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Rumah Gadang Transformation:

Assessment on Sustainable Building Materials

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Abstract

The existence of Rumah Gadang is currently threatened due to the rarity of local/traditional materials and the cultural shifts within the Minangkabau people. Some of the surviving Rumah Gadang had undergone modernization in its form due to the use of modern materials such as concrete, zinc, etc. New questions arise whether the application of these modern materials can be considered sustainable for the Rumah Gadang. This study aims to compare the level of sustainability on the Rumah Gadang building material cycle before and after the modernization. This study conducted a case study of Rumah Gadang Padang Laweh, using a qualitative research approach with two data collection methods: observation and interviews. The collected data were then analyzed using the 'Green Feature' parameters, consisting of 15 assessment points. The study reveals that the building materials in the pre-modernized Rumah Gadang (25/30) show a higher sustainability value than the modernized ones (18/45).

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1. Introduction

Rumah Gadang is a symbol of pride for the Minangkabau people of West Sumatra. This traditional house is owned, maintained, and conserved jointly by the clan and cannot be sold or given to people outside the family lineage (Hardono, et al., 2014). The distinctive shape of *Rumah Gadang* is located on its roof structure that resembles a buffalo horn called "*gonjong*". In addition to its unique roof shape, *Rumah Gadang* has a distinctive carving style on most of its wooden parts, which is heavily influenced by the house's period. These are the things that characterize all the elements in *Rumah Gadang*, which distinguishes it from other traditional buildings (Marthala, 2013). Traditionally, the primary function of *Rumah Gadang* was to support the matrilineal cultural system. In the past, *Rumah Gadang* was inhabited by female family members to carry out daily activities. However, over time, the Minangkabau people gradually shifted toward modern culture. Some houses are no longer used as a residence but rather as a gathering spot to conduct community discussions and traditional ceremonies. The current *Rumah Gadang* was considered unable to accommodate all its residents' modern needs/activities (Wibisono,

2011). Eventually, many ended up building modern-style houses around traditional houses, resulting in the destruction and disrepair of *Rumah Gadang* (Noviarti, et al., 2013).

The previous research explained that from two regencies in West Sumatra, less than 75% of the Rumah Gadang still functioned as residential, and more than 5% were no longer inhabited. The remaining 15% were heavily damaged (Noviarti, et al., 2013). The damage to the houses was because many of the original residents had migrated outside the area. Not only that, the cost of preserving buildings with original materials is expensive and unaffordable for many Minangkabau people (Noviarti, et al., 2013). The availability of local/traditional building materials is increasingly scarce, making the materials expensive for common people. Consequently, during *Rumah Gadang*'s renovation and rehabilitation, many had switched to the more affordable modern building materials such as concrete and zinc.

This transformation is unfortunate because traditional buildings should be very closely related to their environmental context and the availability of local resources, mainly sourced from nature and processed traditionally. Supposedly, traditional communities have roles in maintaining sustainable development in their environment. Even though their settlements were built using surrounding materials, the communities still maintained biodiversity in their environment (Mawardi, 2012). This environmental sustainability should be a question for the *Rumah Gadang* modernization case, especially with the massive influx of modern building materials into the area. Jerroy & Haiyi (2019) stated that other than producing waste and pollution that could damage the environment, modern construction techniques also use unsustainable resources. Therefore, this study aims to discover the level of sustainability on the *Rumah Gadang* building material cycle before and after the modernization.

2. Theoretical Background

Rumah Gadang Minangkabau: Culture and Forming Factors

The Minangkabau community applies a matrilineal kinship system, namely lineage based on the mother's side. This system shows that women who are in the same lineage have special rights and positions. There are three essential characteristics in the matrilineal system: social, economic, and organizational leadership. Women or the so-called "*bundo kanduang*" have a substantial role in the matrilineal system because they are considered a sustainable factor for cultural heritage and a source of successor generations of Minangkabau society (Hardono, et al., 2014). Although it adheres to a matrilineal system, all aspects of community activities adhere to a mutualism cooperation system, both from agricultural activities, weddings, and building the Gadang House. This system is the foundation for the Minangkabau community, which has strong social relations regardless of individuals, families, and communities (Zulfadrim, et al., 2018; Hardono, et al., 2014).

