

Identification of post-disaster housing reconstruction using a lean reconstruction approach (case study: Pasaman earthquake in 2022)

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Abstract. Housing reconstruction for affected communities is a priority need following a disaster. Mechanisms and strategic steps for implementation are needed to ensure that the handling is quicker and more targeted. This aligns with the lean principle of "Let the customer pull—do not make anything until it is needed, then make it quickly," and pursue perfection through continuous improvement. This research aims to identify the stages and mechanisms of housing reconstruction implementation in West Pasaman following the earthquake disaster in 2022 through a lean reconstruction approach. This research is part of a study on developing a lean reconstruction model for post-disaster housing reconstruction in Indonesia. The method used in this research is qualitative with a case study approach. The study results indicate that implementing post-disaster housing reconstruction in Pasaman has not met the lean principle, with several stages being repeated so that it can be classified as a wasteful process. The main problem that causes the repetition of the process is the problem of data collection. In addition, the distribution pattern of post-disaster housing reconstruction assistance has several weaknesses at various stages, so the final value of recipient satisfaction cannot be fully achieved.

1 Introduction

1.1 Background

Housing or housing reconstruction is the main factor in post-disaster recovery. It is a top priority in recovery efforts because decent housing is the foundation for community survival. Community participation, communication, resettlement, and cultural conformity have become recurring challenges and continue to cause housing reconstruction projects to fail [1]. Some beneficiaries modify or outright reject the housing provided or, in some cases, dismantle the house and sell its components.

This reconstruction process requires a holistic approach involving community participation and stakeholders and using environmentally friendly technology to ensure that buildings are resilient to future disasters.

On the other hand, housing reconstruction issues are not solely the result of limited technical capacity or construction engineering but also of factors such as inadequate planning and coordination, chaos among the parties involved, a scarcity of resources and supplies during the project, the simultaneous launch of a significant amount of aid, a lack of knowledge and experience in the provision and construction of post-disaster settlements, socio-cultural considerations, and a

failure to consider the expectations and needs of the beneficiaries [2, 3].

There is more to post-disaster housing reconstruction than simply reconstructing. With all the challenges and problems mentioned above, a method is required to address, mitigate, or resolve the obstacles and issues associated with post-disaster home rebuilding. Lean construction is one methodology applicable to post-disaster house rehabilitation. The term "lean" originated in the manufacturing sector, referring to the lean production strategy implemented by Toyota, which provides high-quality, varied, and cost-effective output to satisfy consumer demands [4].

The aspiration to offer cheap homes, minimize construction waste, and enhance efficiency has resulted in adopting lean building principles. Lean construction projects are typically more manageable, safer, done more swiftly and economically, and exhibit superior quality. Implementing lean construction in-house reconstruction can enhance performance, expedite the process, mitigate environmental effects, and decrease material waste.

Prior studies have not specifically addressed the incorporation or implementation of lean principles in post-disaster home rebuilding. The study initially explored the feasibility of implementing lean methodologies in post-disaster reconstruction, demonstrating that approaches such as Pull Scheduling, Quick Mobilization, Lean Six Sigma, and Just in Time are

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applicable in this context [5]. This indicates that lean thinking has significant potential for exploration within natural catastrophe management. Implementing lean principles in post-disaster rebuilding can facilitate a transition from a reactive to a proactive strategy in catastrophe management.

1.2 Research problems

The main issue in applying lean construction to post-disaster housing reconstruction is determining what kind of lean reconstruction model will be implemented. To develop a lean reconstruction model from the previously applied lean construction model, one can modify the lean construction techniques, combine several lean methods, or even create new strategies for lean reconstruction that utilize lean principles. To address this issue, it is necessary to identify the implementation of post-disaster reconstruction in Indonesia, one of which is Pasaman Regency, which experienced an earthquake in 2022 and whose reconstruction is still ongoing. Identification is carried out to understand what the stages of implementation are and what problems occur at each of those stages.

