

Post-Disaster Housing Reconstruction in Rural Nepal: A Case Study in the Aftermath of the 2015 Nepal Earthquake

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Abstract

Globally increasing intensity and frequency of disasters disproportionately affect rural populations, who are particularly vulnerable to damage. Disasters also have far-reaching impacts on the built environment and lead to significant economic losses required for the post-disaster reconstruction of houses and infrastructure. Housing plays a crucial role in fostering sustainability and well-being in people's lives. If houses are damaged, individuals are compelled to reside in evacuation shelters or temporary residences for extended periods, hindering the potential for sustainable livelihoods and quality of life. This study examines various factors, such as mutual cooperation, local resource utilization, topographical considerations, and seasonal influences, aimed at fostering effective post-disaster housing reconstruction in rural communities in developing countries. A questionnaire survey including key informant interviews was conducted in the affected areas to collect the primary data. The study also incorporates additional information, such as government policies for post-disaster housing reconstruction and physical observation of the affected areas. The collected information is analyzed using descriptive statistics, including data visualization. The study found that households that primarily utilized local resources and engaged in mutual assistance, such as labor exchange, were able to accelerate their reconstruction efforts. The study includes discussions about utilizing local resources and mutual cooperation for prompt reconstruction and the scope for future research on post-disaster reconstruction in rural areas.

Keywords

Local Resources, Mutual Help, Nepal Earthquake, Post-Disaster Housing

1. Introduction

Disasters have a tremendous economic impact. A series of disasters has caused economic losses in the tens of billions of U.S. dollars over the last two decades, requiring more than 59 billion U.S. dollars to reconstruct buildings and infrastructure damaged and destroyed by disaster [1]. Examples of major disasters include the Northridge (United States) earthquake in 1994, the Kobe (Japan) earthquake in 1995, the 2004 Indian Ocean earthquake that caused the Asian tsunami, Hurricane Katrina (United States) in 2005, the 2011 earthquake and tsunami in Japan, and the 2017 Hurricane Harvey in the United States [2].

Severe disasters have received significant aid contributions. For instance, the 2004 Indian Ocean Tsunami received donations of USD 6.25 billion from individuals, businesses, trusts, and foundations [3]. Such extensive humanitarian aid and pressures for rapid outcomes present considerable challenges for reconstruction agencies. Some of the issues, such as lack of coordination [4], ineffective government leadership, political interference [5], challenging mountainous topography, hasty responses, the limited construction expertise of NGOs [4], and insufficient accountability, often hinder the management of reconstruction projects. Efforts towards sustainable recovery prompted the movement to “build back better”, a term coined after the 2004 Indian Ocean [6]. This concept became the core of adequate recovery and reconstruction efforts and was formally integrated into the Sendai Framework for Disaster Risk Reduction in 2015 [7] [8].

Nepal, a small landlocked mountainous country, is facing the highest degree of impacts from climate change and natural disasters, especially those associated with earthquakes. The loss of lives and property due to natural disasters is significantly high in Nepal. After 80 years, a huge 7.8 magnitude earthquake struck Nepal on April 25, 2015, followed by several aftershocks, with a major one on May 12, 2015, of 7.3 magnitude. The earthquake and aftershocks caused severe damage to life and property, killing nearly 9000 people, injuring more than 22,300, and causing destruction or damage to over 755,000 private houses, and more than 166,100 public buildings [9].

Due to the loss of housing in the 2015 Nepal Earthquake, many people were forced to reside in evacuation shelters or temporary residences for extended periods. As a consequence, the quality of life was severely affected as housing plays a crucial role in fostering sustainability and well-being in people’s lives [10]-[12]. To support the goal of “build back better”, the government of Nepal adopted the Owner-Driven Housing Reconstruction (ODHR) process along with the “blanket approach”, wherein equal distribution or assistance to all affected households regardless of their economic status and social vulnerabilities [13]. However, post-disaster housing reconstruction experienced significant delays due to multiple fac-

tors. A primary barrier was the disruption of transportation networks caused by landslides, exacerbated by the timing of the earthquake at the onset of the monsoon season. This infrastructural damage critically delayed the delivery of external aid, including construction materials and skilled labor, hindering reconstruction efforts across affected communities.

This study examines the potentialities and constraints faced by inhabitants in the post-disaster reconstruction of permanent housing in hilly rural regions, specifically focusing on post-earthquake reconstruction. The analysis investigates various factors that influence the post-earthquake reconstruction process, encompassing the utilization of local resources as reconstruction materials, mutual cooperation practices (labor exchange), manpower availability, topographical considerations, and seasonal challenges.

1.1. Post-Disaster Housing Reconstruction Phases

Housing is a valuable asset for inhabitants, and disasters have a significant impact on the built environment of developing countries [10] [14]. The impacts and losses due to natural disasters are 20 times greater in developing countries than in developed states [15]. For example, the 2015 earthquake in Nepal severely damaged and destroyed over half a million houses, mainly in rural areas. Even 18 months after the earthquake, many individuals whose houses were severely damaged still resided in temporary and improvised housing [16].

Quarantelli [17] mentions that post-disaster recovery encompasses four stages: emergency shelter, temporary shelter, temporary housing, and permanent housing. It is important to note that the terms “sheltering” and “housing” were used somewhat inconsistently. Therefore, Quarantelli [18] proposed a differentiation between “sheltering” and “housing”. Sheltering represents the activity of staying in a place during the peak and immediate aftermath of a disaster, where normal daily routines are suspended. However, housing denotes the return to normal daily activities, such as work, school, cooking at home, shopping, and so on. Based on this distinction, the subsequent post-disaster housing types are outlined in relation to Johnson’s work [19].