Traditional architecture is a form of repetition of hereditary traditions bound by rules that cannot be changed (Rapoport, 1969). *Rumah Gadang* is one of the results of traditional architecture—matrilineal values and customs creating a repetition of traditions that always produce similar architectural features from time to time (Hardono, et al., 2014). In addition to tradition and culture, environmental factors also influence the shape of *Rumah Gadang*. The custom that governs the Minangkabau community originates from the customary philosophy of "*alam takambang jadi guru*" which teaches community wisdom in respecting nature (Navis, 1984). This philosophy becomes the guidelines and

rules of society in life. Minangkabau customs teach to take positive values from nature and discard negative things that can interfere with harmony with nature. At *Rumah Gadang*, this is proven by always maintaining the availability of original materials to build the *Rumah Gadang* in ancient times. Harmony with nature is also evident in the structural capability of the *Rumah Gadang*; this house has been proven to withstand seismic activity because it is designed in such a way as to adapt to its earthquake-prone natural conditions (Trisnawan & Rifqih, 2017; Zulfadrim, et al., 2018; Setijanti, et al., 2012).

Unfortunately, the traditionalism of *Rumah Gadang* has now been acculturated with modern culture. Neo-Vernacular architecture that has existed since the colonial period began to enter Minangkabau land by bringing the practice and use of modern materials. However, in the 1998 reform era, modern materials in West Sumatra from wall paint fabricated wood, zinc, concrete, and steel (Indah & Feni, 2019). The Minangkabau people then used this material to shift the original building materials in the *Rumah Gadang*. Using these materials then triggers a new question, whether the philosophy of maintaining harmony with nature is still preserved in Minangkabau.

Material Sustainability

The selection of sustainable building materials and construction methods is one of the easiest ways for architects to incorporate sustainable design principles into buildings (Kim & Rigdon, 1998; Nainggolan, et al., 2020). Sustainable materials are materials that maintain their existence so that they are available on earth and can be used sustainably in the future, with integrated processing without endangering the environment and humans (Syahriah, 2017). Some of the criteria for sustainable materials include having low embodied energy, being environmentally friendly, coming from renewable resources, being recycled or recyclable materials, and considering the design for recycling (Nainggolan, et al., 2020). In other words, in selecting materials to be used in buildings, the entire material life cycle and the various processes need to be considered (Kim & Rigdon, 1998; Syahriah, 2017).

According to Kim & Rigdon (1998), the material life cycle includes three phases: (1) the 'pre-'building' phase, which includes the production and delivery of materials to the point of installation; (2) the 'building' phase, which refers to the useful life of the material in the building; and (3) the 'post-building' phase which refers to the time when the usefulness of the building has ended, and the materials no longer have value in the building (figure 2.1).

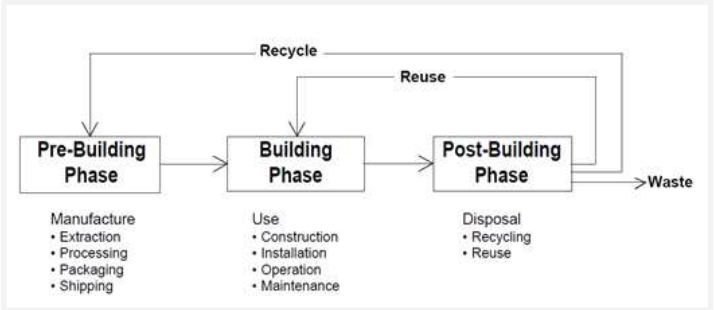

Figure 2.1. Three phases of the building materials life cycle (Kim & Rigdon, 1998)

