

Adaptive reused heritage building based on sustainable architecture Case study: De Tjolomadoe building in Indonesia

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ARTICLE INFO	ABSTRACT
<p><i>Article history:</i> Received September 13, 2023 Received in revised form Oct. 20, 2023 Accepted November 25, 2023 Available online December 01, 2023</p> <p><i>Keywords:</i> Adaptive reused, Cultural heritage buildings, Sustainable architecture Sustainable development</p> <p>*Corresponding author: Sri Yuliani Department of Architecture, Faculty of Engineering, Universitas Sebelas Maret, Indonesia Email: sriyuliani71@staff.uns.ac.id ORCID: https://orcid.org/0000-0002-4288-2959</p>	<p><i>Selective reuse of heritage buildings should be based on consideration of strategic issues of sustainable development. Research that discusses the reuse of cultural heritage buildings in the field of architecture still does not implement the concept of sustainable architecture. The purpose of the study is to obtain a strategy formulation that can be used as a parameter for adaptive implementation of reuse in cultural heritage buildings in line with sustainable development. The research took a case study of De Tjolomadoe building in Surakarta City, Indonesia. The building is a former sugar factory building currently converted as a meeting place, tourist destination, and educational communal space. The benefits of the research provide recommendations for adaptive reused strategies for cultural heritage buildings with the concept of sustainable architecture to support sustainable development. The study used in-depth observation with interview techniques and secondary data from the literature as the determination of the most important factor of the concept of sustainable architecture in optimizing the management of cultural heritage buildings. The results show that there are four architectural aspects that need to be considered so that adaptive reused cultural heritage buildings can provide sustainable benefits, i.e., the need for integration and synergy between building history, culture, environment.</i></p>

Introduction

Indonesia is one of the countries that has a commitment to achieving Sustainable Development Goals (SDGs). Indonesia's development has a basic concept of development contained in the Sustainable Development Goals, adopting 17 aspects of SDGs which are summarized in 4 pillars, i.e., social, economic, environmental, legal and governance. Planning, implementation, and results of development implementation are conducted in the format of cross-sectoral interaction including the field of conservation of cultural heritage objects with various manifestations and conditions spread throughout the territory of the country. Law of the

Republic of Indonesia number 11 of 2010 concerning cultural heritage has accommodated conservation understandings that collaborate synergistically to build empowerment and mutual sustainability. The zoning pattern divides conservation areas into 4 parts, i.e., core, buffer, development and supporting zones ([UNESCO 2010](#)) is a manifestation of proportional solutions in addressing the dynamics of sustainable development.

Research on cultural heritage buildings often intersects with development actors, i.e., the government, communities, and development practitioners. Strict top-down procedures by the government can influence user perception to support the efficiency of governance objectives

(Martínez 2023). It added in detail the importance of national policy, a single institution responsible for leading and planning initiatives, establishing implementation plans, clear protective measures, and platforms and opportunities for integrated public participation (Kuo et al. 2023). Cross-sectoral principles need to be observed to open opportunities to build synergistic interactions. Public participation has evolved in both the theory and practice of urban planning, including heritage planning. Adjustment of the process of public participation in implementing it, considering the relevant factors involved (Foroughi et al. 2023). Policies for managing and organizing legacy resources in a new top-down model characterized by network collaboration between different sectors (Xu, Qian, and Wen 2022).

Heritage buildings are one of the urban identities for cities and should be well preserved not only because of their value and story, but also because of the existing building stock (Hasan, Wahab, and Ismail 2019). There are three stages in managing cultural heritage. The first stage, rescue, is an effort to stop the degradation process experienced by cultural heritage objects due to natural and human factors that should be done after the object is found. The degradation process should be stopped to prevent further damage leading to extinction. The second stage, return, is the process of recovery from damage and degradation by successfully stopped triggering factors. This stage is situational, complex, and dynamic. Situational relates to the application of methods determined by the situation and conditions of the location of cultural heritage objects. Degradation factors are influenced by the dynamics of the interaction of natural and human behavior with objects of cultural heritage. The complex and dynamic nature occurs because various trigger factors work individually or simultaneously with various visual and structural effects and expressions. The third stage is protection. An important understanding of the protection stage is the guarantee that the target produced by the return process should be protected from degradation factors at the time the target is completed and afterwards. Protection relates to aspects of events or phenomena (natural, human) and formal legislation.