Emergency shelters

Emergency shelters are typically set up following a disaster based on individual and household initiatives, considering factors such as the availability of space, convenience, proximity, and perceived safety [20]. They may take the form of a public shelter, refuge at a friend’s or relative’s house, or shelter under a plastic sheet, and are generally employed for one night to a couple of days during an emergency.

Temporary shelters

Temporary shelters are often sought in the form of a second home, a friend’s house, a motel, a tent, or a public facility [21]. These shelters are typically utilized for a few weeks after the disaster and are accompanied by the provision of food, water, and medical treatment.

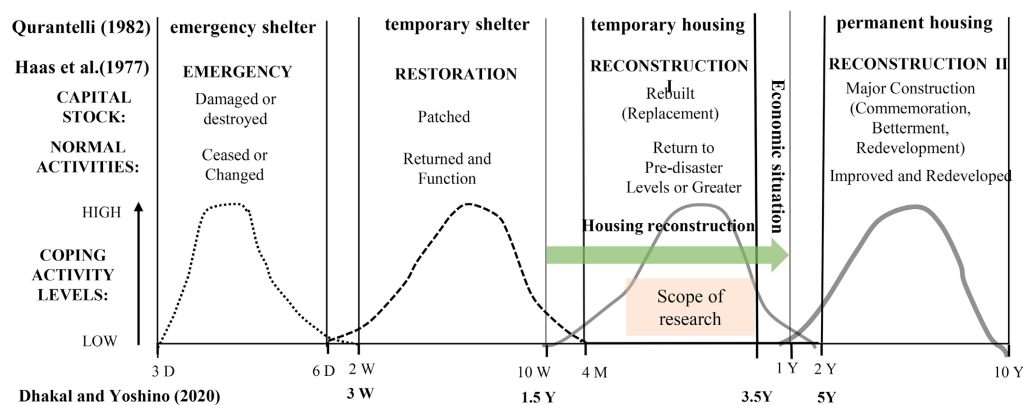
Temporary housing

Temporary housing is the return to the daily activities of home life and the possible return to work and school. Families will live in temporary residences until a permanent housing solution can be found. Temporary housing can take the form of a rented apartment, a prefabricated home, or a small hut, depending on the context.

Permanent housing

Permanent housing is the return to the former home after its reconstruction or resettlement in a new home, where the family can plan to live on a permanent basis. It involves disaster victims returning either to their repaired or rebuilt original homes or moving into new quarters in the community. In both cases, however, the moves involve occupying permanent residential facilities.

After a disaster, actions are generally divided into four phases, as shown in **Figure 1**. Following the Emergency Phase, which involves rescue operations, affected individuals transition to the Restoration Phase (in temporary shelters). This is often followed by the Reconstruction Phase. The Reconstruction Phase is further divided into two sub-phases: Reconstruction-I and Reconstruction-II. Reconstruction-I involves the repair and rebuilding of permanent housing, while Reconstruction-II focuses on major reconstruction projects, such as physical infrastructure (towers, bridges, roads, manufacturing buildings) and public buildings (schools, hospitals, offices, monuments).



Note: D = Days, W = Weeks, M = Months, Y = Years.

Figure 1. Post-disaster recovery phases, adapted from [17] [22] [23].

This study is specifically focused on the reconstruction phases, aiming to achieve a permanent settlement for inhabitants, enabling them to recover their livelihoods in a new normal life.

1.2. Owner-Driven Housing Reconstruction (ODHR) Policy

Ineffective management, such as that caused by weak governance, often leads to delays in post-disaster housing reconstruction and recovery [24]. Therefore, Post-Disaster Housing Reconstruction (PDHR) is considered a crucial part of repre-

senting recovery in developing countries [14]. Studies on PDHR conditions in developing countries have been extensive, such as the 2001 Gujarat earthquake [25], and the 2008 Wenchuan earthquake [26]. Some studies focused on ensuring temporary shelters immediately after disasters during the emergency period [27] [28] and the planning for temporary housing after the emergency period [17] [29]. Other studies investigated the long-term recovery processes, but their focus was exclusively on the adaptation of residents to their new environment after moving to permanent housing [30]-[32]. Approaches to PDHR should take into account a number of factors, such as the scale of the disaster, the capacity of the inhabitants, and the source of available funding. Depending on these factors, the PDHR program may vary [33].

PDHR policies in developing countries focusing on low-income housing reconstruction programs were examined by Fayazi and Lizarralde [34] and found that the Owner-Driven Housing Reconstruction (ODHR) policy is more effective than other policies, such as the Procurement and Turnkey Policy (replacing damaged houses with houses provided by government and reconstruction agencies), Community-driven Reconstruction Policy (active roles of the community in planning the reconstruction process), and Cash Grant Policy (distribution of cash and beneficiary use based on their priorities).

The ODHR policy first emerged in the 2001 Gujarat earthquake in India as a national policy framework [34], which gained recognition for its cost-effective, rapid, and satisfactory approach for citizens [35]. The ODHR policy contributes to preserving the local cultural heritage and vernacular housing styles, which are crucial components of a community's cultural identity [36]. Moreover, it is often regarded as the most empowering and dignified approach to household recovery [35]. However, it carries the risk that highly vulnerable individuals, such as widows, disabled individuals, and the elderly, may lack the capacity to independently manage construction without adequate support mechanisms.

