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Transition of post-disaster housing of rural households: A case study of the 2015 Gorkha earthquake in Nepal

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ABSTRACT

To achieve post-disaster recovery of rural households in developing countries, it is necessary to understand the recovery conditions and the factors that play significant roles in the decision-making process. We aimed (1) to explain the transition of the residential status (i.e., type of places or houses in which affected households stay) after the disaster event and (2) to reveal the factors affecting the housing decisions. We interviewed 124 rural households in Nepal affected by the 2015 Gorkha earthquake to understand the residential status transition up to two and a half years after the earthquake. As a result, more than 50 transition patterns were observed. Social relations in the community were important immediately after the earthquake, followed by the physical resources and subjective factors. Financial resources became influential at a later stage of recovery. The number of households that repaired or rebuilt their houses boosted one year after the earthquake. However, the households who moved to unrepaired houses did not upgrade to repaired or rebuilt houses. This implies that the disparity in residential status among affected households had been determined even before they left the temporary houses and began the recovery process. Our results suggest that, for the prevention of recovery disparity, it is essential to support the recovery of individual households before the community starts the process, identifying their priorities and urgent needs and considering their circumstantial conditions. Thus, our study provides empirical data for effective recovery of vulnerable rural communities after disasters.

1. Introduction

Housing plays an essential role in bringing stability to people's lives [1–3]. If houses are damaged by disasters, people are often forced to stay in evacuation shelters or temporary houses for a long time, and consequently, they cannot entirely maintain the quality of life. In developing countries, housing is usually the most valuable asset for the residents [4], and the impact of disasters on the built environment is more severe than in developed countries [2,5]. Recovery may also be delayed [6] since the required funding and construction materials are less accessible: people face tight budget constraints and lack of disaster insurance [7]. These problems especially affect more vulnerable rural communities and thus they seriously suffer from post-disaster housing challenges. For example, when Nepal, one of the poorest countries in Asia, experienced the 2015 Gorkha earthquake, over half a million homes were severely damaged or destroyed, primarily in rural areas, and most people whose houses were severely damaged continued to live in temporary and improvised shelters over 18 months after the earthquake [8].

Problems with the reconstruction of post-disaster housing in developing countries have been studied extensively. However, there have been a limited number of studies on long-term recovery processes commenced for each vulnerable household immediately after disasters. To contribute to the implementation of better reconstruction policies for developing countries, we need to focus on vulnerable rural communities and to understand the process of residential status transition (i.e., type of places or houses in which they stay) after the disaster and the factors that affect their transition.

The aims of this study are twofold: (1) to elucidate the residential

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status transition over time for rural households in Nepal after the 2015 Gorkha earthquake and (2) to extract factors that affected the transition. We conducted interview-based surveys of 124 households in rural communities affected by the earthquake. In the survey, we asked questions about their residential status up to the time of survey (i.e., two and a half years after the earthquake) and the reasons they changed their residential status. Using the collected data, we established the transition patterns in the study area and possible factors that induced the transition.

The remainder of this paper is organized as follows: Section 2 presents the literature review; Section 3 provides an overview of the 2015 Gorkha earthquake and presents the outline of the survey; Section 4 classifies the residential status in the study area; Section 5 presents the residential status transitions and the factors that affected the changes in the residential status; Section 6 is the discussion of the results obtained in the preceding section; Section 7 concludes the paper.

2. Literature review

Post-disaster housing conditions in developing countries have been extensively studied. Some studies covered topics such as ensuring temporary shelters immediately after disasters [9,10] and the planning for temporary housing after disasters [11–13]. On the other hand, other studies investigated the critical success factors of housing reconstruction projects during the pre-construction stage [14]. Others focused on the challenges of effective resource management [15] and the roles of guidelines [4], participatory planning [16–18], architects [19], collaboration between actors [20], governance [21], and construction training [22] in the permanent housing reconstruction process, as well as proposed practice measures for managing permanent housing reconstruction [23,24].

However, studies on the long-term transition of the residential status are limited. Johnson et al. [25] focused on the schedule and the strategies for the supply side (i.e., organization teams) of post-disaster housing in two earthquakes, which occurred in Turkey and Colombia in 1999. They illustrated the sequence of shelters and housing offered to the survivors after each earthquake, but their focus was limited to the supply side. As for the household side, Arlikatti and Andrew [26] studied the housing improvements of affected rural households at two time points (i.e., six months and three-and-a-half years) after the 2004 Indian Ocean tsunami. They investigated the change in (1) the average size of houses and the number of rooms and (2) the percentage of households that use certain building materials. Rafieian and Asgary [27] examined the impacts of temporary housing on reconstruction for households affected by the Bam earthquake in Iran. The cross-tabulation analysis was conducted to determine the effect of the type of temporary housing (i.e., onsite or campsite temporary housing) on the speed and quality of housing reconstruction. Both studies, however, only considered aggregated household data and not the individual data, and thus, the question of "how individual households autonomously change their residential status with the long-term recovery processes begun immediately after the disasters" remains open. Other studies investigated the long-term recovery processes, but their focus was exclusively on the adaptation of the residents to their new environment after moving to permanent housing [28–30] and the longer-term impacts of housing recovery on community resilience [31,32].

Studies targeting developed countries such as Japan and the United States [3,33–35] focused on the changes in the residential status of households after disasters. Some of those studies analyzed the "preferences" or "opinions" of individual households as to where to live [36–39] while others analyzed the "actions" taken by them. For example, after the 1995 Kobe earthquake, via a large-scale survey, Hayashi [40] explored the residential status (i.e., own home, houses of friends or neighbors, evacuation shelters, or temporary houses) of affected people at logarithmic time points, namely, 10 hours (h) after the earthquake (i.e., the day of earthquake), 100 h later (i.e., several days later), 1,000 h later (i.e., approximately a month later), and 10,000 h later (i.e., approximately one year later). Hayashi [40] also focused on the changes in their residential status from the previous time point. Tamura et al. [41] and Kimura et al. [42] reconfirmed that the residential status of the people affected by the earthquake changed with the logarithmic time. Similarly, Fukutome et al. [43] investigated how residents living in disaster restoration public housing changed their residential status one year after the earthquake. After the 2011 Tohoku earthquake and tsunami, Tomiyasu et al. [44] determined the changes in the residential status (e.g., own home; evacuation shelters; open space or inside of cars) of affected households until they moved to temporary housing. However, none of these studies focused on the "series of" residential status transitions taken by an affected household during the study period. Hayashi [40] and Fukutome et al. [43] limited their focus on the residential status taken by each household one time point before; they did not investigate the changes in the residential status two or more time points before. Tomiyasu et al. [44] focused on the number of residential status transitions; they did not analyze what residential status was taken before moving to a certain residential status. As an exception, Ogawa [45] targeted households who moved to disaster restoration public housing after the 2011 Tohoku earthquake and tsunami and showed a series of residential status transitions after the disaster until the residents moved to public housing. However, Ogawa [45] covered only a small number of households (i.e., fifteen households who moved into public housing).