1.3 Research objectives

This research is part of developing a lean reconstruction model for post-disaster housing reconstruction in Indonesia. This research seeks to delineate the phases of post-disaster house reconstruction and the issues that may be addressed or mitigated by applying lean construction principles. In this paper, the research locus discussed is housing reconstruction implementation after the Pasaman Earthquake disaster in 2022. This research was conducted through a literature study on the report on implementing Rehabilitation-Reconstruction in West Pasaman Regency and other literature in journals and books. Furthermore, Interviews were conducted with stakeholders participating in post-disaster home rehabilitation at the regional level to ascertain the current implementation circumstances.

2 Literature review

2.1 Post-disaster reconstruction

The reconstruction phase is the most essential in disaster management. The principal challenges in the post-disaster rebuilding phase include inadequate planning, impulsive decision-making, disorganized recovery efforts, substandard built environments, material wastage, environmental degradation, protracted restoration timelines, and elevated prices [5]. Post-disaster rebuilding requires interdisciplinary participation, substantial resources, and many skill sets [8].

Reconstruction should rely on established procedures and rules that provide explicit institutional accountability for recovery efforts and promote public engagement. Recovery activities that focus on "building back better »

can shape the fate of local communities and reduce the potential for damage due to future disasters [6].

Reconstruction is a long-term activity [7] that begins as soon as the emergency phase begins. A series of processes must be carried out from when the disaster occurs until the reconstruction ends [8] as shown in Fig. 1.

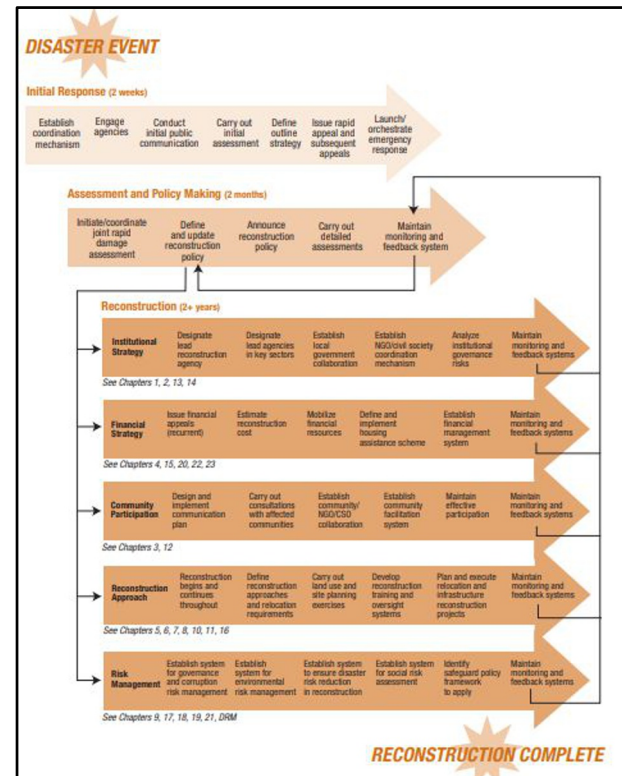


Fig. 1. Post-disaster response and reconstruction process

In the book "Handbook for Post-Disaster Housing and Community Reconstruction" [8], there are ten principles of post-disaster reconstruction:

- Inclusive Policy:** Empowering communities to rebuild their lives with a focus on vulnerable groups.
- Immediate Reconstruction:** Begin immediate reconstruction with new standards to improve building safety.
- Community Participation:** Communities should be involved as partners, not victims, to improve psychosocial recovery and community cohesion.
- Realistic Financial Policy:** Plan policies with sufficient and realistic funding integrated with other reconstruction activities.
- Institutional and Coordination:** Ensure effective policies and coordination before disasters to improve reconstruction outcomes.
- Future Planning:** Using reconstruction opportunities to plan for the future and preserve historic buildings.
- Avoid Relocation:** Relocation should be avoided except for safety, with participatory locations selected.
- The Role of the Private Sector and NGOs:** The contribution of NGOs and the private sector is crucial in reconstruction.

- i. Assessment and Monitoring: Engage the community in evaluating and monitoring to improve reconstruction outcomes.
- j. Sustainability: Reconstruction must be environmentally and economically sustainable without overriding environmental laws.

These principles aim to ensure an effective and sustainable reconstruction process.