The ODHR policy involves providing direct financial and technical assistance to affected families under the supervision of agency technicians, enabling them to reconstruct their houses after the disaster [37]. With financial and technical assistance, families are expected to manage the reconstruction process of their houses, which in turn is likely to result in more sustainable self-built houses [10]. This approach is particularly promoted for low-income households and upholds the cultural values inherent in traditional practices by allowing or authorizing the inhabitants to participate in the reconstruction of their housing themselves [38].

On the other hand, other policies, such as the Procurement and Turnkey Policy, neglect cultural and local conditions, disregarding residents' real needs; the Community-Driven Reconstruction Policy overlooks residents' perspectives as it mainly concentrates on the viewpoints of community leaders and elite groups; and the Cash Grant Policy provides beneficiaries with the possibility of misusing the aid for purposes other than housing [34].

1.3. ODHR Program after the 2015 Earthquake in Nepal

Nepal also faced unprecedented challenges because of topography and political instability in the implementation of housing reconstruction programs after the 2015 earthquake. With regard to the topography, the rainy season started after the earthquake, which damaged the hilly roads, causing landslides and disconnecting the road networks [39]. On the other hand, Nepal was in the political transition phase and the constitution was under discussion when the country was declared a federal democratic republic state. After the earthquake, the constitutional assembly announced the constitution with the support of a two-thirds majority of assembly members, but some political parties were opposed to this constitution and started a strike, which resulted in an “unofficial blockade” from India, a neighboring country. It delayed the post-earthquake reconstruction process in Nepal [40].

With regard to the initiation of reconstruction after the 2015 earthquake, the Nepal government formed the National Reconstruction Authority (NRA) on 25 December 2015, focusing on collecting assistance from different international communities, making appropriate policies and programs for reconstruction, and implementing that policy. The housing reconstruction program started in October 2016. NRA provided financial assistance of NPR 300,000 (US\$3000) for housing reconstruction through the banking system in instalments, which was linked to the progress of construction and government-approved seismic standards. The first tranche involved processes such as eligibility, verification, and enrolment, with a payment of NPR 50,000 (US\$500). The second tranche, totaling NPR 150,000 (US\$1500), was paid upon completion of the foundation up to the plinth level. The third and final tranche of NPR 100,000 (US\$1000) was paid upon reaching the stage of construction up to the roof-band level. These funds were directly transferred into the beneficiaries’ bank accounts [41].

According to Sharma *et al.* [42], in their study of the 2015 Nepal earthquake, a crucial factor affecting the formation of the NRA was the government’s administrative inefficiency and political interference. Over its five-year tenure, the NRA witnessed four changes in its CEO leadership. These changes in CEO appointments, driven by political motivations, were closely linked to the transitional nature of the government formation process. It became apparent that the newly formed government appointed CEOs based on their political agendas, leading to delays in subsidy announcements and inefficient reconstruction outcomes.

Housing reconstruction after the 2015 Nepal earthquake is the largest ODHR program globally, with the reconstruction of more than 700,000 houses. In the 2001 Gujarat earthquake, the South Asian tsunami of 2004, the 2005 Kashmir earthquake, or any other disaster, owner-driven reconstruction had not been undertaken at this scale [43]. In the 2015 Nepal earthquake, ODHR was used by the Nepal government within the framework of the NRA to reconstruct private houses [41]. ODHR ensured that funds went to the beneficiaries and made the owners accountable for reconstruction [44].

Studies on the 2015 Nepal earthquake discussed a wide variety of issues, some of which covered physical damages and human injury immediately after the earthquake [45]-[48], and assessment of aid provision from the government and Non-Governmental Organizations (NGOs) during emergency relief operations [48]. Few studies have paid attention to post-disaster housing reconstruction and the residential status of rural communities [12] [49]. Daly *et al.* [50] engaged in a discussion on housing reconstruction for up to two years following an earthquake, but their scope was limited to urban areas. In contrast, this study focuses its attention on rural housing reconstruction in the aftermath of the earthquake. This emphasis is driven by data from CEDIM [51], which reported that 94% of housing in rural areas was severely damaged compared to urban areas, where 70% of housing was similarly affected. In the context of the 2015 Nepal earthquake in rural areas, Kotani *et al.* [12] conducted observations of the transition in residential status until two and a half years after the earthquake. Their findings indicated a slight increase in the number of repaired houses compared to rebuilt houses. However, their observation did not provide a clear and detailed focus on permanent housing reconstruction. This limitation was due to the timing of their study, which occurred slightly before the completion of the reconstruction of permanent housing in the aftermath of the earthquake.

There remains a significant gap in research examining the long-term evolution of residential patterns, particularly regarding the reconstruction of private permanent housing in the aftermath of disasters. This study aims to address that gap through a comprehensive analysis of post-earthquake housing reconstruction in rural Nepal, focusing on access to financial support, utilization of local resources, and mutual cooperation among residents. Furthermore, it contributes to a more nuanced understanding of Owner-Driven Housing Reconstruction in the context of post-disaster recovery. Additionally, the study explores the pre-earthquake housing conditions of local inhabitants, offering a general overview to contextualize the reconstruction process.

2. Materials and Methodology

2.1. Study Area

The study area is the Betini Village Development Committee (VDC) in the Nuwakot District of the Bagmati Province in central Nepal (Figure 2). It is approximately 90 km from Kathmandu, the capital city, and 160 km from the epicenter of the main earthquake on 25 April 2015. Betini has a mountainous topography and poor transportation infrastructure. During the monsoon season, rainfall worsens road conditions, and local residents must walk far to reach transportation facilities.