The research refers to the theory of cultural heritage building management, adaptive reused strategies in heritage buildings, the concept of sustainable architecture, sustainable development, tourism prospects and policies and

other influencing factors. Theory is obtained from tracing research results published in journals or proceedings, reference books and regulations.

Buildings of cultural value can affect the dynamics of urban development (Devitasari, Suprapti, and Harsritanto 2021). Related to the role of cities towards cultural heritage, the creation and dissemination of new knowledge about the distinctiveness of cities can encourage more sustainable heritage protection (Pieri 2023). Research exploring traveler's willingness to pay identifies those factors influencing traveler interest are duration of service, interpretive style, content about heritage architectural styles, and distinctive local culture (Zhao and Chan 2023). Similar research examines how cultural heritage conservation, often reflecting global values, impacts local sustainable livelihoods in living heritage sites (Tan and Ti 2020). Community members are forced to adapt to the demands of tourism, so it is recommended to organize the management of cultural heritage by organizations, communities, and other stakeholders (Liu et al. 2022).

In an architectural perspective, historically meaningful buildings require preservation efforts to adjust the function, material, and construction of the building (Gandawijaya 2021; Septianto et al. 2023). Heritage and historical buildings have important architectural and cultural value that require building conservation, rehabilitation over demolition and new construction, leading to more sustainable construction (Garcia-Castillo, Paya-Zaforteza, and Hospitaler 2023; Antarkisa, Santosa, and Eka Sari 2021). Built legacy vulnerability assessments should consider the building itself and extend to the site and environment (Damas Mollá et al. 2022). Preservation of modern architectural heritage buildings by emphasizing reinforcement of the construction system (Kopuz and Bal 2023; Quintana, Díaz-Puente, and Gallego-Moreno 2022). The authenticity of architectural heritage is interpreted differently in diverse cultural traditions. These traditions can be transmitted into contemporary design, as illustrated by our experimental designs (Arinto 2018). Self-adaptation and topological deformation of architectural heritage demonstrate a unique perspective in understanding authenticity and contribute to innovative applications in the conservation and regeneration of vernacular architecture (Zhang, Xu, and Wang 2022).

The adaptive reused design strategy is a recent phenomenon that is a translation of the process of accommodation and adaptation of cultural heritage conservation to the demands of the current generation of functions. Heritage objects in various embodiments are designed to be brought to life and for new functions to meet the demands of contemporary activity. The process provides opportunities for synergistic interaction with various aspects to build empowerment together proportionally. The latest technology, materials and operational management are applied in providing vitality for cultural heritage objects in achieving resilience and sustainability to adapt to the changing demands of scoping aspects. Appropriate management and restoration of architectural and cultural heritage contribute to promoting the development of the city. The main results obtained are related to the physical restoration of historical buildings and the promotion of activities of cultural importance. In addition, integration and social participation in the planning and management process to restore heritage is also encouraged and encourages social behavior change. Residents are beginning to perceive his legacy to empowerment and innovation (Quintana, Díaz-Puente, and Gallego-Moreno 2022). It adds that adaptive reuse of cultural heritage can contribute to sustainable development and circular economy, preventing waste production and resource depletion by extending heritage life (Nadia Pintossi et al. 2023). Adaptive reuse of cultural heritage contributes to heritage conservation, harnessing heritage potential to enable sustainable development and improve urban habitability (N. Pintossi, Ikiz Kaya, and Pereira Roders 2023). Some of the implications of land use discussed in heritage buildings need to be considered long-term to provide educational and economic benefits (Chau et al. 2023). Semarang Gallery is the result of a conservation project of Cultural Heritage Buildings that are reused with new adaptive functions, which tend to cause changes in the visual character of the building. Therefore, this study aims to determine the level of change in visual character in the exterior, interior, and proximity of Semarang Gallery due to the adaptive reuse approach. This qualitative research used graphic and descriptive methods to analyze data. The results of the analysis indicate that the adaptive reuse approach changes the typology of existing buildings that require adjustments to technical improvements in almost all aspects,