Our study aims to enhance the understanding of the recovery process for Nepalese rural households affected by the 2015 Gorkha earthquake. Our findings will contribute to the discussion on more appropriate aid provision and recovery policies. Previous studies on the 2015 Gorkha earthquake discussed a wide variety of issues, some of which covered physical damage and human injury immediately after the earthquake [46–49], assessment of aid provision from the government and non-governmental organizations (NGOs) during emergency relief operations [50], evaluation of the migration on rescue and relief processes [51], and investigation of local community's response in an urban residential area [52]. Despite such extensive studies, almost no studies paid attention to housing reconstruction or residential status transition in rural communities. Gao et al. [53] investigated the transition of the way of living inside the houses up to six months after an earthquake but their investigation was limited to an urban area and a short time period. Daly et al. [54] discussed the housing reconstruction until two years after an earthquake but they limited their focus to urban areas. He et al. [55] assessed the vulnerability of rural communities via a survey on dwelling conditions but their target was limited to rural communities that were displaced immediately following the earthquake in the short term (i.e., until ten months after the earthquake) when housing reconstruction had not commenced yet. Therefore, we lack the knowledge of the long-term recovery process of affected rural communities that continue to stay in affected areas. Our targeted rural communities were not displaced; they were able to change their residential status autonomously to a certain degree using government subsidies and supplied construction material [8,56]. This study investigates such a distinct community and focuses on the long-term housing reconstruction process undertaken by local residents.

3. Outline of survey

3.1. Overview of the 2015 Gorkha earthquake and the recovery process in Nepal

A strong earthquake of magnitude 7.6 occurred on April 25, 2015 with its hypocenter located in the Gorkha region (about 80 km northwest of Kathmandu, the capital city of Nepal) [46]. Aftershocks have occurred following the main shock; the major aftershock with a 7.3 magnitude occurred on May 12, 2015 at approximately 140 km southeast of the main shock location [57]. The earthquake and its aftershocks

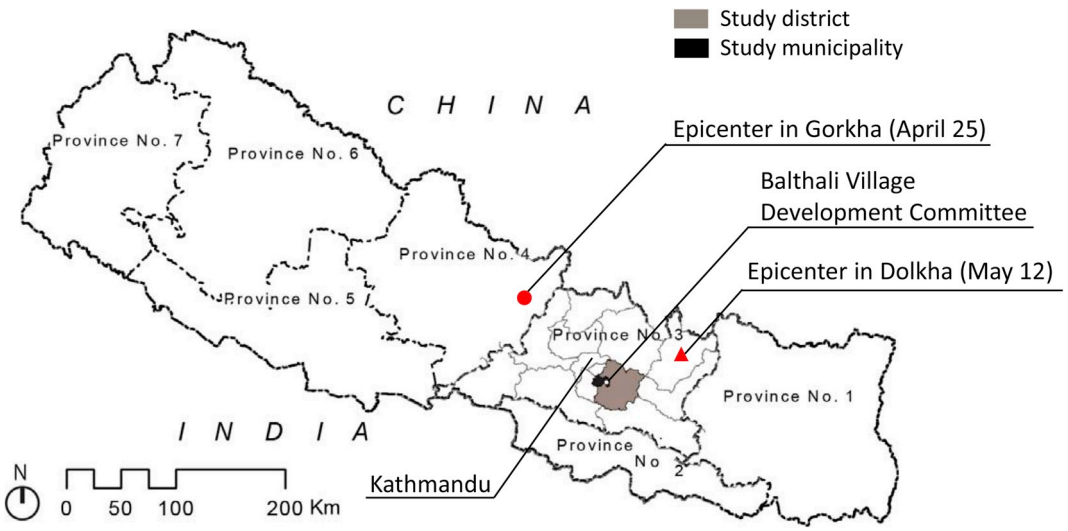

Fig. 1. Location of the study area (Balthali) (This figure is created by authors based on the map provided by the Ministry of Federal Affairs and General Administration [66]).

caused 8,898 deaths and 22,309 injuries [58]. Over half a million homes were severely damaged or destroyed, primary in rural areas [8]. The lives of eight million people, almost one-third of the population of Nepal, were impacted by these earthquakes [59] and the estimated total economic value of the disaster (damage and losses) was USD 7 billion [60]. Disaster risk was compounded by the fact that development efforts over the past five decades have neglected the needs of the poor in Nepal, leading to increased poverty, unemployment, and rural and urban inequality [61].

The government of Nepal delayed the initial response to the earthquake and inappropriately managed the assistance from inside and outside of Nepal, which invited criticism [62]. National governance has been weakened by political conflict in the country [61,63]. Disorders of the ad hoc national-level disaster management agency (i.e., National Reconstruction Authority), which was established after the 2015 earthquake, also eclipsed the local actors in post-disaster situations [64].

Despite criticism, the government, its associated organizations, NGOs, and nonprofit organizations (NPOs) have continued to take various actions for the restoration and recovery of Nepal since 2015. Immediately after the earthquake, many government agencies and organizations in cooperation with the Nepal Engineers' Association were involved in taking a prominent role in the post-earthquake safety evaluation. They assessed many affected buildings and labeled them as red (unsafe), yellow (limited entry/restricted use), or green (inspected) buildings [57]. International organizations came to Nepal to provide life-saving medical treatment, food, water, and emergency shelter. However, the difficulty in accessing remote areas left many villages without aid for days and even weeks following the initial earthquake. While local groups organized relief efforts in Kathmandu to deliver essential items and basic medical services to remote villages by road and foot, extensive infrastructure damage limited the effectiveness of their work [65]. In October 2015, the government provided several types of cash grants—(1) emergency cash grants for funeral costs and the construction of temporary shelters one month after the first earthquake, and (2) winter cash grants to help people make adjustments to their temporary shelters and buy clothes and blankets [8]. In September 2016, almost one and a half years after the earthquake, the government also started the Nepal Rural Housing Reconstruction Program (RHRP) to get people back into sturdy and safe permanent housing units. The cash grants, disbursed in three tranches, are intended to boost the "owner-driven reconstruction" and tied to the use of specific building codes to make homes earthquake-safe and to "build a more resilient Nepal" [8]. Owner-driven reconstruction requires affected people to actively participate in housing reconstruction, providing them with subsidies and construction materials. The actions taken by many stakeholders are expected to accelerate the recovery of Nepal.