In the pre-building phase, the source and processing of materials are the main things that must be considered. The source of the material—including the extraction

process—needs to consider the impact on the environment. According to Ding (2014), sustainable development is characterized by building materials sourced from nature rather than those processed industrially using technology and energy in the production process. Furthermore, the 'building' phase includes the construction period and the period of use of the building, starting from the preparation of the material into a building and continuing as long as the material becomes part of the building (Kim & Rigdon, 1998). In this phase, various things need to be considered, including material waste produced during the construction period and the impact of the material on human safety and health during the use of the building. With entering the industrial era, the construction industry became the most significant contributor of waste and pollution to the environment.

In the final phase, post-building, material sustainability has to do with what happens to the material after the building is demolished—whether it will be reused, recycled, or disposed of entirely. According to Kim & Rigdon (1998), this phase is the most often overlooked, even though this phrase has an enormous impact on the environment and costs. So, to reduce these negative impacts, buildings need to be designed to have a longer life cycle by considering the potential for 'material loops,' i.e., building materials are allowed to be reused in new buildings or new systems (Widyarko, et al., 2021).

It is necessary to have a benchmark to analyze the level of sustainability of the materials used. Based on the phases of the material life cycle in a building, Kim & Rigdon (1998) created parameters for material sustainability analysis, also known as 'Green Features of Sustainable Materials' (table 2.1). This parameter can be used to analyze the level of sustainability of the material by assessing whether the material meets certain features or not. Materials that meet more characteristics are considered more sustainable for use in buildings.

Tabel 2.1. Key Green Features of Sustainable Building Materials (adapted from Kim & Rigdon, 1998 in Susanto & Lubis, 2018)

Manufacturing Process (MP)	**Building Operations (BO)**	**Waste Management (WM)**
Waste Reduction (WR)	Construction Waste Reduction (CWR)	Biodegradable (B)
Pollution Prevention (P2)	Energy Efficiency (EE)	Recyclable (R)
Recycled Content (RC)	Water Treatment & Conservation (WTC)	Reusable (RU)
Embodied Energy Reduction (EER)	Non-Toxic (NT)	Others (O): local materials, renewable resource
Natural Materials (NM)	Renewable Energy Source (RES)	
	Longer Life (LL)	

3. RESEARCH METHODS

This study discusses the effect of shape and construction on the sustainability of the material cycle in one of the *Rumah Gadang* located in Padang Laweh, Dharmasraya. This house was chosen because it has undergone a transformation using modern building materials. The method used is qualitative research with an interpretive and naturalistic approach, where researchers consider things as they are. This research is generally divided into three stages: literature review, collection data, and analysis. A literature review was conducted to synthesize various theories relevant to solving research problems and propose specific data collection and analysis methods (Snyder, 2019; Groat & Wang, 2013). In this study, a literature review plays a role in determining the measuring tools or parameters to assess the sustainability of materials at *Rumah Gadang* Padang Laweh.

The second stage is data collection. This study used two primary data collection methods: observation and interviews. The use of two different data collection methods is believed to complement each other to produce a better and comprehensive understanding (Groat & Wang, 2013). Observations are made by paying attention to the use of the material in the case study. Furthermore, interviews were conducted with the house owner to understand the history, construction stages, and patterns of *Rumah Gadang* Padang Laweh from the building user's point of view. Interviews using open-ended questions also allowed an unlimited variety of answers to be obtained and let the writer understand the respondent's point of view as expressed in their own words (Groat & Wang, 2013; Taylor, et al., 2016).

In the final stage, the results obtained from the observations and interviews were analyzed using the principles of 'Green Features' (see table 2.1). To assess the level of sustainability of the dominant building materials used in the current and former case study buildings when they were still using local/traditional materials. The aim is to compare the level of sustainability of building materials in the two different conditions of the house.