causing changes in the visual character of exteriors, interiors, and close-ups with different levels of significance. The results showed that changes that conform to the principle of conservation increase the value of parameter functions, while those that do not conform eliminate the uniqueness of visual characters (Devitasari, Suprapti, and Harsritanto 2021).

Based on the findings of several studies, it shows the need for a balance between tourism development and environmental conservation that continues to grow the level of community welfare. For such a reason, this study aims to formulate a sustainable tourism management strategy, where the concept of green architecture can be considered to strengthen the implementation of adaptive reused in cultural heritage buildings. The results of the research are useful for the acceleration of sustainable development both for the government, community, private sector and all stakeholders of tourism, culture, and the environment.

Method

Adaptive reused research on cultural heritage buildings uses the study case method with in-depth observation through interview techniques, exploring reference sources for cultural heritage building management and sustainable architecture concepts to support sustainable development. The research method by making in-depth observations on several objects or several related sources is a method that is often used in inheritance object research (Nadia Pintossi et al. 2023).

Research data consists of primary data and secondary data. Primary data is described descriptively including qualitative object data. While secondary data, i.e., theory related to following a systematic review of relevant literature on, can formulate the creation and dissemination of new knowledge about the peculiarities of cities to encourage the protection of more informed heritage (Pieri 2023). The analysis used a matrix model that had been developed by similar heritage research (Fang and Li 2022).

Material

The research took a case study of de Tjolomadoe's building, in figure 1, located in Surakarta City, Indonesia. Such a building

represents the building of a former sugar factory that was originally stalled because it was not used for the production process. After some period, the building began to be converted for other uses. The building is the largest building located in Surakarta City, in [figure 2](#), and has strategic prospects in supporting sustainable development.



Figure 1. De Tjolomadoe building

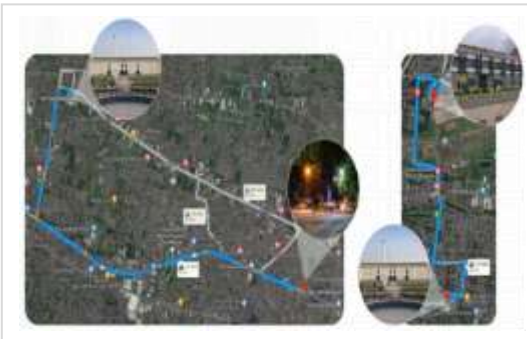


Figure 2. Location of the object of study

Results and discussion

Although the composition is simple, the algorithm to generate it has a few components that, to an inexperienced programmer, would be pretty challenging to arrange. The ideal, as shown in [figure 3](#), is an architect that, as an inexperienced programmer, only focuses on the creative process of defining the shape rules and constructing the shape grammar method and allows the generation of shapes and their transformation procedures to be automated process through a set of modular and parametric instructions.

The conservation of heritage buildings is based on historical aspects related to how long the building took to be built. Criteria relating to the

time or period of conservation of cultural heritage become important to be updated after the phenomenon of demands to accommodate the dynamics of current and future expediency. Heritage values in cultural heritage formed in the past should be rearranged with a synergistic interaction of benefits of the present and the possibility of surviving in the future.