3.2. Study area

The study area is the Balthali Village in the Kavrepalanchok District of the Bagmati Zone of central Nepal, which was affected by the 2015 Gorkha earthquake. Balthali has approximately 850 households and 2,500 people, many of them are Tamang. Balthali is located approximately 30 km from Kathmandu and 100 km from the epicenter of the main earthquake on April 25 and the major aftershock on May 12 (Fig. 1). Balthali is located in a mountainous area (Fig. 2). The main industries are agriculture on paddy fields and stock-farming of goats and buffaloes. Owing to the mountainous terrain, rainy season precipitation worsens the road conditions, preventing contact with the world outside. Before the earthquake, electric power supply and mobile phone connection were established, but gas pipes and fixed phones were unavailable. The earthquake caused severe damage to both the infrastructure and individual houses. Some roads were blocked for approximately a week due to the landslide, electric supply was stopped for a few weeks, and some water resources were depleted.

Almost all houses in Balthali are made with bricks and many houses were completely or partially damaged by the earthquake (Fig. 3). In some areas, more than 80% of the houses were partially or completely destroyed [66]. No direct deaths were reported [66]. Based on the severity of damage and the priority for rescue and relief operations, the government of Nepal categorized the earthquake-affected districts as: (1) severe hit, (2) crisis hit, (3) hit with heavy losses, (4) hit, and (5) slightly affected [59,60]. The Kavrepalanchok District, in which Balthali is located, was categorized as a "crisis hit" district.

Following the earthquake, the government and NGOs provided residents with aid. Caritas [67,68], a Christian NGO, provided affected households with food and blankets. It also supplied farm animals and crop seeds to farmers to assist them return to their work. Furthermore, tents and building materials (e.g., plastic sheets and corrugated galvanized iron (CGI) sheets) for building temporary houses (Fig. 4) were provided. The government provided subsidies for the repair and rebuilding of houses according to the damage level as well as technical guidance for the reconstruction of houses. Approximately 550 out of 850 households in Balthali were eligible to receive subsidies. At the time of the survey, approximately 150 houses were under reconstruction or already reconstructed [66]. Such aid schemes provided by NGOs and the

Fig. 2. Study area located in the mountain area.

Fig. 4. Temporary houses made of CGI sheets after the earthquake.

Fig. 3. Damaged house in the study area after the earthquake.

Fig. 5. Construction of the foundation and damp proofing course of a house.

government became effective with the help of community members (Figs. 5 and 6) in the process of rebuilding the houses (Fig. 7). It is important to understand the recovery actions undertaken by each household as these are representative of the community-level recovery.

In general, housing reconstruction in developing countries is strongly restricted by land ownership [69–72]. In fact, in the recovery process after the 2015 Gorkha earthquake, some land ownership issues became prominent, particularly in urban areas [64,73,74]. However, land ownership problems were not common in our study area. Only 2% of households who participated in our survey received earthquake damage to their land and 5% had troubles with the land in the recovery process. In our survey, households that had lived in their parents' land rebuilt their houses there if they obtained consensus from the parents without transferring land ownership. Some households who lived in their parents' land and whose parents were either expired or lived outside of the village could not get their parents' consent and had trouble in transferring the land ownership, which delayed the reconstruction. However, the number of such households was quite small in the village. Therefore, we assume that the land ownership problem did not have a significant effect on the transition of the residential status of the community.

3.3. Survey method

The authors conducted a semi-structured interview on the transition of residential status since the earthquake, targeting households in Balthali between November 30 and December 4, 2017 and between December 9 and 10, 2017. Households were selected randomly and all participants agreed to respond to the interview survey (100% response rate). The total sample size was $n = 124$, which accounted for approximately 15% of the population. The survey assistants, who were native speakers of Nepalese, asked the participants (1) questions about the household characteristics and damage to houses (the details are listed in Appendix A) and (2) open-ended questions about the transition of residential status, such as the following:

- *How and when after the earthquake has your residential status changed?*
- *Why did you change your residential status?*

The detailed information of household characteristics and damage to the houses is also provided in Appendix A. 84% of the participants were farmers. In addition, 82% of the houses were assessed as being at either "yellow" or "red" damage level.[1] Only 3% of the houses were assessed as "green," and the rest of the houses were not visited and thus not assessed. As for the impression of damage, all households responded either "some damage" or "very severe damage."

4. Types of residential status

Based on the interview survey, we determined six types of residential

[1] As described in Section 3.1, "green," "yellow," and "red" correspond to "inspected," "limited entry/restricted use," and "unsafe," respectively [57,75].

Table 1
Definition of residential status in the study area.

Type of residential status	Definition
1. Open space	Places to which affected households were able to escape without preparation (e.g., open fields, crop fields, livestock shelters, and school).
2. Temporary house	Places created after the earthquake for evacuees (e.g., tents and temporary houses which were made of plastic sheets and CGI sheets).
3. Houses of relatives and friends	Houses of affected households' relatives and friends.
4. Unrepaired house	Damaged houses in which households had lived since before the earthquake.
5. Repaired house	Repaired houses in which households had lived since before the earthquake.
6. Rebuilt house	Newly constructed houses after the earthquake.

Fig. 6. Construction of the wall of a house.

statuses taken by the affected households (Table 1). As typical living conditions experienced by many households, we chose (1) open space, (2) temporary houses, (3) unrepaired house, and (4) repaired/rebuilt houses. The following sections describe these four conditions in detail.

4.1. Stay in open space

Immediately after the earthquake, almost all households evacuated to open fields, crop fields, the school, and livestock shelters. This study refers to such places to which affected households were able to escape without much preparation as "open space." Households who evacuated to open fields or the school reported that they were with other households. Some households who evacuated to open fields together were protected from rain and dew using blankets that they had. They complained about leaks and severe cold, while they stated that they were relieved to stay together with acquaintances (e.g., cooking and having meals together). Other households who evacuated to crop fields survived by eating farm products that they grow there.

4.2. Life in temporary houses

Some households created temporary houses (Figs. 4 and 8) made of materials purchased by themselves or supplied by the government and NGOs. The provided materials included tents, plastic sheets, CGI sheets, blankets, and bed sheets. Some households renovated their temporary houses when new materials were supplied. For example, using blankets provided immediately after the earthquake, a household created a temporary house near their own damaged house. Two weeks later, as plastic sheets were supplied, the temporary houses were reinforced by the sheets. Moreover, using the CGI sheets that were provided later, the household created a new temporary house. Since many households were concerned about their livestock left in their unrepaired houses, they built their temporary houses close to their original houses.

4.3. Life in unrepaired houses

According to the interview, some households returned to their unrepaired houses (Fig. 3) mainly because they thought that aftershocks would no longer occur or they were not able to stand the cold weather any longer. However, they were also concerned about the risk of collapse of their unrepaired houses, especially at night, while they sleep; thus, some households spent the night in temporary houses and the day (e.g., meal times) in unrepaired houses. Other households continued to stay in unrepaired houses since immediately after the earthquake because their family members who were old or had serious illnesses were not able to leave the house.

4.4. Life in repaired/rebuilt houses

A house that was repaired for the damage caused by the earthquake is referred to as a "repaired house" (Fig. 9) and a newly constructed

Fig. 7. Rebuilt house after the earthquake.