4. Results & Discussion

Rumah Gadang Padang Laweh Kingdom; Past and Present

Dharmasraya is one of the regencies in West Sumatra, Indonesia (figure 4.1). Before becoming a regency, Dharmasraya was the first kingdom in West Sumatra (Sasongko, 2017). Over time, the Dharmasraya Kingdom expanded and produced eleven kingdoms, the Padang Laweh Kingdom. *Rumah Gadang* Padang Laweh is one of the royal relics today. This house was built during the reign of king Sutan Alif Tuanku Bagindo Sutan Muhammad in 1213 (Alif, 2021). Based on the interviews, the establishment of *Rumah Gadang* is always close to the headwaters of \the river because the Minangkabau people used boats as transportation. Thus, new residential land is continuously developed near the upstream of the river. Similar conditions are also seen in the Padang Laweh Kingdom, where the first *Rumah Gadang* also stood on the bank of the broad Batanghari River (Alif, 2021) (see figure 4.1).

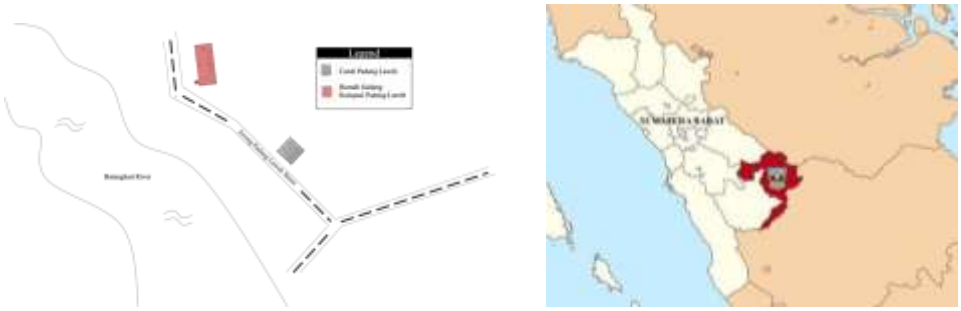

Figure 4.1. Map of *Rumah Gadang* Padang Laweh
Source: https://docplayer.info/97722239-Deskripsi-cagar-budaya-tidak-bergerak-kabupaten-dharmasraya.html

The form of *Rumah Gadang* Padang Laweh is almost similar to the general condition of *Rumah Gadang* in other Minangkabau areas: a stilt house with an arrangement of poles with a particular slope and a pointed roof shape at the ends—also known as "*gonjong*". What differs each *Rumah Gadang* is the number of *gonjong* roofs. The number of tops owned by a *Rumah Gadang* reflects how many tribes it sheltered; thus, the four *gonjong* roofs owned by the case study (fig. 4.2) indicates that four tribes are inhabiting, namely: (1) Piliang, (2) Chaniago, (3) Ketapang, and (4) Tigoni (Alif, 2021).

Figure 4.2. Number of roofs and building form of *Rumah Gadang* Padang Laweh
Source: Author, 2021

In addition to the form, building a traditional *Rumah Gadang* in all areas of West Sumatra has a similar construction process. This process becomes a hereditary rule for the community in developing (Alif, 2021). There are three stages of the house construction process: planning, finding materials, and building. The planning stage was carried out with the approval of all family members (Toeah, 1969). The proposal was then brought to the *Nagari* (village) for further support, including selecting the location, size, material, technical, construction time, and selection of the 'craftsman's head (Hardono, et al., 2014). The next stage is finding materials "*("Maramu Kayu di Rimbo*"). The type of wood commonly used in the *Rumah Gadang* Padang Laweh is *"kulim"*. The search for this wood must be by the advice from the head of the craftsman, namely, (1) the wood comes from a tree that grows well and is not in a state of flowering and is old, (2) the trunk selected must be perpendicular, (3) for the main post, the tree must be grown on a higher ground than the tree for other stakes. In addition, there are also rules in the felling process, namely: (1) felling trees as the main post must be carried out by the chief handyman *(Tukang Tuo)*, (2) trees used as support posts can be carried out by the community (Alif, 2021). After being cut, the wood was moved from the logging location to the village in

cooperation known as "*Maelo Kayu*" (Habibi, 2018). The wood was then immersed into a *tabek* (pond) containing mud—this process is also known as "*Marandam Kayu*"—to preserve wood so that it would not rot and become termite resistant (Hardono, et al., 2014).