The principles of sustainable architecture provide guidance on the interrelation and sustainability of aspects/potentials of heritage values based on the past for the benefit of the present and continue in the future. Narrative formulation related to the time criteria for conservation of cultural heritage could develop to accommodate the demands of contemporary and futuristic functions without neglecting the value of literature. The time dimension related to cultural heritage conservation has a strong consistency when it becomes a manifestation of sustainable development. The security aspect in the process of inheritance from generation to generation can include two things. First, the security of heritage values as the spirit of cultural heritage is guaranteed not to be degraded by other interests. Second, security is related to the protection of the generation of recipients of the relay of values and perceptions of literature, they will still receive consistent information even though it goes through a long span of time with dynamics in accordance with the growth and development of the scoping components.

Humans have an important position in the dynamic conservation of cultural heritage, as subjects and objects in the process. Humans could participate more meaningfully in ensuring success in achieving cultural heritage conservation targets. Dynamic conservation provides spaces for community participation in a varied manner according to the demands of the designation. Humans function as subjects when interested in the technical aspects of cultural heritage conservation policy determinants. The group is human resources with qualifications in accordance with the technical field. Man as an object when it becomes part of the values of the literature of the past and in the process of present and future expediency. Sustainable architecture places humans as an important element, becoming objects and subjects of sustainable development. Humans are prepared to be actors who have skills in planning and implementing development that provides safe benefits for nature, humans are also prepared to receive and utilize the results of

development responsibly for sustainability to the next generation.

Cultural heritage conservation puts literary values in their rightful place, maintained authenticity to be passed on to the next generation. The principle of sustainable architecture provides opportunities in the next period when the usefulness and empowerment of cultural heritage should accommodate the dynamic demands of growth and development of its scope components in various aspects. The value of literature in cultural heritage should be packaged in such a way that it is able to interact synergistically with the interests and needs of present and future generations. The existing limitations challenge creativity design to create new expressions that inspire life force. The principles of sustainable architecture provide direction for translating the essence of cultural heritage preservation about synergistic interaction with nature. The concept of sustainability is manifested in the design aspect of both micro and macro-objects.

Nature in the understanding of cultural heritage conservation was originally understood as an object site land. In the next period, when the understanding develops into objects of cultural heritage as *saujana*, a new mechanism of synergistic interaction between the protection of library value and the protection of natural resources for benefit and culture now and in the future, is needed.

The concept of cultural heritage preservation should be comprehensive and integrated in the aspects of buildings and nature on which cultural heritage objects stand. The stability of architectural and structural aspects of buildings should be complemented by land surface management, drainage, and vegetation design. New activities are placed in spaces that are safe against possible degradation of heritage building components. The components of cultural and natural heritage are ultimately harmonious components of a sustainable development mechanism by considering aspects of safe benefits from generation to generation. This is in line with the research that has been done (Quintana, Díaz-Puente, and Gallego-Moreno 2022; Nadia Pintossi et al. 2023; Devitasari, Suprapti, and Harsritanto 2021).

Case study of De Tjolomadoe heritage building

De Tjolomadoe is the product of a conservation mechanism with an adaptive reused

strategy, which is a process of revitalizing cultural heritage buildings by providing vitality related to benefits and empowerment for the accommodation of today's demands for sustainability for present and future generations. The building occupies an area of 6.4 Ha. At first was a sugar factory owned by Puro Mangkunegaran founded by Sinuhun Mangkunegara IV in 1861 and began operating in 1862. In 1998 PG Colomadu no longer functioned as a sugar factory which later became a stalled building. Decades later the building underwent significant changes related to physical and non-physical degradation experienced over a long period of time.

The revitalization of PG Colomadu began in 2015 inspired by the awareness of the collapse of a cultural heritage located in a very strategic site accompanied by the revival of the cultural heritage-based tourism sector. Law no. 11 of 2010 provides an opportunity for conservation action as a response to the demands of needs and functions across time and generations. The big concept of PG Colomadu revitalization is the provision of facilities, space, and atmosphere for the needs of convention, recreation and entertainment functions for current and future generations based on the use of reconstruction of library values in the physical old building, as in [figure 3](#).