2.2 Post-disaster housing reconstruction

Reconstruction of housing is an essential component of post-disaster recovery activities since it enables communities that have been affected to reestablish themselves. Post-disaster housing rehabilitation represents a significant obstacle in recovery efforts, particularly in developing nations [9]. Housing is essential for individuals as it pertains to their well-being. Housing serves as an asset that enhances family life in domains including health, education, economy, security, and social welfare. Facilitate social engagement, cultural pride, identification, political dynamics, and economic resources [2].

Several approaches can be used as models for post-disaster housing reconstruction. The selection of the best reconstruction approach to use is context-specific. It must consider the cost of reconstruction, improving housing and community security, livelihood recovery, political environment, cultural contexts, and the community's welfare, empowerment, and capacity goals. Conducting consultations with the community and evaluating capacity and requirements is essential before deciding which reconstruction approach to use. There are 5 approaches to post-disaster housing reconstruction that are generally carried out, including [8]:

- a. Cash Approach (CA): offers unconditional financial aid without technical help.
- b. Owner-Driven Reconstruction (ODR): offers conditional financial aid and regulatory and technical help to guarantee the improved reconstruction of the dwelling. Individuals who lost their residence received financial assistance or support for independent repairs.
- c. Community-Driven Approach (CDA): Reconstruction is spearheaded by an institution that incorporates community involvement in decision-making and building processes.
- d. Contractor-Driven Reconstruction In-Situ (CRIS): A designated contractor oversees reconstructing a damaged home at its original site before the disaster.
- e. Contractor-Driven Reconstruction in Relocated Site (CRRS): Reconstruction is overseen by a contractor designated to construct a new residence at a different location.

The housing provision process, community engagement in housing design and oversight, the acquisition of building materials and skilled labor, and the government's involvement and policies contribute to enhancing and facilitating the post-disaster housing rehabilitation and reconstruction process in Indonesia [10].

The precision of beneficiary data in the housing allocation process is crucial to prevent redundant housing reconstructions. The government's capability is essential and must be strengthened from the initial phases of the home rehabilitation operation. Community involvement in housing rebuilding must be meticulously evaluated, analysed, and administered, contingent upon the contextual circumstances. Moreover, training and capacity building for communities before engaging in house construction would substantially enhance their involvement in the project [10]. Ill-informed communities can incite conflicts with contractors and builders, leading to building delays.

Furthermore, there is a need to raise awareness of earthquake safety problems among home builders, homeowners, and government authorities. Inspection and quality control must be performed throughout construction to ensure that the structure is created by the design and seismic safety criteria. [11].

Early community involvement, particularly in decision-making during the planning phase, is crucial for influencing future engagement. These results guide disaster recovery methods by promoting project concepts that integrate community involvement throughout the project's lifetime [12].

The experiences in Japan, Gujarat, and Bam illustrate that a crucial driver of success is the presence of a suitable institutional structure. A national specialized entity with representatives and units at the state and local government levels should enable centralized coordination and facilitate recovery and reconstruction initiatives. This case study demonstrates that the institutional framework and overarching principles for the design and execution of home rebuilding initiatives are mandated by legislative measures [1].

The housing reconstruction has been identified as the most arduous and complex initiative throughout the recovery period from the catastrophe. A community-based strategy is a procurement method applicable to home rebuilding. In this approach, the community not only serves as a beneficiary but also possesses the authority to oversee the construction phase [13]

During the pre-construction phase, twelve essential criteria have been recognized as Critical Success criteria (CSF) for community-based home rebuilding following a disaster. These factors include [14]: (a) Clarity and responsibility, (b) Suitable reconstruction policies/strategies, (c) Comprehension of community-oriented approaches, (d) Building public trust, (e) Capacity for facilitation, (f) Effective coordination and communication, (g) Sufficient financial resources, (h) Capability for implementation, (i) A notable degree of community engagement/control, (j) Support from governmental entities, (k) Participation of all community members, (l) Effective identification of beneficiaries

2.3 Lean reconstruction

Deliberately utilizing resources to cut down on waste and increase user value is what we mean when we talk about lean thinking. The success of the Toyota Company

provides a clear illustration of the effectiveness of lean manufacturing. Because of this, there is a substantial demand for professionals knowledgeable in lean thinking and its implementation in fields other than manufacturing, such as logistics, distribution, services, retail, healthcare, construction, maintenance, and government. [15].