Among the nine wards in Betini VDC, wards 7, 8, and 9 were selected as the primary study areas, which were severely affected by the 2015 earthquake. Based on a field study conducted in 2020, the study area includes 405 households and 2874 people from four ethnic groups: Tamang, Gurung, Sherpa, and Dalit. The

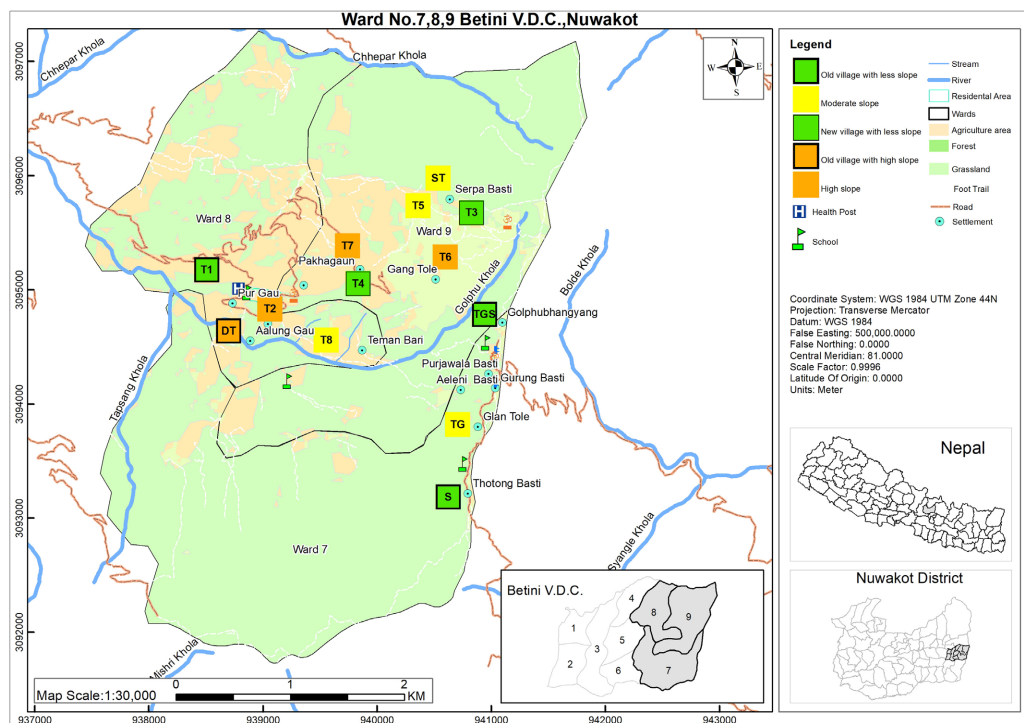


Figure 2. Study area Betini VDC (ward No. 7, 8, and 9). Source: Map visualized using GIS by Dipendra Dhakal.

earthquake caused severe damage to lives, infrastructure, and housing. The majority of the housing was either completely or partially damaged, as most of them were constructed using stone, mud, and wood before the earthquake, without any earthquake-resilient measures in place.

Betini VDC is located within a severely hit (impacted) district, based on the government categorization. The government categorized the earthquake-affected districts based on the severity of damage and priority for rescue and relief operations. The categories are: 1) severely hit, 2) crisis hit, 3) hit with heavy losses, 4) hit, and 5) slightly affected.

2.2. Data Collection

The impact of earthquakes is considered at the household level. For this study, data and information were collected in August 2019 through door-to-door questionnaire surveys of households, key informant interviews, focused group discussions, and field notes.

Initially, semi-structured questionnaires in the Nepali language were employed to collect data on socio-economic conditions using the following categorization: 1) pre-earthquake situation, such as demographic characteristics, farming system, and employment of family members; 2) the earthquake's impact, with a focus on earthquake-induced damage, losses, interruptions, secondary risks, and the reconstruction process in the study area. The sample examples of questions used in the questionnaire surveys are:

- What was your profession and annual income before the earthquake?
- What is your family size, including dependents, before and after the earthquake?
- How much damage is caused by earthquakes, including human casualties, livestock, buildings, and physical assets?
- Have you moved to the evacuation center? If so, how long have you been staying there?
- How long have you been staying in a temporary shelter?
- Did you build a new house? If so, how long did it take to complete? What type of house is it (government-criterion or advanced)?
- What types of construction materials were used? Where did you obtain them?
- Did you source labor from outside the local community?

Sample households were selected randomly using the voter registration list recorded in the VDC office. A total of 188 sample households were interviewed, accounting for 47% of the 405 relocated households. Among the 188 sample households, all 50 households were selected from minority ethnic groups (Gurung, Sherpa and Dalit) for a specific comparative analysis, and the remaining 138 households were selected from the Tamang ethnic groups who stayed in temporary shelters after the emergency evacuation.

All participants agreed to respond to the interview survey. Household heads preferred interviews as they were considered well-informed about their family affairs. When the head of a household was not available, the spouse was invited to participate in the interview. The duration of each interview was about 30 - 40 minutes.

During the questionnaire survey, respondents shared their relevant experiences and opinions, which generated enriching information on the study topics. To address the language barrier, a local leader from the Tamang ethnic group assisted in translating from Nepali to the Tamang language, as some members of the Tamang ethnic group exclusively spoke their own ethnic language. Consequently, separate group discussions were conducted with inhabitants in each ward to receive information concerning infrastructure damage, communal damage in the ward, and the available resources for permanent house reconstruction.