Fig. 8. Temporary house made of materials provided by the government after the earthquake.

Fig. 9. Repaired house after the earthquake.

Fig. 10. Newly constructed house slightly far from the original house.

house after the earthquake as a "rebuilt house" (Fig. 7). Almost all households who already reconstructed their houses relied on government subsidies or loans from community banks, neighbors, or friends. Until the new houses were built, many households had resided in temporary houses made of plastic and CGI sheets; thus, the newly-built houses likely improved their quality of life greatly.

Living in repaired houses, however, does not necessarily mean the completion of recovery for some households. Several households used more than one house simultaneously even after the construction of their new houses. One example is a household who received government subsidies and built a new house (Fig. 10) slightly far from their original house two years after the earthquake. The household spent some time during the day in the unrepaired house and spent the night in the temporary house, which was in front of the unrepaired house, because they were unwilling to live separately from their livestock (Fig. 11), the latter still residing in the original house.

In Section 5, such households who used more than one house simultaneously were interpreted as households with the most recovered residential status.[2] For example, households who used a rebuilt house, an unrepaired house, and a temporary house simultaneously were categorized into "6. Rebuilt house" in Table 1.

5. Transition of residential status and influential factors

5.1. Target time points

This section examines (1) the residential status transitions and (2) factors that influenced the transitions. Hayashi [40], Tamura et al. [41], and Kimura et al. [42] described the recovery process of people affected by the 1995 Kobe Earthquake by recording their residential status at logarithmic time points, 10, 100, 1,000 and 10,000 h after the event. Targeting more than one hundred households in small rural communities, our study demonstrated the pattern of residential status changes at six time points: (1) first day (~10 h later), (2) fifth day (~100 h later), (3) one month (~1,000 h) later, (4) one year (~10,000 h) later, (5) two years later, and (6) two and a half years later (at the time of survey). We added two stages, two and two and a half years later, to investigate the effect of the Rural Housing Reconstruction Program (RHRP) taken by the government, which commenced in September 2016, about one and half years after the earthquake.

Our study traced the series of residential status transitions of each household across these time points suggested by Ogawa [45]. This approach allows us to reveal the residential status transition at both the individual and the community level over the recovery process. We employed the alluvial diagram [76–79] (Fig. 12) to visualize (1) the time series of the transition of each household's residential status and, as the accumulation of them, (2) the proportion of residential status at each time point.

5.2. Residential status transition

Based on the answers to the open-ended question "*How and when after the earthquake has your residential status changed?*", we constructed the alluvial diagram in Fig. 12. The horizontal and vertical axes represent the time points and the number of households, respectively. The bar at each time point indicates the proportion of residential status at that time. For example, the leftmost bar demonstrates the proportion of residential status on the day of the earthquake. Each flow between the bars corresponds to the group of households who took the same residential status transition over time. For example, the flow located at the top between the first day and one year later represents the group of households who stayed in "1. Open space" in the first year and lived in "5. Repaired house" since two years after the earthquake. Fig. 12 has 53 flows that represent 53 types of transitions over time. The thickness of the flow is proportional to the number of households in a group.

In the following, we demonstrate the residential status at each time point as well as the transition from the previous time point to the next one in chronological order.

- **Residential status on the first day** (approximately 10 h later)

Fig. 11. Livestock raised in front of an unrepaired house.

[2] We assumed that in Table 1, the larger number corresponds to the more recovered status (i.e., "6. Rebuilt house" is the most recovered; "1. Open space" is the least recovered.).

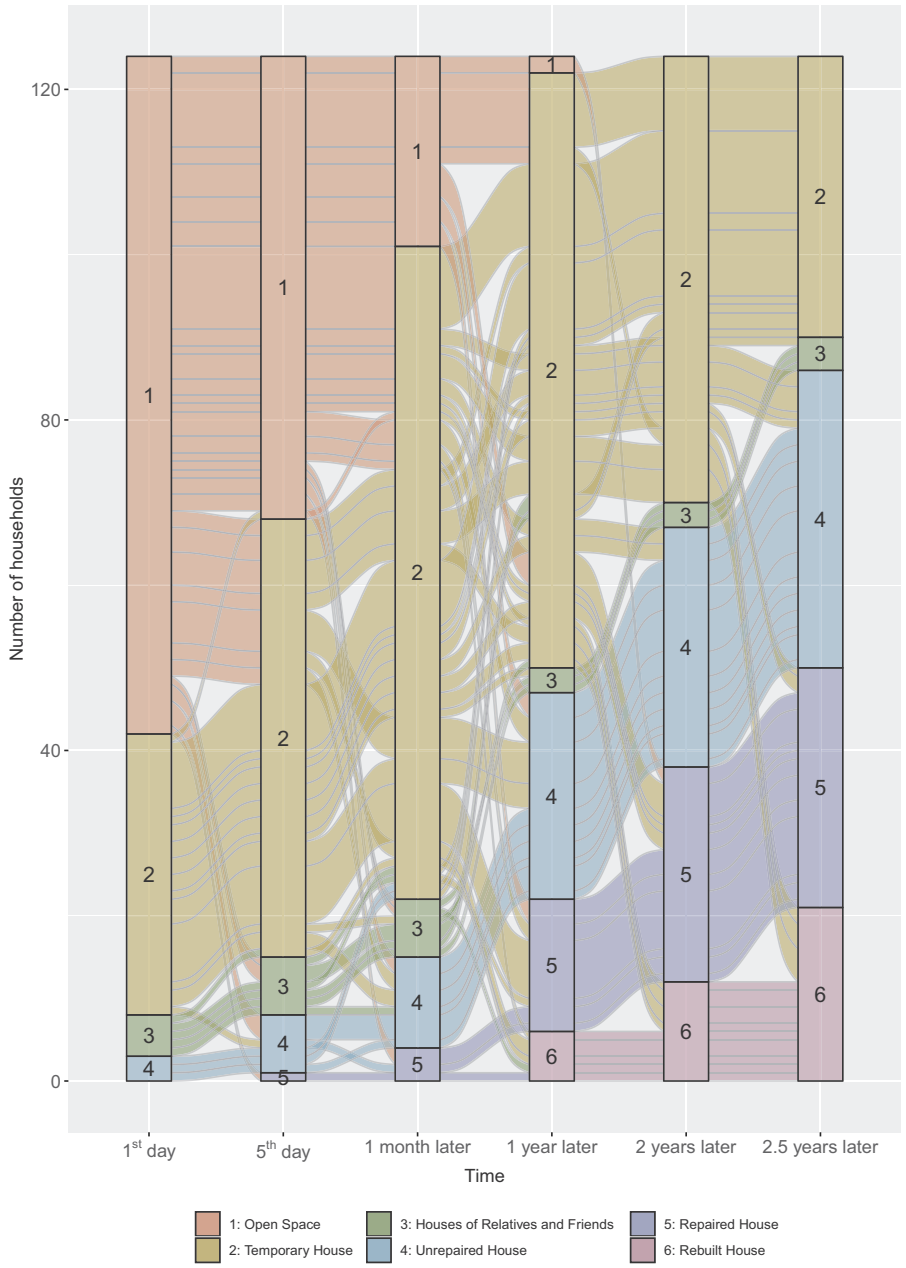

Fig. 12. Alluvial diagram presenting the transition of residential status over time.