Lean construction emerged as a solution to the issues faced by the construction sector, characterized by inflated costs, prolonged schedules, and a culture that sometimes contravenes regulations [16, 17]. Lean construction derives from lean manufacturing, encompassing a multifaceted array of concepts such as continuous improvement, a flat organizational hierarchy, collaboration, waste elimination, resource efficiency, and cooperative supply chain management [18]. Lean Construction emerged as a solution to the issues faced in the construction sector, characterized by inflated expenditures, prolonged timelines, and a culture that often contravenes regulations [16, 17].

Lean construction is no longer novel; several studies have examined lean construction. The Last Planner System is a methodology within lean construction that has demonstrated efficacy in enhancing construction management practices across several dimensions. [19]. The use of BIM in workflow visualization to support the implementation of lean construction shows increased transparency of the process where the physical and managerial state of the site becomes more apparent, which has the potential to increase worker safety motivation and perception, thereby improving workflow and reducing waste as visualization helps reduce uncertainty and misunderstanding [20].

In addition to construction projects, lean construction is also implemented in housing development projects. Implementing lean construction can ensure effectiveness in housing development projects [21]. The results show increased efficiency, encouraging increased speed, reduced waste, and decreased work accidents. Lean construction will create better designs, improve communication and collaboration, and increase user satisfaction.

Over time, several studies began to discuss the application of lean construction to post-disaster reconstruction. Previous research has also identified lean construction strategies that can be implemented during the rebuilding of post-disaster housing, including, Pull Scheduling, Value Stream Mapping, Last Planner System, 5S (Sort, Straight, Shine, Standardize, and Sustain), and Lean Six Sigma. These five techniques need further study regarding the conditions for implementing housing reconstruction [22].

3 Results and discussion

3.1 Data collection

The data needed in this study is the existing condition of the post-disaster housing reconstruction implementation stages and the problems faced. Secondary data was obtained from institutional documents, including the Rehabilitation and Post-Earthquake Reconstruction Plan

in West Pasaman Regency and Implementation Technical Instructions. The data is also supported by primary data from interviews conducted with parties implementing post-disaster housing reconstruction in the West Pasaman Regency Rules and other decisions. The following table (Table 1) shows a list of respondents interviewed in this study.

Table 1. List of interview respondents

No.	Position	Institution
1	Chief Executive	West Pasaman Regional Disaster Management Agency
2	Head of Rehabilitation and Reconstruction Division	
3	Facilitator	
4	Beneficiary Communities	West Pasaman

3.2 Results and analysis

3.2.1 Disaster profile and impact

The earthquake in West Pasaman Regency occurred on February 25, 2022. It had a severe impact on the Region. The 6.1-magnitude earthquake, accompanied by aftershocks, resulted in other aftershocks in the form of flash floods, liquefaction, and landslides, especially at the main points of the earthquake.

3.2.2 Post-disaster housing reconstruction implementation policy

The Post-Earthquake Rehabilitation and Reconstruction Plan (R3P) in West Pasaman Regency is contained in the Decree of the Regent of West Pasaman Number 188.45/704/BUP-PASBAR/2022. In the R3P, the recovery period set out in this rehabilitation and reconstruction plan is from 2022 to 2025. The priority for recovery is the residential sector because it directly impacts people's lives. For relocation, land needs will be provided between the district and provincial governments. In contrast, the government will give or finance stimulant funds to construct houses and residential infrastructure.

However, until now, the implementation of rehab in West Pasaman has not been based on this R3P because West Pasaman is still in an emergency transition period, while according to the provisions of the R3P, it is carried out during the recovery period (after the emergency harmonization period). Housing reconstruction is implemented during the emergency transition period for heavily damaged houses, and the BPBD of West Pasaman Regency handles it. Meanwhile, the relevant service, the West Pasaman Settlement Office, will carry out moderate and light damage. Housing reconstruction implementation during the emergency transition period uses BNPB's Ready to Use Fund (DSP) to accelerate reconstruction. Therefore, initially only 14 days, the emergency transition period continues to be extended until housing reconstruction is implemented. One of the provisions for

using DSP is that it can only be used during the emergency transition period.