At the construction stage, the first process was to remove the wood from the *tabek* and bring it to the construction site in mutualistic cooperation known as "*Mambangkikkan Batang Tarandam*". While waiting for the wood to dry, the community cleaned up the construction site (Alif, 2021). The following process was manufacturing the central column known as "*Mancatak Tiang Tuo*". In the process, there is a traditional ritual where the central column is splashed with the blood of livestock, which is believed to make the wood durable and sturdy (Habibi, 2018). Next, the other columns are constructed and arranged into six series, which will then be erected; this procession is known as the "*Batagak Rumah*" (Alif, 2021). After the frame stands, the construction of the truss begins, also known as the "*Manaikkan Kudo-kudo*". Finally, the structure ends with installing roof coverings, floors, and walls of the house (Habibi, 2018). The roof covering material is palm fibre *(ijuk)* installed with a certain slope to facilitate the flow of rainwater, making the roof dry quickly and durable (Alif, 2021). According to Habibi (2018), this material is suitable for the West Sumatra climate because it can absorb sunlight during the day and bring warm air into the house during the nighttime.

Over time, the *Rumah Gadang* Padang Laweh became damaged and needed repairs because the materials used in the old house were no longer feasible to maintain. The redevelopment of *Rumah Gadang* Padang Laweh was carried out in 2017, with the most significant structure and roof construction (Alif, 2021). After 2017, the materials used in *Rumah Gadang* Padang Laweh are concrete for most of the structure, zinc sheet for the roof covering, and non-local wood for trusses, walls, and part of building structures. The change of materials—primarily due to the use of concrete—affected the shape of the building. The newer buildings were perfectly upright, in contrast to the older building with slightly slanted walls (figure 4.3) (Alif, 2021).

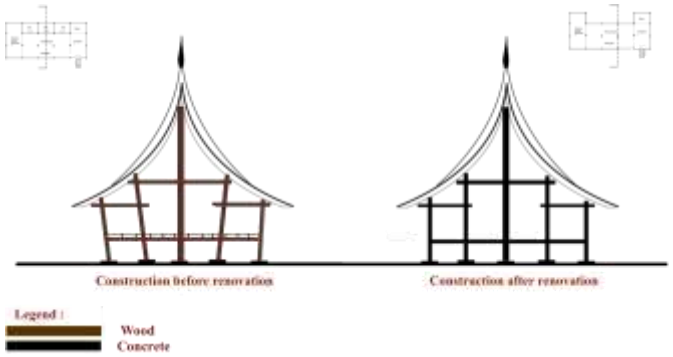

Figure 4.3. The Difference of construction and materials of *Rumah Gadang* Padang Laweh
Source: Author, 2021

Modern materials also contribute to the sustainability of traditions in buildings. The tradition in the process of building the old *Rumah Gadang* was no longer used due to modernization (Alif, 2021). Special treatment in material processing to maintain the sturdiness and longevity of the material no longer existed. The construction is carried out using modern methods and is entirely done by familiar craftsmen (Alif, 2021). Although the old tradition of *Rumah Gadang* has faded, the matrilineal system is still applied in the

Kingdom of Padang Laweh (Alif, 2021). The inheritance rights of the *Rumah Gadang* Padang Laweh remained in the mother's lineage, even though the house no longer functions as a residence. The heir *(Bundo Kanduang)* now lives in a modern house known as "*Rumah Ketek*" around the yard of *Rumah Gadang*. Currently, *Rumah Gadang* Padang Laweh has changed its function into gathering and deliberation for the community.

