offering initial funding for feasibility studies, which was crucial for initiating the project. Additionally, producers aided architects in construction analysis and historic-cultural value assessments of the building.

Furthermore, engaging with the local community was integral to the process, particularly the fort's neighbors. Regular meetings were held to raise awareness about the project and garner support from the community.

Figure 13 Interior of one of the educational rooms of Fort van Hoofddorp (2022)

3.4.3 The AR process and the used methods and tools in the AR process of the Fort van Hoofddorp project

The two private individuals initiated the project, with one of them serving as the project architect. Consequently, they swiftly progressed through Steps 1 to 5. The NRP jury recognized the innovative nature of this private-led initiative, acknowledging its positive impact and potential as a replicable model for similar cases, particularly concerning vacant forts in the Netherlands (NRP Jury Report, 2021).

Upon presenting the design to the municipality and seeking a building permit (Step 6), the lack of investors delayed progress for years. Subsequently, upon securing financial support, one of the initiators (the architect) revisited Steps 1 to 5, meticulously preparing detailed drawings and designs. During this period, he considered input from other stakeholders while also adhering to his own approach.

The evaluation by the NRP jury highlighted several positive impacts as sublimation in cultural aspects, including the "realization of a heritage building with future value," "presentation of the site's history for public viewing," and "preservation of the building's unity" (NRP Jury Report, 2021). Additionally, aspects such as "creating a pleasant atmosphere," "effective preservation via contemporary additions," and "attention to detail in recuperating the building" were noted as sublimations in architectural aspects. The identification of spatial qualities and values of spaces, identified in Steps 1 to 4, and regular site visits during these steps likely contributed to these outcomes.

Regarding the definition of design strategy (Step 5), analysis of the interviews revealed the following strategies applied by the architects:

- Preserving and enhancing the spatial and esthetic qualities and atmosphere of the building rather than simply maintaining its original state.
- Designing appropriate additions and modifications in the building to make it more functional and comfortable.

During final decision-making (Step 6), the architects and the municipality engaged in numerous meetings with residents to address concerns and obtain permits, spanning two years. The project was recognized for its social value creation, but the need for further validation over time was noted by the NRP jury. Increasing involvement from the local community in current activities could enhance this aspect (*NRP Jury Report, 2021*).

As the main architect also serves as the investor, he is actively involved in aftercare (Step 8), regularly visiting the project and evaluating it from various