3.2.3 Implementation of housing reconstruction after the Pasaman earthquake

Based on the analysis of institutional documents, such as technical instructions for implementation and interviews, Fig. 2 describes the existing conditions of the stages of post-disaster housing reconstruction implementation in the West Pasaman Regency.

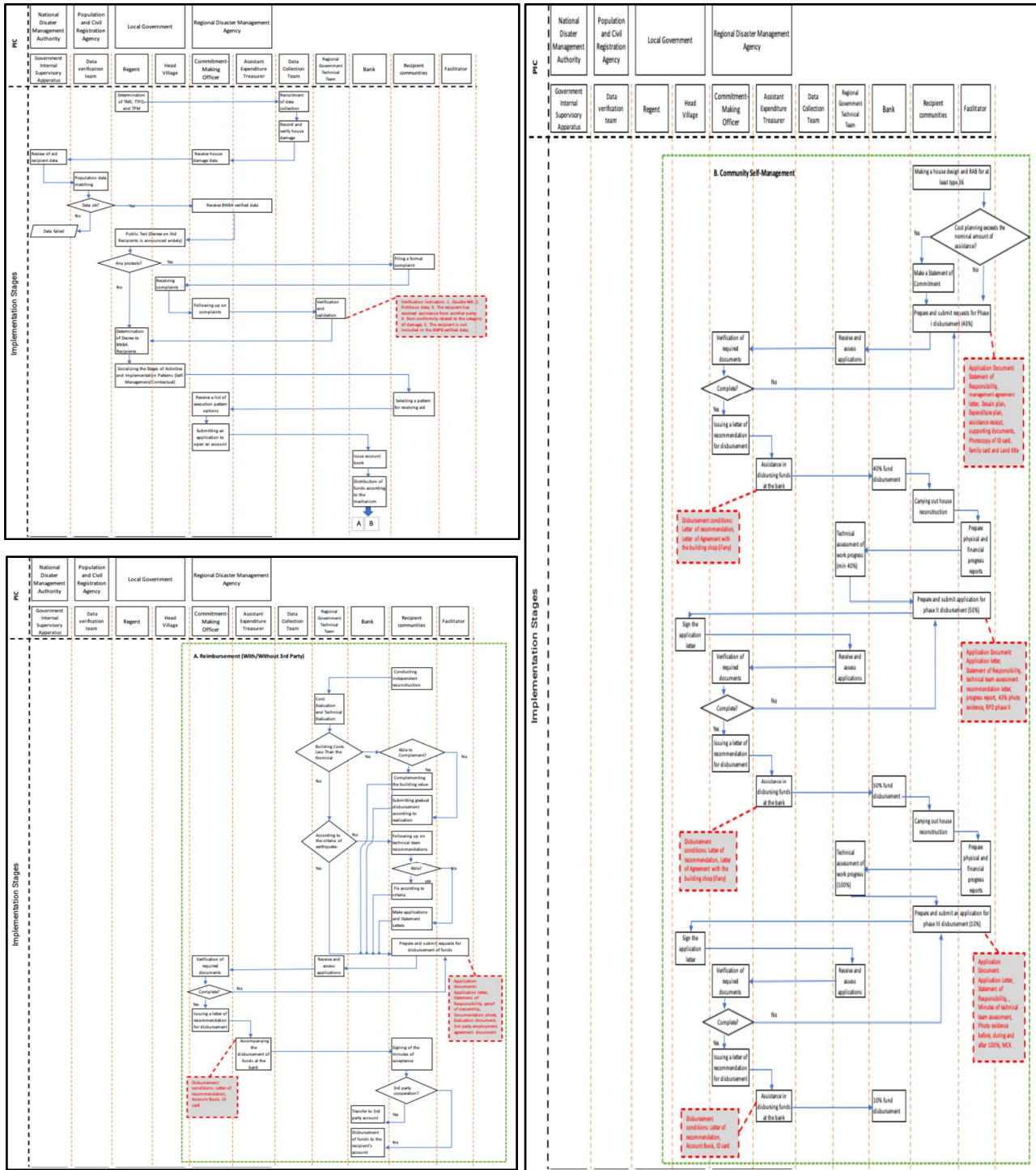


Fig. 2. Stages of housing reconstruction after the 2022 Pasaman earthquake

The implementation of housing reconstruction in West Pasaman Regency can be pretty slow if you compare the damage to previous disaster events, such as Lombok and Palu in 2018, which had a much more significant impact.