2.3. Data Analysis

The data collected from the field study was in both non-numeric and numeric formats. The non-numeric data were summarized to perform the qualitative analysis using experts in community-based disaster management. However, the numeric data was compiled in Excel for quantitative analysis.

Qualitative analysis

The non-numeric data include the perceptions and experiences of local people regarding the response to the disaster, especially in the reconstruction of both private and public properties, as well as photographs and a seasonal calendar of local events, festivals, weather seasons, and cropping schedules. The government pol-

icies in housing reconstruction of the affected areas were also gathered. The qualitative analysis was performed with the help of experts in community-based disaster management in the context of rural areas of Nepal. The comments and feedback from the local seminar were also accounted for in the study. The knowledge gained from this qualitative analysis has been utilized as the baseline in analyzing and interpreting the qualitative analysis.

Quantitative analysis

The numerical data comprise statistical information gathered from both the household questionnaire survey and key informants' interviews. These data were organized and compiled in Excel format. The statistical data were then processed and summarized using a pivot table, and the summarized data were visualized through quantitative analysis performed in the Python programming language.

3. Results

3.1. Pre-Earthquake Housing Condition

Figure 3 shows the pre-earthquake house structure in the study area. These traditional, non-engineered buildings were constructed using locally available materials, such as stone, mud, timber, and bamboo. The buildings featured stone walls with mud mortar and roofs made of thatch/stone/tin. Typically, these compact buildings comprised two or three stories and showcased artistic wooden carvings on doors and windows. However, these carvings had diminished over time in comparison to older settlements.



Photograph: Dipendra Dhakal.

Figure 3. Vernacular house building before the earthquake.

The ground floor served as storage for firewood, planks, grains, and even a chicken coop. A standard first floor hosted the kitchen, dining area, and *pidhi* (a resting space and temporary storage space in front of the house). The second floor was designated for sleeping, while the attic provided additional storage. Partitions for the separate room were made from wooden planks or piles.

The kitchen evolved over time, integrating improved cooking stoves, traditional

cooking patterns, or gas stoves, along with traditional utensils. Notably, a distinct corner within the kitchen held religious significance, reserved for worship and restricted to outsiders. A wooden balcony adorned with carvings added to the rural housing charm. In recent times, sanitation and hygiene awareness have grown among residents, leading to the presence of an outdoor toilet within the compound of every house.

3.2. Housing Reconstruction Recovery after Earthquake

Reconstruction affected by seasonal events

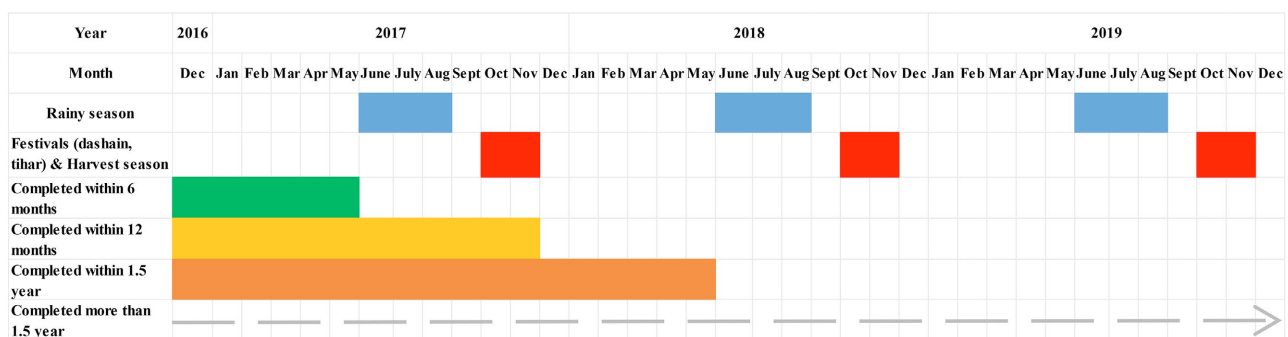
After the earthquake, the government formally announced the beginning of the housing reconstruction in October 2016. However, the housing reconstruction of the study area started in December 2016 because of seasonal issues, such as the rainy season, festivals, and the harvesting season. **Figure 4** shows the seasonal calendar of the study area, which affected post-disaster reconstruction.

The study area belongs to the hilly region with a sloped landscape. Landslides typically occur in many places during the rainy season, which disrupts transportation due to damage to the road. The disruption of transportation affected the delay in delivery of the construction materials, which resulted in hindering the reconstruction during the rainy season. Moreover, festivals and harvest time also affected the reconstruction because people were often busy with their agricultural work. In Nepal, October and November contain the main national festivals, such as *Dashain* and *Tihar* and November is considered harvest time.

Therefore, the post-disaster reconstruction was found to be disrupted during October and November because of the national festivals and harvest time in the study area.

Distribution of the reconstruction period

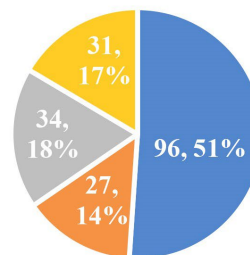
As soon as the households started the housing reconstruction, they obtained permission from the community (*gaun*, autonomous traditional local unit) to use local public resources, such as timber, sand, stone, mud, and water. All the households used local public resources, whereas 43% of households used only local resources for reconstruction. Local resources are generic terms used for both private and public resources.



Source: Based on a field study (2020).