On the first day, more than 90% of the survey participants chose either "1. Open space" or "2. Temporary house." More than half of them lodged in "1. Open space."

· **Residential status on the fifth day** (approximately 100 h later)

By the fifth day after the earthquake, approximately one-third of the households who stayed in "1. Open space" on the first day moved to "2. Temporary house." Consequently, these two groups, "1. Open space" and "2. Temporary house," had approximately equal numbers of households and occupied approximately 80% of the entire sample size.

· **Residential status one month later** (approximately 1,000 h later)

One month later, approximately half of the households, who previously stayed in "1. Open space," moved to "2. Temporary house." As a result, the number of households who stayed in "2. Temporary house" peaked one month after the earthquake.

· **Residential status one year later** (approximately 10,000 h later)

By the end of the first year, almost all of the households who stayed in "1. Open space" one month after the earthquake moved on to other types of residential status. In addition, one-third of households who stayed in "2. Temporary house" at the one-month point, later moved to either "4. Unrepaired house," "5. Repaired house," or "6. Rebuilt house." Consequently, the number of households who stayed in either "4. Unrepaired house," "5. Repaired house," or "6. Rebuilt house" rose significantly, occupying approximately 40% of the entire sample.

· **Residential status two years later**

Two years later, approximately one-fourth of the households who stayed in "2. Temporary house" at the one-year point started staying in either "4. Unrepaired house," "5. Repaired house," or "6. Rebuilt house." In addition, households who stayed in either "3. House of relatives and friends," "4. Unrepaired house," "5. Repaired house," or "6. Rebuilt house" one year later continued the same residential status even two years later. As a result, the number of households who stayed in either "4. Unrepaired house," "5. Repaired house," or "6. Rebuilt house" (Table 1) occupied slightly more than half of the entire sample. No households lodged in "1. Open space" two years later.

· **Residential status two and a half years later**

The change in the residential status two years later was similar to that observed between one-year and two-year marks. Therefore, two and a half years later, the number of households who stayed in "2. Temporary house" diminished and the number of households who stayed in either "4. Unrepaired house," "5. Repaired house," or "6. Rebuilt house" increased, occupying approximately 70% of the entire sample.

There was a slight flow from "4. Unrepaired house" to "5. Repaired house," or "6. Rebuilt house." Flow from "5. Repaired house" to "6. Rebuilt house" was also severely limited. These results mean that the affected households did not improve their residential conditions gradually, but settled down in one of the following statuses—unrepaired houses, repaired houses, or rebuilt houses—in the long term.

5.3. *Influential factors for the change of residential status*

We identified the factors that influenced the transition to a different residential status ("influential factors" hereafter). In the interview survey, we asked "*Why did you change your residential status?*" (open-ended question). From answers to this question, we derived the influential factors. More specifically, the responses of two or more households were extracted as influential factors.

Fig. 13 demonstrates the influential factors that affected the transition from a certain residential status to another at the next time point. The number in parenthesis of each influential factor corresponds to the number of households who responded to the question. For example, "1 → 2 Weather & Insects/Animals (7)" on the first and fifth days in the figure denotes that seven households stated that "Weather & Insects/Animals" induced their change of residential status from "1. Open space" on the first day to "2. Temporary house" on the fifth day. Influential factors that appeared multiple times (i.e., "Material assistance from the government and NGOs," "Recognition of the end of the aftershocks," "Sufficient money," and "Weather & Insects/Animals") are colored. The extracted influential factors are listed as follows.

· **Concern for livestock**

This factor was related to answers such as "I was worried about my livestock left in my home" and "I had to take care of livestock." This factor was the reason for transitioning from open space to temporary houses by day 5 after the main shock.

· **Assistance from neighbors**

This factor corresponded to answers such as "I obtained helping hands and materials from my neighbors." The factor also emerged as a motivation to change the residential status from open space to temporary houses by the fifth day.

· **Material assistance from the government and NGOs** (the factor marked in pink in Fig. 13)

This factor corresponded to answers such as "I received material assistance from the government and NGOs." The factor was observed as a trigger to change the residential status from open space to temporary housing between the day of the earthquake and one year later. This factor played a significant role in the decision of many households between the fifth day and one year later. Although more than 90% of