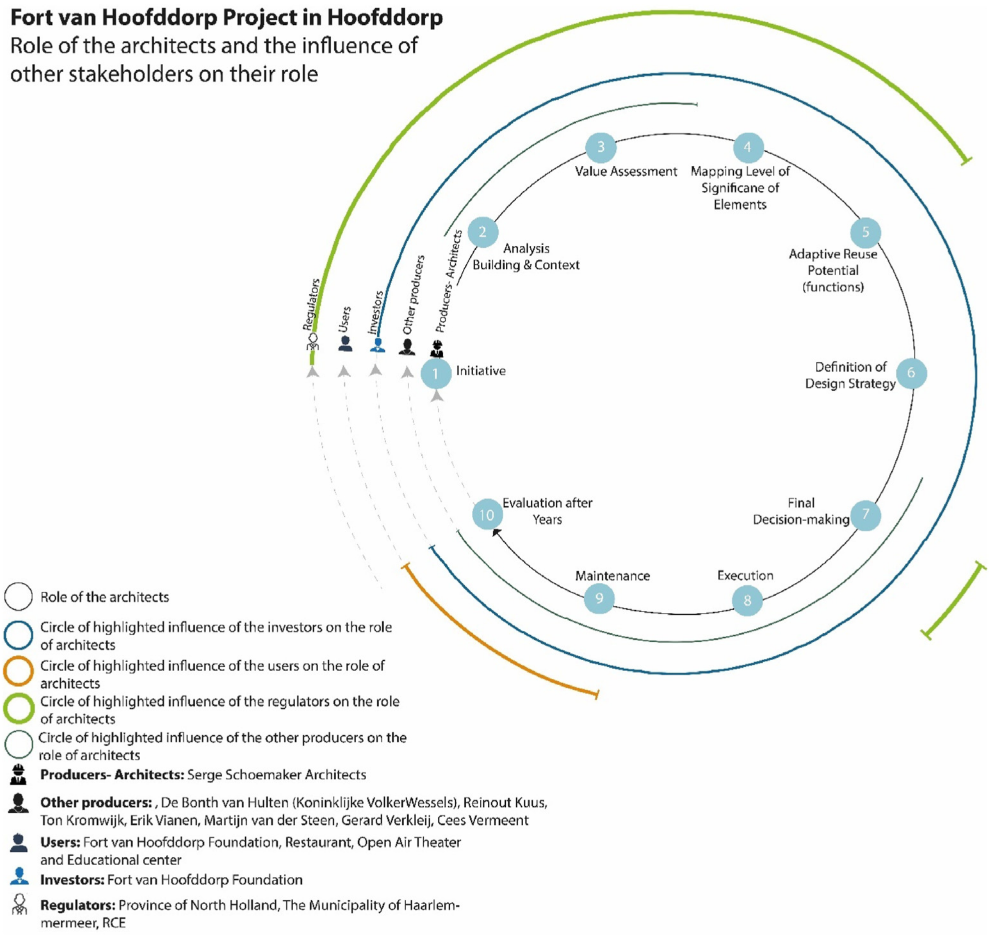

Figure 14 Role of the architects and the influence of other stakeholders on their role based on the analysis of the collected data

perspectives, particularly architectural aspects and its attraction to visitors (Step 9).

The AR process of the Fort van Hoofddorp project, as confirmed by the architect, aligns with the theoretical model depicted in Figure 2. However, the architect emphasized that architects are primarily involved in “aftercare” rather than “maintenance.” The process was relatively lengthy, spanning approximately 10 years for the architect. While all steps were followed, the progression between Steps 1 to 6 took a significant amount of time. During the final decision-making phase, where financial support was secured, the architect revisited all steps (from 1 to 6) to conduct a more thorough investigation. This examination of each step contributed to the effectiveness and quality of the project.

The AR process, derived from the data analysis, is illustrated in Figure 15.

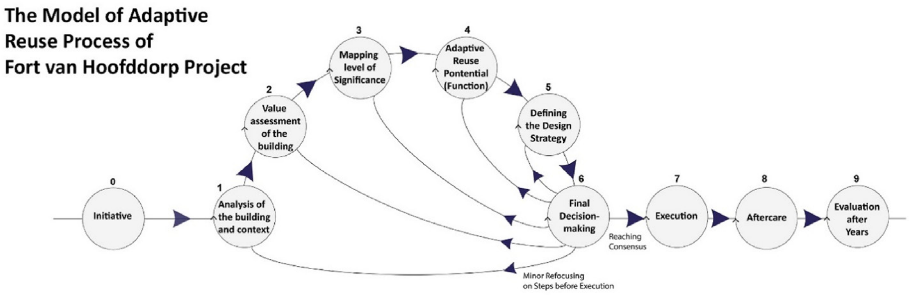

Figure 15 The AR process of Fort van Hoofddorp, based on the analysis of the process and the interviews with stakeholders

4 Discussion

4.1 Validated and refined steps model for the AR process of heritage buildings based on the investigation of the effective cases in the Dutch context

Every architect or architectural firm has its unique approach to the AR of heritage buildings. Nonetheless, an examination of four effective cases in the Netherlands has uncovered a shared framework, which will be discussed in this section.

Regarding the reuse of heritage buildings, several key steps must be taken. Interestingly, all four cases followed similar steps with minor differences. Each project commenced with a comprehensive analysis. Even if this analysis was expedited due to time constraints, a reassessment was conducted before final decision-making. A significant finding from this study is the non-linear nature of the process, with loops occurring between steps preceding execution (Steps 1–6). According to insights gathered from the architects, stakeholders, and NRP reports, these loops seem to enhance the effectiveness of AR projects.

Drawing from the analysis of these four effective cases, the initial model (Figure 2) has been refined and renamed as the EARHB (Effective Adaptive Reuse of Heritage Buildings) model (see Fig. 16).

It should be noted that there are additional parallel steps focused on the involvement of other stakeholders in the AR process, which are beyond the scope of the current research.