Figure 4. Seasonal calendar based on the study areas.

Figure 5 shows the housing reconstruction progress among households. The majority of households, about 51%, managed to reconstruct their houses within six months. The prompt reconstruction was possible due to simple and safe houses, primarily relying on government subsidies and local resources.



■ 6 months ■ 12 months ■ 1.5 year ■ above 1.5 year

Source: Field study (2020).

Figure 5. The situation of reconstruction of houses by households.

However, 14% of households took 12 months to construct due to several factors, such as a shortage of active manpower, family injuries, and a lack of clarity on the procedure for receiving government subsidies. Approximately 18% and 17% of households completed their house reconstruction within 1.5 years and beyond, respectively. Among these, the majority of households upgraded their houses beyond the government's criteria by contributing their own funds alongside the provided subsidies. The construction sites for government-criterion and upgraded houses are shown in **Figure 6**. The upgraded housing necessitated procuring certified materials and skilled labor from outside the local village, rather than solely relying on locally available resources. However, challenges arose from the scarcity of skilled labor and disruption in road transportation in the rainy season for the delivery of construction materials, resulting in extended reconstruction time.



Photograph: Dipendra Dhakal.

Figure 6. Under-reconstruction based on government criteria (left) and advanced than government criteria (right).

On the other hand, the reconstruction experienced delays of over 1.5 years, especially for certain categories of households. These categories encompass vulnerable households with disabled members and dependents who lack readily available manpower. Additionally, households engaged in personal business also encountered similar delays. Furthermore, approximately 17% of households underwent reconstruction, which was initially expected to finish by the 1.5-year mark.

3.3. Reconstruction and Quality of Houses

Distribution of construction periods by type of housing

In the aftermath of the earthquake, the central government developed building codes for earthquake-safe home inspections conducted by government engineers. However, decisions regarding materials, building design types, and the management of laborers were delegated to the house owners through the ODHR program. Based on the government subsidies and house owners' rights, a disparity in housing quality emerged. Out of a total of 188 sampled households, 125 (66%) households constructed houses that met the minimum government requirements, categorized as "government criteria", while 63 (34%) households went beyond these requirements, achieving a higher standard termed as better than government criteria.

Concerning the utilization of local resources, houses adhering to the government criteria were primarily constructed using locally available resources and supplemented by a few mandatory external resources, such as cement, CGI roofing sheets, and iron rods. However, houses that followed the better than government criteria were constructed using more external resources and fewer local resources.

When examining the subset of government-criteria houses in **Figure 7**, 64 households (51%) completed construction within six months by heavily relying on locally available, cost-effective materials, which were more accessible than external alternatives. Similarly, 16 households (13%) primarily used local resources but took up to one year to finish construction. This delay was due to limited family labor and unfamiliarity with the official process for receiving government subsidies through the bank. In contrast, 45 households (36%) constructed their government-compliant houses using a greater proportion of external resources and fewer local materials. These households took 1.5 years or more to complete construction, facing challenges such as injuries, a lack of working family members, and transportation disruptions caused by rain. From a financial standpoint, households that built government-criteria houses reported a lower average annual income (NPR 139,691) prior to the earthquake. As a result, they relied solely on government subsidies to construct simple yet safe homes.

Regarding the houses classified as better than government criteria shown in **Figure 7**, the majority of these households, 32 (51%) households, successfully constructed their houses within a six-month period. They achieved this primarily by using external resources and incorporating a limited number of locally available resources. This rapid progress was attributed to their proactive management of

external resources and initiation of construction by using their personal funds before the onset of both subsidies and the rainy season. On the other hand, the remaining 31 (49%) households were delayed in housing construction due to insufficient information regarding the central government's housing construction policy. Insufficient information caused confusion among homeowners and hindered timely decision-making for initiating construction. These delays were compounded by seasonal factors. The rainy season, characterized by landslides that obstructed road transportation, coincided with the rice plantation season, further occupying the local people. With the end of the rainy season, the beginning of festivals and the harvesting season further diverted their attention. Moreover, a shortage of skilled manpower and deliberate delays due to income-related considerations also contributed to housing construction delays in a few households. All the households with better than government-criteria houses used their personal funds in combination with government subsidies for reconstruction. Financially, they were considered as good economic condition households and were found to have a higher average annual income (NPR 296,932) before the earthquake.



Note: 1 USD = NPR 120. Source: Field study (2020).

Figure 7. Quality of house and time to reconstruct the houses.

Budget allocation of government subsidies

Beneficiaries were free to procure imported materials from any market supplier with price bargaining. Here is an illustrative example (Table 1) displaying the cash expenditure of a Gurung household that completed the construction of a government-criteria house in November 2017, accomplishing this within a year without labor exchange.

Table 1 provides an example of expenditure for the reconstruction of a house using government subsidies (US\$3000) within a household that abstained from labor exchange, locally known as “*perma*”, due to the household head’s business obligations. Notably, a significant portion, 64% of the total expenditure (US\$1934.61), was allocated for labor wages within this household.

Table 1. Expenditure of subsidies (US\$3000) for a government-criteria house.

Items	Unit	Qty.	Unit cost (US\$)	Total cost (US\$)
Stones (delivery cost only)	m ³	36.61	2.51	92.98

Continued

Cement bag (50 kg)	pcs	39.93	8	319.24
Sand (delivery cost only)	m ³	2.78	21	58.38
Wood (delivery cost only)	m ³	0.93	400	372
CGI sheet	bundle	3	75	225
Iron	kg	527.27	0.72	379.63
Skilled labor (mason and carpenter)	daily rate	75	8.15	611.25
Unskilled labor	daily rate	100	6	600
Snacks for workers	-	-	-	200
Others (nails, paint, plastics, Fevicol glue, etc.)	-	-	-	141.52
Labor cost total	-	-	-	1934.61 (64%)
Grand total	-	-	-	3000

Source: Based on a field study.