Figure 3. De Tjolomadoe building

The concept and action of field construction towards the selection of the identity of the object of the case, i.e., the change of the former Colomadu sugar factory into De Tjolomadoe convention, expression and recreation vehicle has met the main criteria of rescue, protection, utilization, and development regulated in formal ethical and legislative norms. The salvage aspect

includes physical/object and non-physical/intangible components related to building components, tools and production mechanisms in various positions and expressions have been successfully excavated and represented for various new and different interests quite expressively, in [figure 4](#). The concept conducted is in line with the principles of building and environmental conservation in several other countries that have been studied by other researchers ([Hasan, Wahab, and Ismail 2019](#); [Zhao and Chan 2023](#); [Kopuz and Bal 2023](#)).



Figure 4. An old building with a new expression

Protection aspects conducted in the format and packaging of components and library values of cultural heritage objects for the benefit of new functions reflect a maximum and proportional protection effort in the process of fulfilling current and future functions. Degradative factors have been well considered regarding the process and its countermeasures.



Figure 5. Protection of old building for new functions

The Utilization aspect includes the new functions presented in the rides and old spaces have been considered very proportionally and maximally, as in [figure 6](#). This reflects a guarantee of value security and the old formation that has been conducted preservation measures will be able to withstand degradative factors in the dynamics of its utilization.

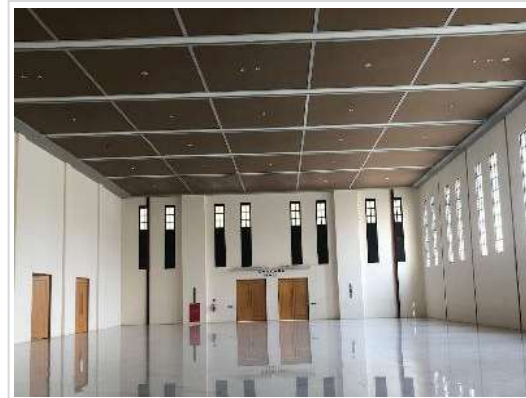


Figure 6. Utilization and development of old space for new functions

The development aspect is conducted by changes, i.e., changing the visual appearance of old elements as fulfillment of the demands of the new function is conducted with a proportional technical consideration of conservation actions. BPCB central Java has provided technical and applicable field assistance. Some components or parts of the building should undergo adjustments and additions for the development of new

function accommodation but still guaranteed safety.

A historical site

De Tjolomadoe was presented as an effort to accommodate new functions that are the demands of current and future generations. Various forms of activities concerning various interests have been conducted since the inauguration of its functions. However, the intensity of activities within the year still needs to be increased to add an indication of the wearability of the building. The type and volume of activities need to be adjusted to the factual dynamics that are happening in the present time and generation. The dynamics of MSMEs among the millennial generation are given the opportunity for more friendly time and costs to provide synergistic benefits.

Culture

The design of the De Tjolomadoe complex has provided spaces for human creation across generations with each importance. However, it needs to be refined about the concept of activities that ensure the safety and comfort of the perpetrators. Conditions and situations of chaos, discomfort that endanger the perpetrators of activities at every major event have been felt both humans in the complex and around it. More permanent zoning and circulation patterns are needed to unravel such a problem with multifunctional and flexible designs in large open spaces, in [figure 7](#).



Figure 7. New faces for new generations and functions

De Tjolomadoe is located not far from the traditional Javanese local wisdom area. Such a

cultural heritage object was even born and became part of the chronology of local wisdom because it occupies a piece of history of Mangkunegaran temple and Surakarta cultural city. Major activities that have been held in spaces of expression do not raise the potential of local wisdom so that the specific atmosphere is quite potential less awakened in the next period, in [figure 8](#).



Figure 8. A new face for a new culture

This is quite unfortunate because it occurs in a period when the component of local wisdom is becoming a trend and the basis for tourism and tourism development.