4.2 Comparative analysis of the architects' role and influence of other stakeholders on this role

Analysis of the interviews revealed that in effective projects, architects play a broader role beyond design, spanning from Step 1 to Step 9 of the AR process

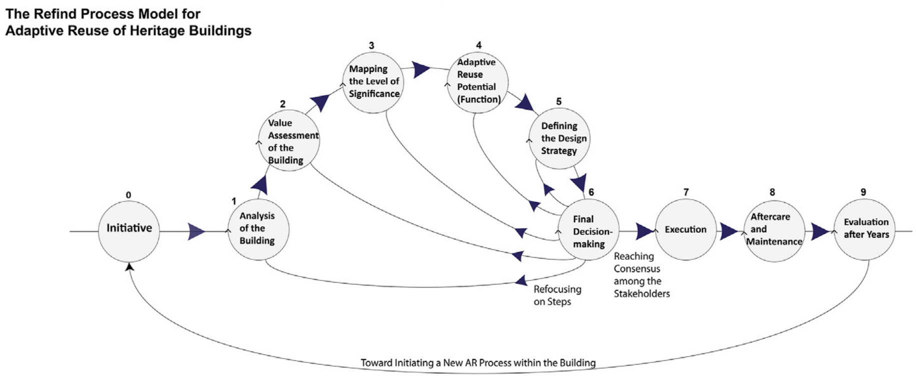

Figure 16 EARHB model, adapted from Arfa, Lubelli, et al. (2022) after validation on case studies

(see Figure 17). Three main aspects of the architects' role emerged from the collected data:

- Importance of professional skills complemented by soft skills: Stakeholders in the investigated projects highlighted the significance of architects' soft skills, which positively influenced the entire process. Attributes such as openness, responsibility, effective communication, and negotiation skills were highly valued. Architects demonstrated receptiveness to criticism and possessed the ability to persuade other stakeholders with their ideas. Moreover, they exhibited a strong sense of responsibility toward their projects.
- Adaptability to changes and adjustments in the preliminary design: Architects acknowledged the inevitability of having initial ideas at the project's outset. However, they emphasized the importance of not being overly influenced by these early concepts before fully assessing the building's values and considering the perspectives of other stakeholders.
- Impact of a larger number of stakeholders on the project: This study revealed that despite the notion that a higher number of stakeholders may hinder progress, the study found that a larger stakeholder group can positively contribute to the project's final quality. In the examined projects, the presence of multiple stakeholders facilitated constructive discussions throughout the process. Consequently, if architects can effectively convey and negotiate compromises, diverse stakeholder ambitions can enhance both the process and the overall quality of the project.

While this research primarily focused on the role of architects, insights from interviews with various stakeholders offer additional conclusions:

- Role of the investors and their influence on the architect's role: Investors, often municipalities in the studied cases, sought recognition through their involvement in AR projects, which positively impacted the outcomes. For