According to Indah & Feni (2019), modernity introduces a new vocabulary into Minangkabau culture—new materials, new tectonics, new approaches, and new comforts in housing—which were marked by the emergence of the phenomenon of architectural transformation in the *Rumah Gadang*. These changes were not only experienced by the Padang Laweh Kingdom and almost all kingdoms in the Dharmasraya regency. Changes in the function of the building affected the sustainability of *Rumah Gadang* in Dharmasraya. For this reason, the Dharmasraya Government is now working hard to maintain the shape and uniqueness of the original *Rumah Gadang* in its area, which only consists of 300 houses left through a revitalization program (Jansen, 2021).

Material Sustainability Analysis at the *Rumah Gadang* Padang Laweh Kingdom

Rumah Gadang Padang Laweh Kingdom with Traditional Building Materials

Two materials were used to construct the traditional *Rumah Gadang*: local *Kulim* wood and *palm fibre*. In the MP phase, the wood has three green features. Wood processing is traditional practice while maintaining the natural material content and does not produce pollution (P2+, EER+, NM+). However, this wood does not contain recycled content, and the process had residual waste from branches when felling because it only uses wood that is in accordance with the size (WR-, RC-). In the BO phase, the local wood fulfils all the existing features. The construction process used the traditional method, such as wood preservation in the *tabek* by maintaining the content of natural materials.The *tabek* could be used repeatedly to not affect water quality (EE+, WTC+, NT+). With this preservation process, wood has a long service life and fulfils the passive cooling principle due to its low thermal conductivity (LL+, RES+). Moreso, the remaining waste generated can be used as fuel (CWR+). Whereas in the WM phase, wood checks all the green features. Wood is a natural and biodegradable material; the used wood splinters can be used by the community as fuel, while the solid ones can be reused (B+, R+, RU+). Furthermore, the wood used is obtained from the village forest—a local material—although not from renewable resources (O+).

The traditional *Rumah Gadang* used *fibres* obtained from palm plants (Sutan Alif, 2021). In the MP phase, the palm *fibres* contained most green features. The harvesting and processing were done traditionally, so it does not produce pollution (WR+, P2+, EER+, NM+). However, palm *fibres* are a natural resource, so they do not contain recycled content (RC-). The fibres have five of the six green features in the BO phase. Traditional methods carried out the assembly process; therefore, it did not contain toxins (EE+, WTC+, NT+). Palm *fibres* also have a long service life because they are flexible and not easily brittle and have the ability to absorb heat (Habibi, 2018) (RES+, LL+).

Furthermore, the waste from palm *fibres* or the rest of the assembly can be used as a *rangkiang* (granary) roof (CWR+). In the WM phase, fibres have two of the three green features. Palm *fibre* is a natural and biodegradable material, and its waste can be recycled for fuel (B+, R+). However, palm *fibres* can only be used once (RU-). The *fibres* used are local materials sourced from village forests and from renewable resources (O+).

Table 4.1. *Rumah Gadang* Material Analysis of TraditionalConstruction Against Green Features

Building Material	***Green Features***		
	MP	***BO***	***WM***
Local Wood	3 *(P2, EER, NM)*	6 *(CWR, EE, WTC, NT, RES, LL)*	3 *(B, R, RU, O)*
Palm Fibre	4 *(WR, P2, EER, NM)*	5 *(CWR, EE, WTC, NT, RES)*	3 *(B, R, O)*

Both materials used in the traditional *Rumah Gadang* are natural materials from local forests, processed using traditional practices and methods without expending excessive energy. Thus, the materials in the traditional construction of the *Rumah Gadang* Padang Laweh have a high level of sustainability with 25 out of a maximum of 30 features (table 4.1).