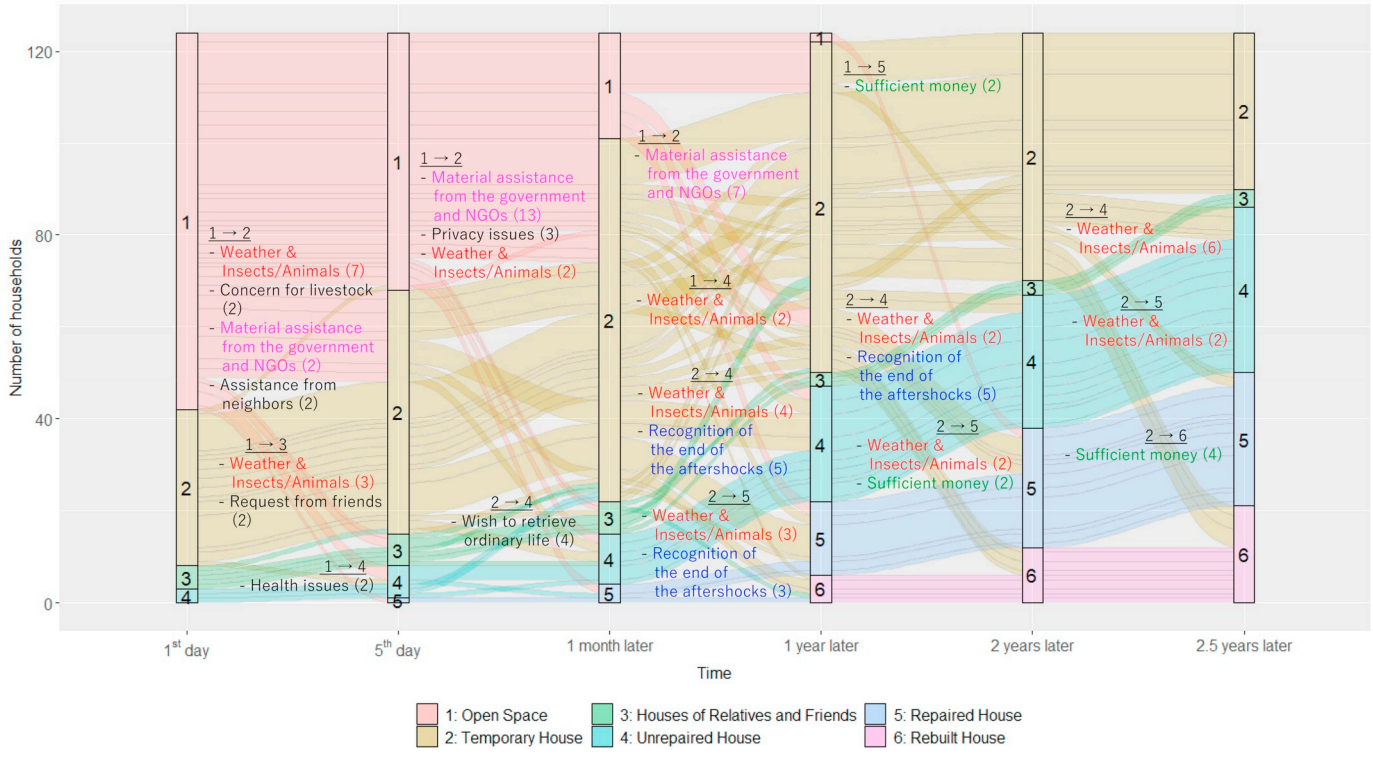

Fig. 13. Influential factors extracted from answers to open-ended questions; the numbers in parentheses show the number of households that answered the questions.

survey participants stayed in either the open space or temporary houses immediately after the earthquake (i.e., on the first day), many of them moved from the open space to temporary houses probably due to the material assistance from the government and NGOs within one year.

· **Request from friends**

This factor was derived from answers such as "My friends requested us to stay at their home." This factor was a reason to change the residential status from the open space to the houses of relatives and friends until the fifth day.

· **Health issues**

This factor corresponded to answers such as "I had an illness" and "I was worried about the health condition of an elderly family member, and thus I felt that it was better for us to return to our own house." This factor was the reason for their return to unrepaired houses from the open space before the fifth day.

· **Privacy issues**

This factor was related to answers such as "I wanted my privacy protected" and "many people gathered around" and was the motivation to change the residential status from the open space to temporary housing between the fifth day and one month later.

· **Wish to retrieve ordinary life**

This factor corresponded to answers such as "I wanted to resume daily life that I had before the earthquake" and "I wanted to resume my work in my crop fields" and motivated some households to move from temporary houses to unrepaired houses between the fifth day and one month later.

· **Recognition of the end of the aftershocks** (the factor marked in blue in Fig. 13)

This factor was associated with answers such as "I felt that the aftershocks no longer occurred" and "I felt less scared by the aftershocks" and was the reason the households moved from temporary houses to either unrepaired or repaired houses between one month and two years later.

· **Sufficient money** (the factor marked in green in Fig. 13)

This factor was derived from answers such as "I had sufficient money to repair or rebuild my house" and "I received the government subsidies." Such answers were listed as the assistance for their move to either repaired or rebuilt houses since one year after the main shock. Sufficient money allowed some households to move from not only temporary houses but also the open space, which largely improved their quality of life.

· **Weather & Insects/Animals** (the factor marked in red in Fig. 13)

This factor corresponded to responses such as "I felt uncomfortable with rainy and cold weather" and "I felt scared at insects and tigers." Such answers were the reason they left the open space or temporary houses regardless of time.

In Fig. 12, 53 flows in the alluvial diagram represent the transitions that varied from household to household. These variations in transition were observed because the households adapted to the influential factors depending on their needs and capacity. For example, a household who evacuated to the school for the first two weeks after the earthquake received CGI and plastic sheets from the government. Then, that household created a temporary house using these materials near the original house, which represents the factor of "Material assistance from the government and NGOs." The location was chosen so that the household could take care of their livestock, which represents the factor of "Concern for livestock." Two years after the earthquake, the household finally reconstructed their house using the government subsidies, which represents the factor of "Sufficient money."

Another household spent two days in the open space after the earthquake. When that household could not stand severe weather conditions any longer, the government provided them with a tent, which represents the factor of "Material assistance from the government and NGOs." Although they spent two months in the tent, they were very uncomfortable because of the cold weather and returned to their unrepaired house, which represents the factor of "Weather & Insects/Animals." This was also because the household thought that aftershocks would no longer occur, which represents the factor of "Recognition of the end of the aftershocks." Until the time of the survey, the household had not left the unrepaired house because they lacked the money to build a new house, which implies the absence of the factor, "Sufficient money." These examples demonstrate that the series of transitions of the residential status for each household varied depending on their adaptation to the extracted factors.

6. Discussion

We classified the residential status in the study area and subsequently revealed the residential status transitions and the factors that promoted the transitions. In this section, we discuss (1) the features of the influential factors and (2) the recovery process of the community and households to explore appropriate policies for post-disaster aid and recovery.

6.1. *Features of influential factors*

The factors extracted in Section 5.3 are grouped into five categories as follows:

(1) Minimum environmental conditions: "Weather & Insects/Animals" and "Health issues"
(2) Social relations: "Assistance from neighbors," "Request from friends," and "Privacy issues"
(3) Physical resources: "Concern for livestock" and "Material assistance from the government and NGOs"
(4) Desire for normal life: "Wish to retrieve ordinary life" and "Recognition of the end of the aftershocks"
(5) Financial resources: "Sufficient money"

Their effect and role in the recovery process are discussed in the following.

(1) Minimum environmental conditions

"Weather & Insects/Animals," which represent the desire to escape from undesirable weather conditions and vermin, promoted the change from open space or temporary houses to other residential statuses. Such climate and natural conditions are typical in this mountainous and rural terrain. Many households took these conditions seriously to make a decision in the recovery process. These conditions also significantly affected the households who had to consider the "health problems" of family members. These issues are about the most fundamental human needs and the concern about the minimum environmental conditions had always been an influential factor throughout the recovery process of this rural community.