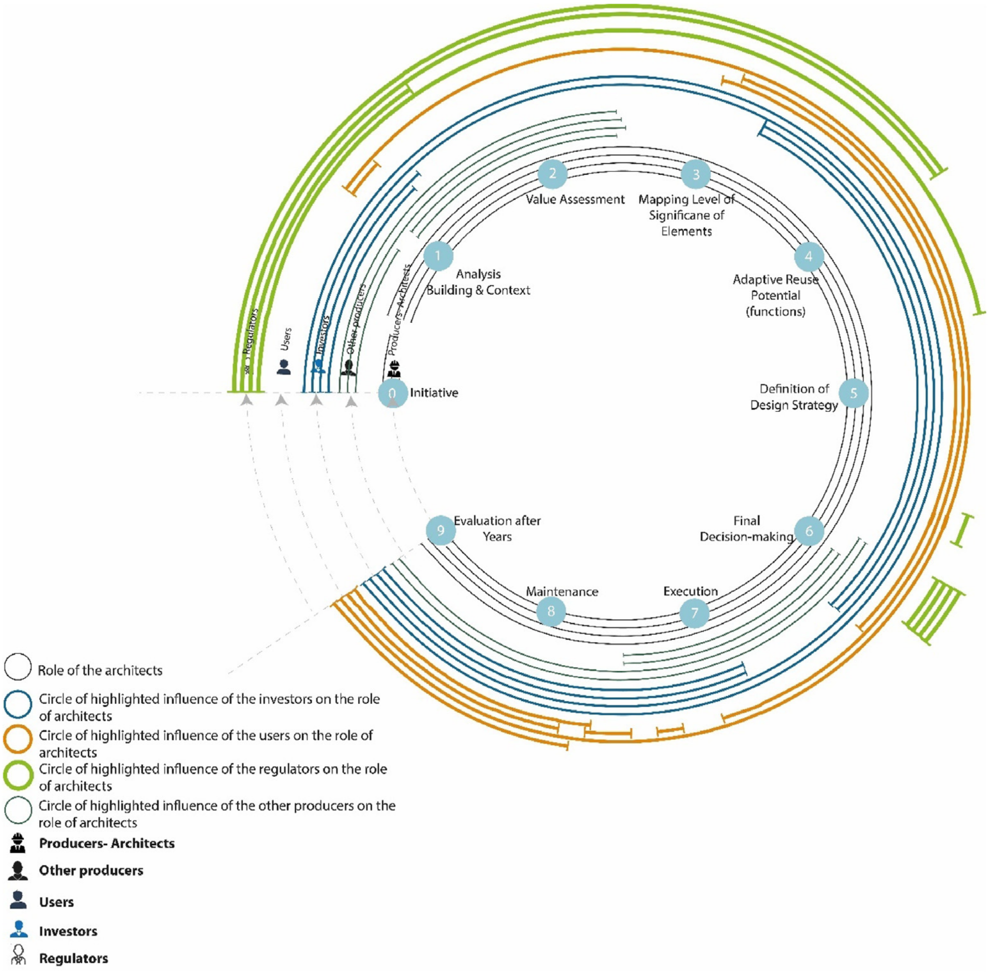

Figure 17 Role of the architects and the influence of other stakeholders on their role based on the analysis of the collected data of the four investigated cases

instance, municipalities aimed to showcase their capabilities to other municipalities, fostering a sense of healthy competition and driving the process toward effective results. This trend aligns with findings from the OpenHeritage project report by Veldpaus et al. (2019), indicating a growing interest among developers and municipalities in the Netherlands toward sustainable approaches to the built environment and cultural preservation. However, the actual contribution of these projects to sustainable development goals warrants further investigation.

- Role of the regulators and their influence on the architect's role: Regulators played a supportive role in the AR process, ensuring its smooth progression. They valued both the historic significance and functional utility of heritage buildings, reflecting a balanced approach that evolved over time. This positive stance toward preserving heritage while acknowledging its functional value represents a significant achievement in heritage conservation policies in the Netherlands (Janssen et al., 2017).

- Role of the other producers and their influence on the architect's role: Various stakeholders, including cultural-heritage experts and sustainability advisors, contributed to the AR projects. Their involvement, particularly in the initial steps (Steps 1 and 2), provided valuable insights for architects to rely on. In the studied cases, local construction companies, driven by a passion to prove themselves in AR projects, were predominantly selected as producers, contributing to the projects' effectiveness.
- Role of the users and their influence on the architect's role: Original and end-users were actively engaged throughout the AR process (see Figure 17), offering input and insights. In effective cases, original users provided valuable materials such as personal stories (social values), spatial usage patterns (functional values), and technological aspects of the buildings (scientific values), aiding architects in their designs. Managing the high ambitions of end-users effectively is crucial for architects to ensure their contributions enhance, rather than hinder, the AR process's effectiveness.

4.3 Used methods and tools by the architects in the AR process and the relationship with the effectiveness of the project

The methods and tools utilized in the investigated AR projects are outlined in Table 1. While there is no conclusive evidence that the project's effectiveness solely relies on these methods and tools, it is probable that their application contributes to project effectiveness. Table 2 indicates the potential connection between the employed tools and methods discussed in each case and the effectiveness of the projects, as noted in the NRP jury reports.

Tables 1 and 2 can serve as a toolkit for architects dealing with heritage buildings. Table 1 outlines the methods and tools employed by architects in the investigated case studies. As highlighted by previous researchers, exploring the past and precedents during the initial steps of the design process not only structures design strategies but also garners support from other stakeholders and engages a more diverse group of stakeholders (Oak, 2006; Otto, 2016; Umney & Lloyd, 2018; Zuljevic & Huybrechts, 2021). Many methods and tools in Table 1 are centered around the concepts of "participatory adaptive reuse" and "comprehensive analysis of the past (building and context)."