***Rumah Gadang* Padang Laweh Kingdom with Modern Building Materials**

Reinforced concrete used as a structural material in the modern construction of *Rumah Gadang* only fulfills 4 of the total 15 green features. In the MP phase, reinforced concrete does not meet any features. The production of concrete produces a lot of pollution and waste (P2-, WR-). The concrete is made using new basic material. It contains cement and steel base materials that are not classified as natural (RC-, NM-), and the cement used has a high embodied energy (EER-). In the BO phase, reinforced concrete fulfills four features: it has a high thermal resistance and low thermal conductivity, which plays a role in energy savings (Brownell, 2012; Susanto & Lubis, 2018) (EE+, RES+), is not harmful to human health (NT+), as well as having high durability and easy maintenance (LL+). However, the concrete construction process generates a lot of waste and requires a lot of water (CWR-, WTC-). Whereas in the WM phase, reinforced concrete does not meet any features: it is not biodegradable and not reusable (B-, RU-), as well as efforts to recycle concrete generally require higher energy, so it is considered ineffective and very rarely done (R-). In addition, reinforced concrete is also an industrial material and is not sourced from the local area, so it does not meet other features (O-).

Figure 4.1. The construction of Rumah Gadang
source: https://sumbar.antaranews.com/berita/424410/pemkab-dharmasraya-alokasi-dana-sebanyak-ini-di-2021-untuk-merevitalisasi-15-unit-rumah-gadang

In the modern construction of *Rumah Gadang*, non-local wood is used as the main structure in the center of the building and other parts (figure 4.3). Based on the analysis of the green features, this material satisfies 9 out of 15 features. In the MP phase, non-local wood fulfills 2 of 5 features: wood is a natural material (NM+), and the wood processing process does not require high energy (EER+), but it is not known that any special efforts have been made to minimize pollution and waste (P2-, WR-), and the materials used are new materials (RC-). In the BO phase, wood fulfills 4 of 6 features. The waste generated from wood construction is not large and can be collected again for other uses (CWR+). The construction process does not consume a lot of energy and water (EE+, WTC+), and has a low thermal conductivity so that it saves operational energy (RES+). However, the new wood used is classified as level III, which means its durability is not high (LL-), and the wood is protected with chemical varnish, which can be harmful to health (NT-). The wood used is no longer obtained from the local area but is purchased from a shop that generally gets supplies from outside the area, so it does not meet the features of local materials (O-).

The roof covering at the modern *Rumah Gadang* used a zinc sheet that meets five green features out of 15. In the MP phase, this material fulfills one feature: several zinc sheet products sold in the market contain recycled materials (RC+), but the production process requires a lot of energy (EER-), produces a lot of pollutants and waste (P2-, WR-), and the basic ingredients are not classified as natural materials (NM-). In the BO phase, the zinc sheet fulfills four features. It is a prefabricated material, so it does not produce a lot of construction waste (CWR+), the construction process also does not require a lot of energy and water (EE+, WTC+), and its use is not harmful to human health (NT+). However, zinc sheet is a heat conductor, does not support passive design (RES-), has low durability, and is easy to rust (LL-).

In the WM phase, the iron sheet does not meet any features. The material is not biodegradable (B-), and interviews indicated that the zinc sheet had been replaced, and no attempts were found to reuse or recycle those that were no longer used (RU-, R-). In addition, the zinc roof is not sourced from the local area, so it does not meet the features of local materials (O-).

Table 4.2. *Rumah Gadang* Material Analysis of Modern Construction Against Green Features

Building Material	***Green Features***		
	MP	**BO**	**WM**
Reinforced Concrete	-	4 *(EE, NT, RES, LL)*	-
Non-Local Wood	2 *(EER, NM)*	4 *(CWR, EE, RES, WTC)*	3 *(B, R, RU)*
Zinc Sheet	1 *(RC)*	4 *(CWR, EE, RES, WTC)*	-

Only wood has a reasonably high sustainability value of the three materials used, while the other materials have a low value. As a whole building, the materials used in the construction of *Rumah Gadang* Modern only fulfill 18 features from a maximum of 45 (table 4.2).