In the implementation of post-disaster housing reconstruction in West Pasaman, several problems were found, and these problems were dominated by the problem of collecting data on aid recipients both at the

beginning of the implementation and during the reconstruction. At the start of the implementation of the activity, which began with the collection of data on damaged houses, several problems were found, including:

- a. There is a data collection team using rules that are not by National Disaster Management Authority (NDMA) provisions, where 50% of the damage is categorized as badly damaged; even though NDMA is listed for the category of severe damage, the level of damage is above 70%, so re-data collection or re-verification is carried out related to this.
- b. As a result, the problem in point A caused protests in the community where the damage to their houses decreased from severely damaged to moderately damaged, and those that were initially moderately damaged became lightly damaged.
- c. The data collection process also experienced interference from the community, which forced the categorization of houses at the highest level to be severely damaged).

Furthermore, in the implementation of activities, based on the stages of implementation in Fig. 2, it is known that the phases of reconstruction implementation do not support the acceleration of reconstruction. In addition, the community has complaints and dissatisfaction about the implementation procedures and reconstruction results.

The following is a description of the results of the identification of the implementation of post-disaster reconstruction in West Pasaman Regency:

- a. The implementation procedure is unclear. The Government Internal Supervisory Apparatus of NDMA sends the data collection results of damaged houses to NDMA for review and matches them with population data. However, the type of data reviewed and the review indicators are unclear.
- b. From the technical instructions, it is known that after the data on the list of beneficiaries is reviewed by NDMA, a public test of the data is carried out. If there are, the local government technical team will carry out complaints from the community, verification, and revalidation. After the public test, a Regent Decree was issued regarding the list of recipients of By Name by Address assistance. However, the procedure for determining the Decree based on verification and validation results is unclear. In addition, there are still many complaints from the public after the decree was issued.
- c. The Regent's Decree should be the last used to assist. However, while monitoring activities, NDMA found indications of data errors, so it reviewed the data on the list of recipients again. The review results show that the number of aid recipients has decreased significantly. This, of course, has provoked protests from the community.
- d. The technical instructions provide three (three) patterns or mechanisms for distributing assistance: Reimbursement, Self-Management, and Contractual. However, the contractual procedure is not described in detail, resulting in unclear

procedures that will trigger problems in implementation.

- e. The implementation of reconstruction with a reimbursement pattern is chosen by the community that has done repairs and reconstruction before the aid funds are distributed. In this pattern, the community must meet many requirements for the disbursement of funds. In addition, there is a technical evaluation where houses built independently by the community must meet the criteria for earthquake-safe and livable dwellings. However, the community did not know the requirements for these two things in advance because they were only conveyed during socialization. Meanwhile, quite a lot of people have repaired their houses before socialization was carried out.
- f. The implementation pattern with self-management is a pattern that is generally chosen by people who do not have the financial ability to repair their houses before the disbursement of aid funds. This pattern is quite difficult for the community because of the requirements that must be met. One of them is that the community must prepare house design documents and cost budget plans as one of the requirements for the disbursement of funds. In making these documents, the community is indeed assisted by facilitators, but the limited number of facilitators will undoubtedly slow the completion of activities. The number and ability of facilitators largely determine the time it takes for this requirement.

4 Conclusion

The implementation of post-disaster housing reconstruction in Indonesia faces various problems that hinder its effectiveness and efficiency. Significant issues include poor data collection of aid recipients, resulting in repeated verification and disappointment in the community. In addition, complicated administrative requirements make it difficult for the community in an emergency, causing delays in the disbursement of funds. Socialization related to earthquake-safe and habitable housing standards was not carried out before the community reconstructed their homes independently. All of these problems are interrelated and contribute to the low level of community satisfaction and the failure to achieve the goal of post-disaster reconstruction, namely "building back better." Therefore, developing a lean reconstruction model for post-disaster housing reconstruction is essential to minimize existing problems and increase community satisfaction as beneficiaries.

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