With regard to the materials used, as presented in **Table 1**, stone, sand, and wood are sourced locally, whereas cement, CGI sheets, iron, and other minor materials (e.g., nails, paint, plastics, Fevicol glue) are procured from external suppliers. Labor costs are categorized into skilled and unskilled labor, including the delivery expenses associated with locally available materials. Analysis of the overall budget reveals that labor constitutes approximately two-thirds (64%) of the total expenditure. This underscores the importance of mutual assistance (labor exchange), which enables households to redirect labor costs toward higher-quality construction materials rather than relying on lower-quality alternatives.

On the other hand, skilled labor within the majority of households meeting Government criteria actively engaged in the labor exchange system, which was reciprocally managed using locally available skilled labor. It is apparent that mutual help plays a vital role in supporting this labor exchange system, as described below.

In this system, a group consisting of approximately 5 to 7 households from the same village, referred to as a “*gaun*” was formed for this specific purpose. Any household with more than one active adult member was eligible for participation in the group. The reciprocity within the labor exchange system was accurately calculated, where one skilled male worker (valued at US\$10) is equal to 1.3 unskilled male workers (valued at US\$7.5), and one male unskilled worker (valued at US\$7.5) is equal to 1.25 female unskilled workers (valued at US\$6). Unfortunately, the study area did not have any female skilled workers.

3.4. Reconstruction and Use of Manpower

In rural Nepal, the practice of mutual cooperation through labor exchange, known as “*perma*”, still exists significantly. Typically, residents utilize labor exchange for

agricultural work in normal situations in the study area. However, it is important to note that labor exchange also plays a crucial role in post-disaster reconstruction, significantly influencing the pace of early recovery efforts. In exceptional cases, certain households opted to privately borrow interest-free loans from friends and relatives. These loans were utilized to clear debris and initiate the foundational construction process.

Figure 8 illustrates the relationship between manpower utilization and the reconstruction period for government-criteria houses. The majority of labor exchange households (55%) completed their construction within a 6-month period.

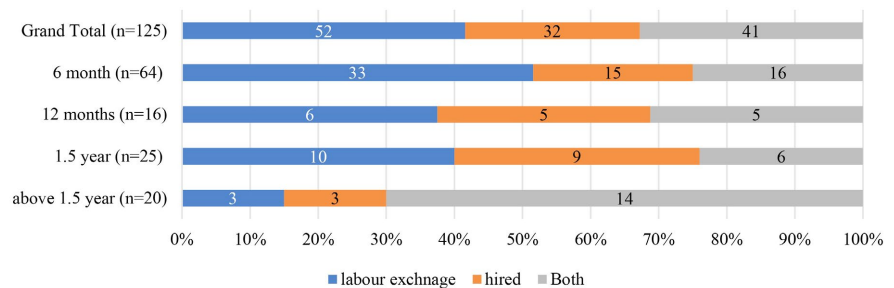


Figure 8. Manpower and time to reconstruct government-criteria houses. Source: Field study (2020).

Moreover, **Figure 8** reveals that 20 households (25%) with government-criteria houses took more than 1.5 years to complete the construction. Among this group, seven households within the same village “*gaun*” had initially built their houses prior to the announcement of the criteria in order to get government subsidies earlier. However, they subsequently discovered that their constructions did not meet the earthquake safety requirements outlined in the criteria by the government, rendering them ineligible for the subsidies. Consequently, these households had to reconstruct their houses to meet the criteria and receive the subsidies, leading to significant delays in completion.

Furthermore, six households deliberately delayed their reconstruction efforts because they were running businesses as shops in temporary shelters. Two of these households belonged to the *dalit* ethnic group, which is the relatively vulnerable group in the study area. Interestingly, their decision to delay construction was not solely driven by their vulnerability; rather, they prioritized business opportunities over reconstruction. In seven other households, reconstruction was delayed due to various vulnerabilities. Among them, the heads of four households had suffered severe injuries, which hindered them from initiating reconstruction promptly. Three households were led by widows, and due to a lack of available active manpower, they faced challenges in carrying out the reconstruction process.

4. Discussion

This study provides a concise analysis of the housing conditions of the inhabitants

prior to the earthquake. The housing condition was found to be highly susceptible to earthquake damage. In rural areas, construction is primarily informal and self-constructed. The traditional construction style involved dry-stone masonry using mud mortar, with roofs made of thatch or zinc plates. Households with lower annual income before the earthquake were constructed earlier than households with higher annual income. Those with lower incomes directed their construction efforts towards government-criteria housing, relying solely on government subsidies. They managed their expenses within the subsidy amount by primarily utilizing local resources and unskilled labor. These resources were readily available and easily transported to the construction site, facilitating a prompt construction process.

On the other hand, households with good economic conditions were able to construct better houses compared to government-criteria houses by supplementing government subsidies with their own funds. These types of housing projects relied primarily on imported materials rather than local resources. Construction materials were procured from urban areas through road transportation. However, during the rainy season, the hilly roads faced disruptions and damage due to landslides, which further hindered the reconstruction process.