Milieu

The principle of sustainable architecture provides direction to efforts to empower building management and operations in building sustainability. De Tjolomadoe's design concept provides an opportunity to utilize renewable strategies and technologies in the operational segment of the building both as experimental and regular vehicles. The concept of energy conservation can be applied in various technical and aesthetic elements of buildings ([Devitasari, Suprpti, and Harsritanto 2021](#); [Zhou et al. 2023](#); [Mazzetto 2023](#)). Green governance patterns need to be presented to utilize rainwater capture arrangements and create activity comfort. Photovoltaic applications for solar power sources provide an alternative to providing renewable electrical energy, as [figure 9](#).



Figure 9. Application of solar panels on rooftops of conserved buildings as utilization of renewable energy



Figure 10. A new face for a new natural order
 Source: PT. Colomadu synergy

Open spaces within the site provide a maximum alternative in the placement of solar panels (Lucchi 2022; Chae and Kim 2022; Icaza, Borge-Diez, and Pulla-Galindo 2023). Mandir waste treatment technology has a historical background and is meeting current needs as an effort to support pollution mitigation and reuse of liquid waste. These aspects provide learning and understanding of the synergistic interaction between buildings and nature as a foothold, as shown in figure 10.

Table 1. Adaptive reused and sustainable architecture relationship analysis matrix

	Historical	Culture	Environment	Interactive description
Adaptive reused cultural heritage buildings	The history of the building has historical value	Culture as a result of human cultivation becomes an inspiration for empowerment that marks history	The cultural dynamics of development chronology have an influence on the environment	Historical The potential of the past becomes the basis for empowerment in the present and accommodates potential over time in a synergistic and safe manner
	Heritage value must provide benefits over a sustainable period/span of time	The historical value of the building becomes a cultural marker in development	The economic aspect is a consideration for the sustainability of cultural heritage buildings through adaptation of function and management	Culture is an element of building sustainability. Culture includes physical and non-physical products. Culture is understood more broadly
	Development continues to provide historical value across generations on an ongoing basis	Human culture experiences continuous dynamics of knowledge and technology	It is a sustainable target in the development of various fields/interests	Relating to the mechanisms of human life and existence individually or in groups in each period
Sustainable architecture	Building materials have become architectural knowledge at certain times	The dynamics of human knowledge periodically influence architectural trends which are always developing	Organic and inorganic-based building materials are aligned with the impact they have on the environment	Environment nature is understood in a broader context, namely above and below the ground surface. Harmonization and synergistic interaction between the design and construction of natural components is a sustainable component
	Historically, development has become an interesting moment to be remembered for all time	Culture as the estuary of architecture is a local component that becomes a sustainable inspiration in development	Buildings as works of architecture are indicators of sustainability. The meaning of sustainability is a guarantee of protection of the natural environment	

Conclusions

Cultural heritage conservation mechanisms should produce products that are able to accommodate the dynamics of regional and environmental components. The conservation outcomes should form a synergistic interaction with the demands of the needs of current and future generations of activities as a guarantee of forming sustainability in empowerment safely.

The essences in sustainable architecture provide an opportunity for the process of creativity when the demands of literary values of cultural heritage objects should be guaranteed continuity in the process of accommodation, the dynamics of meeting the demands of generational civilization progress from period to period. Cultural heritage conservation criteria could be empowered by expanding the target scope without the risk of degradation of the value of the library.

The principles in sustainable architecture provide sustainability assurance to the target of a more dynamic cultural heritage conservation mechanism with several alternatives to the application of the latest technological aspects as a strategy in forming synergistic interactions between objects and their scope environment, including the application of clean water and waste management, the application of solar panel electricity, vegetation arrangement and post-action space utilization for creative and productive activities. This is an effort to form sustainability in empowerment.

The formulation of the interaction of cultural heritage conservation principles with sustainable architecture principles provides an opportunity to develop process strategies and achieve more dynamic targets to build sustainability and empowerment in the interaction process with the demands of environmental components that have different characters.

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Author(s) contribution

Bambang Triratma contributed to the research concepts preparation, methodologies, investigations, data analysis, visualization, articles drafting and revisions.

Sri Yuliani contribute to the research concepts preparation and literature reviews, data analysis, of article drafts preparation and validation.

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