(2) Social relations

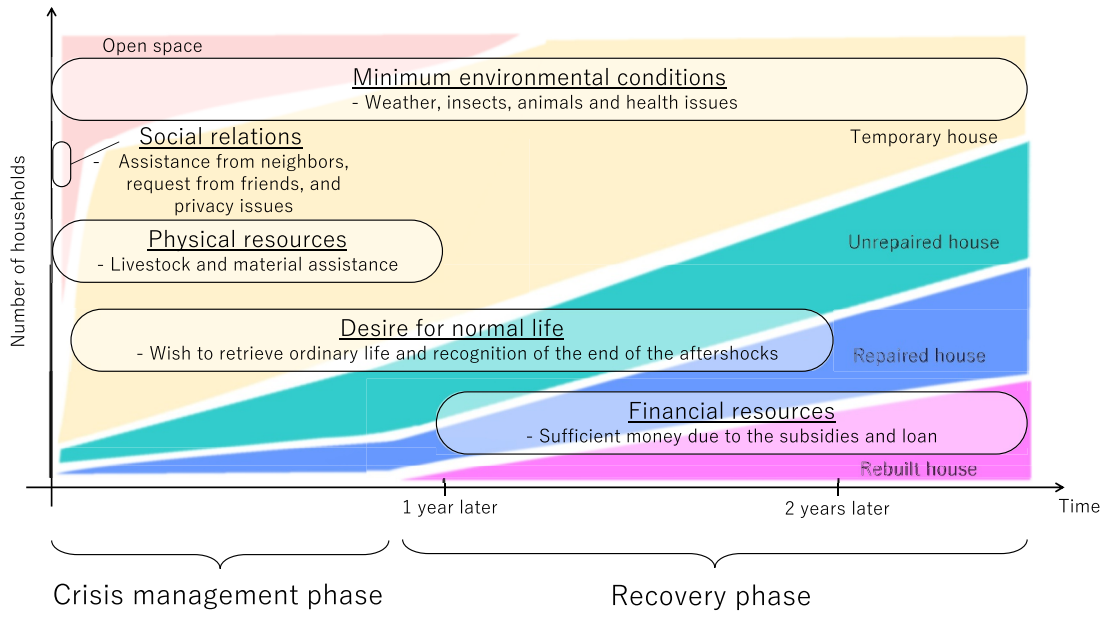

Fig. 14. Summarized transition factors (rounded squares) and recovery pattern of the community.

Other factors, including social relations, depend on the time passed after the earthquake. "Assistance from neighbors," i.e., material and labor supplies from community members, worked effectively for creating temporary houses at least for a short time after the earthquake (before the fifth day). "Request from friends" represents the offer from friends and acquaintances to stay in their safer houses immediately after the earthquake when the affected households had no idea about what to do. Communication with the acquaintances helped them to make a decision. However, staying with friends might have caused stress for some households. These households were concerned about "privacy issues" when they stayed together in an open space, which led them to leave the site.

(3) Physical resources

Soon after the earthquake, physical resources that met the basic human needs affected the change in the residential status from the open space to temporary houses. "Concern for livestock" indicates that taking care of their livestock was a serious factor for them during the first five days after the earthquake. Some households built temporary houses near the original house so that they could stay close to their livestock. Since the main industries in the study area are stock-farming and agriculture, livestock are indispensable for the livelihood of the residents. Such characteristics of their occupation also had a great influence on their decision-making about the reconstruction.

"Material assistance from the government and NGOs" had also been highly effective for constructing temporary houses until one year after the earthquake. This assistance was vital to improving the quality of temporary houses as discussed in Section 4.2. In the study area, more than half of households complained about the situation in the open space [80] but reported that the rapid material assistance (i.e., tents and construction material) from the government and NGOs met their needs. This implies that material aid provided from the outside of the community had been effective at least for one year after the earthquake. Our results are consistent with those of Paul et al. [50] that investigated how the emergency materials (e.g., food, clothing, and tents) were provided by the government and NGOs to the affected people, performing a survey on 300 households including those living in rural areas, and concluded that such assistance was delivered in an appropriate and timely manner in contrast to the international and national news reports on relief efforts.

(4) Desire for normal life

From the fifth day to two years later, subjective factors were found to play a more important role in changing the residential status than other factors. "Wish to retrieve ordinary life," i.e., the motivation to move from temporary houses to unrepaired houses between the fifth day and one month later, was extracted first, followed by "Recognition of the end of the aftershocks" as a reason to move from temporary houses to either unrepaired or repaired houses between one month and two years after the earthquake. Recent studies showed the importance of subjective factors in accelerating the recovery actions [81,82]. Our results also indicate that subjective factors promoted autonomous recovery. Information regarding the end of the aftershocks has likely played a similar role in triggering autonomous recovery actions. Kotani and Honda [83] statistically showed that information about the aftershocks was effective in starting the recovery efforts. Note that some households returned to unrepaired houses, knowing that they were unsafe because they thought unrepaired houses were better than open space or temporary houses. They had to take action although they knew it was not the most suitable choice in the long run.

(5) Financial resources

In the later stage of the recovery, financial resources were key to accelerating recovery. "Sufficient money" was mentioned as an important factor after one year had passed since the earthquake. It promoted the transition from temporary houses to either repaired or rebuilt houses rather than to damaged houses. "Sufficient money" was realized owing to the financial assistance from the government. After one and a half years later, the government of Nepal launched the Rural Housing Reconstruction Program (RHRP), aiming to provide subsidies for constructing earthquake-safe buildings [8,56]. The program covered the study area. Households were able to accelerate the rebuilding efforts significantly owing to the subsidies provided by the program. Financial assistance was probably more effective in this region because of the local conditions; a large proportion of households in the study area were

farmer families. Their independent—or self-sustaining—way of life reduced their dependency on the monetary market, which implies that they did not have a sufficient amount of cash to reconstruct their houses.

6.2. Recovery processes for community and households

6.2.1. Recovery of community

Considering the rate of housing reconstruction as a proxy of community recovery, we discuss the recovery process of the community by reviewing the proportion of each residential status. Fig. 14 displays the temporal changes in the relationship between the influential factors and the proportion of residential status with the horizontal axis adjusted to the linear time scale. The figure indicates the existence of the two phases: "crisis management phase" and "recovery phase."

The "crisis management phase" refers to the time period when many households lodged in the open space or temporary houses. The households managed to survive the post-disaster crisis, changing their residential status using social relations and physical resources. Subsequently, many households were able to take action based on their desire for a normal life one year after the earthquake.

The period that started approximately one year after the earthquake was defined as the "recovery phase." In this phase, households lodging in the open space disappeared and the number of those who stayed in temporary houses decreased. The number of households living in repaired or rebuilt houses increased at a significantly larger rate than that in the crisis management phase. In this phase, the role of financial resources as a trigger for recovery activities gained importance because they enabled the households to take the costliest recovery actions, such as repairing and rebuilding their houses. The desire to have minimum environmental conditions motivated the recovery regardless of phase.

6.2.2. Recovery of households

Fig. 14 shows that the affected community has a constant need for minimum environmental conditions, while various factors played important roles in residential status transition. Influential factors varied depending on the progress of the recovery and the circumstances. For effective assistance, it is essential to identify the concerns and priorities of the residents, paying attention to the living conditions of individual households. Some households spent the subsidies on daily necessities and food, not for the repairs or rebuilding. It is not because they did not understand the purpose of the subsidies, but they had to prioritize their needs. Another household devoted the subsidies to the reconstruction of their store; their house had been damaged, but they must have prioritized their store to start earning income. Consequently, they did not have enough money to rebuild their house because the subsidies covered only one building per household.