Role of local institution/body in reconstruction

Considering the various levels of activities involved in post-earthquake reconstruction, **Table 2** shows the roles played by individuals (house owners), communities (*gauns*), and the government, which collectively influenced the post-earthquake reconstruction process.

At the individual level, the ability to promptly gather necessary construction materials, effectively manage manpower, and make informed decisions regarding design and structural aspects significantly impacted reconstruction efforts. Some house owners faced challenges in managing essential materials due to physical injuries, disabilities, a lack of understanding about financial subsidies, and difficulties in making decisions about house design.

Table 2. Activities of the individual, community (*gaun*), and government on post-earthquake housing reconstruction.

Individual (house owner)	<i>Gaun</i> (community)	Government
Construction material collection	Labor exchange (group formation to construct by <i>perma</i>)	Financial subsidies (US\$3000)
Manpower management decision-making regarding the design and structure of the house	Permission to use local public resources, such as timber, sand, stone, mud, and water	Technical support and inspection
Personal loan (exceptional)		Official support for land registration to needy people

Source: Based on a field study.

At the community (*gaun*) level, the formation of groups for construction through labor exchange (*perma*) and the utilization of local public resources played crucial roles in facilitating reconstruction. Additionally, personal connections and assistance from relatives aided in managing construction materials. However, the major challenge remained financial support for post-disaster reconstruction, directly influencing the overall progress.

The government was crucial as well. The government announced the subsidies and criteria to support the construction of earthquake-safe housing. However, due to political instability and weak governance, the distribution of financial subsidies and technical support encountered delays, directly hindering the pace of reconstruction efforts.

Factors affecting the reconstruction

Table 3 outlines the factors influencing post-disaster reconstruction in hilly rural regions. Various seasonal and topographical factors, such as the rainy season, festivals, and harvesting periods, alongside the topography of hilly regions, posed hindrances to the reconstruction process. These challenges were exacerbated by road closures caused by landslides in vulnerable hilly areas during the rainy season. Furthermore, the celebration of festivals and engagement in crop harvesting activities diverted the attention of inhabitants, making them unavailable for construction during these times.

Table 3. Influencing factors for reconstruction.

Factors	Influences	Reasons
Rainy season	Hindered reconstruction	Disruption on delivery
Festivals, harvesting season	Hindered reconstruction	Stop work, busy with celebration
Topography	Hindered reconstruction	Landslides prone area
Mutual cooperation (labor exchange)	Early reconstruction	Enough manpower
Vulnerability (widow, household head's severe injury)	Hindered reconstruction	Lack of management of manpower (could not get labor exchange)
Prioritise the personal business	Deliberately delayed the construction	Good income

Source: Based on a field study

Mutual cooperation in the form of labor exchange at the community (*gaun*) played a significant role in expediting reconstruction efforts. This cooperative approach supported early reconstruction by enabling collective contributions. On the other hand, significant obstacles emerged for vulnerable households, particularly those headed by widows with non-working members, those that had experienced death a member, and those with severely injured household members as the lack of available working manpower of the households to actively engage in the reconstruction

process. Additionally, some individuals prioritized personal business endeavours and income generation over reconstruction, intentionally causing delays in the reconstruction process.

In summary, government-standard houses were designed to be simple, compact, safe, culturally appropriate, and cost-effective, while also enabling homeowners to engage in self-employment during reconstruction. However, many households expressed dissatisfaction with the subsidy amount, particularly when it was insufficient to construct housing suitable for larger families requiring additional space. In terms of quality and efficiency, the government's reconstruction policy proved effective. For vulnerable households, however, local governments should play a leading role in managing the reconstruction process and administering subsidies.

Nevertheless, the policy requires improvement, particularly in addressing the needs of larger families, as the allocated subsidies often fail to cover the costs of adequate housing. Wealthier households tend to pursue higher-quality housing beyond government standards, supplementing subsidies with personal resources. Such advanced constructions demand skilled labor, imported materials, and additional capital, which in turn delay the overall reconstruction process.

5. Conclusions

The study found that the utilization of local resources, such as locally available reconstruction materials, mutual cooperation (labor exchange), and local manpower, proved to be time-effective in the post-disaster reconstruction of government-criterion housing in the context of rural areas of developing countries. The study also identified several factors that influence households in post-disaster housing reconstruction. The factors are: 1) households that are vulnerable (with disabled members and dependents) and lack sufficient working manpower, 2) households that have experienced physical loss and psychological trauma due to the loss of their family members during the disaster, and 3) households that intentionally delayed their income-generating activities, whether by working as paid labor in relation to reconstruction or by running temporary shops in shelter areas.

However, households with a good financial status would prefer to build advanced houses rather than the government-criterion one. These advanced houses required skilled manpower and imported construction materials, which caused delays in reconstruction because of transportation disruptions and supply chain issues.

This study emphasizes the consideration of multiple factors for earthquake-resilient housing construction that integrate securing safe living space and sustainable livelihood of the residents. Additionally, this study has made a number of recommendations for effective post-disaster housing reconstruction. Firstly, the government should consider providing subsidies based on the number of family members, since the majority of the households are dissatisfied with the subsidy amount, which was insufficient for proper-sized housing, especially for large families. Secondly, the government should provide interest-free loans to households through the banking system. Thirdly, the government should coordinate with local author-

ities to provide alternative land for reconstruction to households residing in highly disaster-vulnerable locations if they lack alternatives and financial capability.

The study was conducted in a rural area of Nepal, which lacks a proper road transport system. However, future work will consider extending the study to other developing countries with similar geographical and socio-economic conditions.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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