In Table 2, the methods and tools used at different steps are presented alongside their potential impact on effectiveness criteria within the selected projects, as reported in the NRP jury reports. It is evident that social value creation has primarily been achieved through the involvement of original and end-users (a participatory design approach (Zuljevic & Huybrechts, 2021)) and local

Table 1 The methods and tools used by the architects in the AR process of the selected cases, as resulting from the interviews (L: LocHal, B: Blokhuispoort, E: Energiehuis, F: Fort van Hoofddorp)

Methods and tools	*Case*
M1. Involving a lesser-known but capable architecture firm *[Tool: Participation in matchmaking meetings]*	L
M2. Analyzing the building and site (architectural/functional aspects) *[Tool: Analogue and digital surveying tools]*	L, B, E, F
M3. Analyzing technical aspects of the building (e.g., hazardous chemical materials; acoustical properties) *[Tool: Hiring related specialist for analysis]*	L, E
M4. Collecting data about the buildings from archives	L, B, F
M5. Involving original users during the AR process *[Tool: Holding meetings with them]*	L
M6. Reviewing documents, photographs, drawings, writings, and logbooks of the building and site	L, B, E, F
M7. Digitally storing all collected and produced data *[Tool: Data management tools for documenting the process]*	L, B
M8. Avoiding reliance on personal assessment to limit subjectivity *[Tool: Hiring a company for historic value assessment with predefined code]*	L, B, F
M9. Repeatedly analyzing the building *[Tools: Reviewing all collected and analyzed data; Reinspecting the building to reveal possible hidden aspects]*	L, B, E, F
M10. Involving end-users and the local community during the AR process *[Tools: Holding several meetings with end-users for input; Using renders and 3D models in presenting the project to end-users]*	L, B, E, F
M11. Applying structured design strategies for the AR of the building [Tool: Reviewing the literature on the AR process and accordingly developing specific frameworks and schemes for AR process]	L, B, E, F
M12. Considering the well-being of users within the required functions *[Tool: Hiring experts on sustainability and well-being]*	L
M13. Getting inspired by other effective reuse projects *[Tool: Visiting and analyzing the effective reused buildings with similar functions]*	L, B, E
M14. Employing digital and innovative tools to complement the architects' strategies and stories *[Tool: Hiring experts on digital tools in storytelling]*	B
M15. Striking a balance between the existing situation of the building and the requirements *[Tools: Meetings with stakeholders involved in the process and discussing their needs and possible solutions]*	L, B, E, F
M16. Discussions between the (leader) architect and the contractor and being involved in the execution step *[Tools: Meetings with the contractors; Regular visiting of the site during the execution; Hiring of a flexible contractor]*	L, B, E, F
M17. Being open to modifying and adapting the design even after the execution of the project	
M18. Discussions with the end-users after the execution of the project *[Tool: Holding meetings with the end-users]*	
M19. Regular inspecting and visiting of the building after the execution	
M20. Being open to receiving feedback on the project and learning lessons for future projects *[Tool: Following and analyzing social media posts about the impact of the project]*	

communities. Sublimation, in terms of cultural value and architectural value, has also been considered throughout the entire AR process. However, environmental sustainability has not been significantly addressed in the NRP jury reports, nor was it emphasized by the architects during the interviews. Further investigation into the methods and tools used by architects in AR projects to enhance this criterion is needed.

The broader implications of the EARHB and its methods and tools extend beyond the AR of heritage buildings. AR is not a novel concept and is already

Table 2 The nexus between the architects' used methods and tools in the AR process of the selected projects and the criteria of effectiveness, as defined in Arfa, Lubelli, et al. (2022)

Identified criteria of effectiveness	*Steps in the process*									
	Step 0. Initiative	*Step 1. Analysis of building*	*Step 2. Value assessment of building*	*Step 3. Mapping level of Significance*	*Step 4. Adaptive reuse potential (function)*	*Step 5. Defining design strategy*	*Step 6. Final decision-making*	*Step 7. Execution*	*Step 8. Aftercare/ maintenance*	*Step 9. Evaluation after years*
Social value creation	M1				M10	M11, M12, M14	M10, M15	M16	M17, M18	M10, M19, M20
Sublimation-cultural aspects		M2, M3, M4, M5, M6, M7	M8			M9, M11, M13, M14	M15	M16	M17, M18	M19, M20
Sublimation-architectural aspects		M2, M3, M4, M5, M6, M7	M8	M9	M10	M9, M13, M14	M15	M16	M17, M18	M19, M20
Environmental sustainability						M12	M15	M16	M17, M18	M19, M20
Economic value creation					M10		M15	M16	M17, M18	
Innovation	M7	M7	M7	M7	M7	M14	M7	M7	M7	M7