The housing conditions of the community recovered gradually, but individual households took different actions. Fig. 12 shows that the number of households living in "4. Unrepaired house" did not decrease after one year. Once households moved to "4. Unrepaired house," they seldom improved their residential status to "5. Repaired house" or "6. Rebuilt house." Similarly, once they settled in "5. Repaired house," they rarely built a new house ("6. Rebuilt house"). It means that the affected households did not upgrade their residential status gradually. When they decided to leave the temporary houses, they made their decision regarding the next residential status, which turned out to be the final (as of the time of our survey, or two and a half years after the earthquake) residential status. Those who could afford to wait for the subsidies provided by the RHRP were able to repair or rebuild their houses. Those who were not able to continue living in temporary houses, however, had to move to the unrepaired houses; they did not have another chance to repair or rebuild their houses (before the time of our survey). In the recovery phase, many households started living in the repaired or rebuilt houses, but those who had to move to unrepaired houses did not see further improvement in housing conditions.

7. Conclusions

Rural communities in developing countries have limited access to physical and financial resources. Once severe disasters cause damage to them, they are forced to stay in evacuation shelters or temporary houses for a long period of time. The reconstruction of vulnerable communities after disasters has been an important problem. To effectively assist them to recover their residential conditions, we need to primarily understand when, why, and how the affected households change their residential status after the disasters.

Through door-to-door interview surveys targeting approximately 120 rural households affected by the 2015 Gorkha earthquake, we collected detailed information on the residential status of affected households as well as the reasons for the changes in their residential status. Based on the obtained data, we identified the residential status transitions via an alluvial diagram and found the influential factors up to two and a half years after the earthquake (i.e., the time of our survey).

We observed more than 50 transition patterns among the interviewed households (Fig. 12), which indicate the large diversity of the recovery process of the affected households. The number of households moving from temporary houses to the repaired or rebuilt houses increased rapidly one year after the earthquake, which marked the "recovery phase" of the community. They moved directly to the repaired/rebuilt houses after leaving the temporary houses, without staying in the unrepaired houses. Those who had returned to the unrepaired houses did not later move to the repaired/rebuilt houses.

Recovery of each household was motivated by a wide variety of factors. We extracted the factors that were most influential in residential transition over time (Fig. 14). While the concern about "minimum environmental conditions" had been influential over the entire process, "social relations" in the community were important immediately after the earthquake, followed by the "physical resources" and "desire for normal life." In the recovery phase, "financial resources" played a significant role in motivating the people to move to the repaired or rebuilt houses.

Our findings have two implications for effective recovery aid:

(1) It should be recognized that the recovery of the community does not necessarily mean the recovery of every individual household. During the recovery phase for the community, the number of households that began living in repaired or rebuilt houses increased. However, several households also moved into unrepaired houses during this phase and their living conditions did not improve thereafter. Further, for households that had moved into unrepaired houses prior to the community recovery phase, housing conditions remained unimproved during the recovery phase. This means that the decision these households took when moving turned out to be final as of two and a half years after the earthquake, and they had no scope for improving their living condition. The residential status of the affected households had been determined by the time the recovery phase of the community started. Since at least for the several households that moved into repaired or rebuilt houses, having "Sufficient money" was a triggering factor for the move, we can conclude that providing financial support as recovery aid sufficiently early, i.e. before the community as a whole begins to recover, so that affected households can navigate through the crisis more efficiently and are in a position to take better decisions. In the studied case, had the subsidies by the Rural Housing Reconstruction Program (RHRP) been provided earlier, a larger number of households might have availed better housing recovery options.
(2) Attention should also be paid to the variety of influential factors and the diversity of recovery processes relevant to individuals. Our survey shows that such variety and diversity were not because of fickle or inconsistent decisions by the affected people. Each individual household properly perceived their

circumstantial conditions and took rational decisions accordingly. For instance, when a household needed to restart their business and had no pre-existing funds with which to pay for the reconstruction of their store, the rational course of action was to use the subsidies for rebuilding the store rather than the house. Then, for the reconstruction of their house, they needed additional financial support. Different recovery processes require different kinds of support in terms of the amount, type, and timing, because affected people from poor rural communities do not necessarily have abundant resources to manage the crisis. Recovery aid should be tailored to individuals' concerns and circumstances.

Our findings serve as the basis for the effective support to the recovery of vulnerable rural communities after disasters. Some problems, however, remain to be addressed. First, the cross effects of the influential factors should be analyzed. For example, the concern about the "Weather & Insects/Animals" might have increased the effect of "Material assistance from the government and NGOs." This will help us understand the roles of extracted factors more accurately. Second, a follow-up study is required. Our survey covers the time period up to two and a half years after the earthquake. It would be worthwhile to investigate how residents rebuild their lives over the longer term; how those staying in unrepaired houses recover and what factors affect their recovery process, including the lifestyle and customs of local residents [68]. Third, because influential factors for the recovery process are context dependent, the applicability of our findings to various cases needs to be discussed, including an incremental process of recovery based on transitional shelters [84,85].

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Appendix A. Household characteristics and damage to houses

The following questions about household characteristics and damage to houses were asked to the participants:

- ➢ Household characteristics
  - · Number of migrant workers
  - · Number of school-attending children
  - · Family structure (nuclear/two generations/three generations/others)
  - · Occupation of the head of household (farmer or not)
  - · Age of the head of household
- ➢ Damage to houses
  - · Damage assessment conducted by the government: *What was the level of damage to your house after the earthquake? Please select either "Green," "Yellow," "Red," or "Others."*
  - · Respondent's impression of damage: *What was your immediate thought about the level of damage to your house? Please select either "Almost no damage," "Some damage," or "Very severe damage."*

Table A1 presents a summary of the answers to these questions.

Table A1
Sample characteristics.

		n	%
Number of family members	≤ 5	81	65.3
	6–10	40	32.3
	> 10	3	2.4
Number of migrant workers	0	68	54.8
	1	33	26.6
	2	15	12.1
	≥ 3	8	6.5
Number of school-attending children	0	48	38.7
	1	34	27.4
	2	28	22.6
	≥ 3	14	11.3
Family structure	Nuclear	64	51.6
	Two generations	48	38.7
	Over three generations	8	6.5
	Others	4	3.2
Occupation	Farmer	104	83.9
	Others	20	16.1
Age of the head of household	10–19	0	0.0
	20–29	8	6.5
	30–39	21	16.9
	40–49	27	21.8
	50–59	26	21.0
	60–69	23	18.5
	70–79	18	14.5
	80 and older	1	0.8
Level of damage to houses	Green	4	3.2

(*continued on next page*)

Table A1 (*continued*)

		n	%
	Yellow	33	26.6
	Red	69	55.6
	Others	18	14.5
Impression of damage to houses	Almost no damage	0	0.0
	Some damage	40	32.3
	Very severe damage	84	67.7

Appendix B. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijdrr.2019.101443.

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