5. Discussion

The matrilineal system in Minangkabau society is still attached, even though it is no longer tied to *Rumah Gadang*. This is because of the modernization of the matrilineal system. It also marked by the emergence of the phenomenon of "*Rumah Ketek,*" which is a modern reinterpretation of the bedroom (the personal space of women in the *Rumah Gadang*) and is used as a residence, but still within the same yard of *Rumah Gadang* (Indah & Feni, 2019). It triggered changes in the function of *Rumah Gadang*, where the house was no longer used as a residence for the heirs but remained its ownership. That way, the matrilineal system continues to run according to ownership rules but is no longer tied to the *Rumah Gadang*. This phenomenon is also the beginning of the emergence of modern materials. Due to the lack of efforts to preserve local natural materials, the original materials used in the traditional construction of buildings had become challenging to find, and modern materials were easier to obtain. As a result, there was a change in the tradition of building the *Rumah Gadang*—the tradition did not work properly due to the influence of materials, construction, and modern architectural styles.

These changes also affect the sustainability of the building assessed from the use of materials. Based on an analysis conducted on 15 Green Features (Kim & Rigdon, 1998), it was found that the two materials in the traditional construction of *Rumah Gadang* have high sustainability values (13/15 and 12/15). Meanwhile, the newer/modern construction only has one of the three materials of moderately high value (9/15) and the other two of low value (4/15 and 5/15). The total sustainability value of the traditional *Rumah Gadang* is 25/30, while the new/modern one is 18/45 (table 4.3).

Tabel 4.3. The Comparison of Material Sustainability of *Rumah Gadang* Traditional and Modern Based on Green Features Analysis

Type of *Rumah Gadang*	Building Material	Total (Green Features/15)	Total
Traditional *Rumah Gadang*	Local Wood	13/15	25/30
	Palm Fibre	12/15	
Modern *Rumah Gadang*	Reinforced Concrete	4/15	18/45
	Non-Local Wood	9/15	
	Zinc Sheet	5/15	

Of all these features, the traditional *Rumah Gadang* excels mainly because all the materials used come from natural sources (NM) and are obtained from local areas (O: local materials). Due to its natural nature, all the materials used in *Rumah Gadang* Traditional also meet the features of biodegradable (B) and recyclable (R). The final phase of the material has more potential to be sustainable. Based on this analysis, it can be seen that the traditional *Rumah Gadang* has a higher level of material sustainability than the newer/modern one.

However, even though the sustainability value of the material is higher, it does not mean that the traditional construction of the *Rumah Gadang* could be considered fully sustainable. This is evidenced by the absence of local materials, which used to be abundant. It is based on the traditions that did not consider the final phase of the material life cycle and the lack of efforts from the community to preserve the material resources used in traditional *Rumah Gadang*, causing a scarcity of materials. As a result, the construction of the new *Rumah Gadang* was forced to use modern materials that are less sustainable than the original materials. This is very unfortunate, especially since, according to Susanto & Widyarko (2017), certain types of wood—including *kulim* wood—have the potential to be reused as building materials because their performance remains relatively good compared to replacing new ones.

6. Conclusion

Modernization introduces a new culture into Minangkabau, one of which occurs in the matrilineal system, which caused changes to the existence of the house, making it no longer used as a dwelling place. As a traditional building, *Rumah Gadang* has traditions and rules that bound the form, material, and construction process, although this tradition has begun to be abandoned in practice. Therefore, several traditional aspects of *Rumah Gadang* became substituted with modern aspects, such as materials, techniques, and architectural styles. Thus, there is a simplification in the house, which was initially tilted, now upright. In addition, modernity also influences the sustainability of the material. When the *Rumah Gadang* building still uses traditional construction, the materials were sourced directly from nature and processed with traditional practices without emissions, making the material cycle more sustainable, especially in the pre-building phase. Unfortunately, the post-development phase of the materials cycle is poorly considered, and no efforts were made to conserve natural resources. It leads to a scarcity of original materials; thus, new buildings are forced to be constructed using modern materials even though they have a lower level of sustainability.

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