being addressed at various urban and building scales. This model can align with the Do-It-Yourself (DIY) movement (Camburn & Wood, 2018) and serve as a guide for end-users seeking to reuse, repurpose, and repair their belongings. Additionally, the steps of "analysis," "value assessment," and "mapping the level of significance" of the model can underscore the importance of considering existing values in the early steps of urban development projects through citizen-designer engagement (Törnroth, Wikberg Nilsson, & Luciani, 2022).

5 Conclusions

This research aimed to validate a previously developed model for adaptive reuse (AR) of heritage buildings by investigating AR processes in four cases in the Netherlands. All four cases were recipients of the prestigious NRP prize, denoting their effectiveness. Additionally, the study explored the relationship between architects' methods and tools during the AR process and the ultimate effectiveness of the projects, as reported in the NRP jury reports.

The validation process of the theoretical AR model resulted in a refined version named the EARHB (Effective Adaptive Reuse of Heritage Buildings) model. This model includes the same steps as the theoretical model but incorporates inner loops within and between the steps. The refined model departs from a linear progression, striving to offer a more nuanced depiction of the AR process and its inherent complexities in practical application. While the EARHB model is based on the perspective of architects, it holds potential for integration with parallel steps to have practical use for all stakeholders in the AR process. It should be noted that it was not the authors' intention to prescribe a singular correct AR process, but rather to explore potential AR processes of effective cases, identifying commonalities that could inform future AR processes.

The validation process highlighted areas warranting further research. While ample research exists on analysis, design strategy definition, and adaptive reuse potential (function), there is a notable gap in understanding execution, maintenance/aftercare, and post-evaluation steps. Furthermore, while the model has been validated in practice across four cases in the Netherlands, it has yet to undergo testing in the actual development of an AR project.

In addition to process-related insights, this study shed light on pertinent stakeholder dynamics. Architects played a pivotal role throughout all steps, with the effectiveness of AR projects significantly influenced by the methods and tools employed in each step. Architects adeptly navigated stakeholder engagement, balancing the needs of producers, regulators, investors, and users. The interviews revealed strong, collaborative relationships among stakeholders, indicative of high-quality professional partnerships.

One notable challenge encountered during the process of effective AR projects pertained to budget constraints and financial issues. In such instances, the commitment of investors proved pivotal in project continuity. Architects demonstrated flexibility by adjusting designs to reduce costs without compromising quality. Notably, architects' attitudes and communication skills were paramount alongside their professional expertise, emphasizing flexibility and minimal emotional attachment to their design ideas.

Addressing the second aim of the paper, it provides an overview of methods, tools, and their potential impact on AR project effectiveness, beneficial for architects working with heritage buildings. The analysis highlighted that involving people, including original and end-users, as well as local communities, throughout the entire AR process is crucial for social value creation.

This research shows that the methods and tools used by architects primarily focused on functional aspects and indirectly related to economic value creation. However, proposing appropriate functions by architects to other stakeholders can significantly impact economic value creation. Regarding environmental sustainability, it seems that architects need to proactively consider diverse aspects beyond energy efficiency in AR projects. Given the challenges of the 21st century, future research on validating this model in real AR projects and exploring architects' role in sustainable and circular AR processes in heritage buildings is highly encouraged.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

CRediT authorship contribution statement

Fatemeh Hedieh Arfa: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Software, Validation, Visualization, Writing – original draft, Writing – review & editing. **Barbara Lubelli:** Conceptualization, Methodology, Supervision, Validation, Writing – review & editing. **Wido Quist:** Conceptualization, Methodology, Supervision, Validation, Writing – review & editing. **Hielkje Zijlstra:** Conceptualization, Methodology, Supervision, Validation, Writing – review & editing.

Data availability

Data will be made available on request.

Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.destud.2024.101252.

Notes

1. Het Nationaal Renovatie Platform in Dutch; in English: The National Renovation Platform.
2. Rijksdienst voor het Cultureel Erfgoed (RCE) in Dutch; in English: Cultural Heritage Agency of the Netherlands.

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