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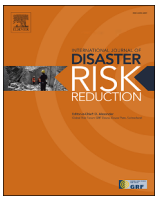

Rebuilding historic urban neighborhoods after disasters: Balancing disaster risk reduction and heritage conservation after the 2015 earthquakes in Nepal

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ABSTRACT

The 2015 Nepal earthquakes devastated the Kathmandu Valley and exposed the challenges of conserving andrestoring architectural heritage in historic urban neighborhoods damaged by disasters, while also trying to rapidly rebuild houses, revitalize livelihoods, and reduce vulnerabilities to future hazards. In this paper we use quantitative and qualitative data to investigate how traditional housing was transformed during the post-earthquake reconstruction of four historic neighborhoods in the Kathmandu Valley. We assess how traditional housing stock in these neighborhoods was transformed by a combination of the direct impact of the earthquake; the enforcement of seismic-resistant modern building technology; the costs and logistics of rebuilding; and the priorities of local residents. Our findings indicate that the enforcement of seismic safety building codes and the expense of incorporating traditional architectural elements led to notable changes to the tangible cultural heritage of Kathmandu's historic urban neighborhoods, but likely also improved seismic safety.

1. Introduction

The 2015 Nepal earthquakes[1] caused extensive damage to large religious complexes, museums, and prominent cultural monuments, including components of the UNESCO Kathmandu Valley World Heritage Site [1–7]. Many of these heritage sites are integral aspects of Nepali cultural identity and ritual practices, as well as tourist attractions important to the country's economy. After the earthquakes, images of historic structures in ruin drew attention to the depth of the cultural loss caused by the disaster. Local and in-

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[1] Nepal was hit by a 7.8 earthquake on 25 April 2015, which killed almost 9000 people and caused extensive damage to the built environment. The first earthquake was followed by numerous aftershocks, including a particularly destructive 7.3 aftershock on 12 May 2015. In this paper we do not distinguish the damage caused by various aftershocks/subsequent earthquakes and for simplicity refer to these various events as the 2015 earthquakes.

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ternational stakeholders worked to repair, conserve, and rebuild some of the most prominent cultural heritage sites [8,9]. Most of this important work focused on large communal heritage sites such as temples, palaces, and museums.

However, much of the cultural heritage in Nepal damaged by the 2015 earthquakes was embodied in the less prominent vernacular domestic, religious, communal, and commercial structures and spaces that make up historic urban neighborhoods in the Kathmandu Valley [4,10]. Post-earthquake Nepal is important for studying the interface of cultural heritage and disasters because of the dual nature of these areas as historic urban landscapes filled with monumental and vernacular heritage sites and neighborhoods where people live and work. The destruction of traditional houses and buildings left people displaced and/or without the facilities necessary for their livelihoods. Therefore, during post-disaster reconstruction, heritage conservation had to be considered alongside urgent humanitarian, development, and administrative concerns to rapidly re-house people, build more resilient structures and neighborhoods, and re-vitalize local livelihoods and economies [8].

The restoration of damaged historic urban areas has received increased attention over the past decade due in part to the 2009, 2012, and 2016 earthquakes in Italy that damaged the historic core of L'Aquila and other historic areas [11–18] and the extensive damage to historic urban areas in Iraq and Syria during recent periods of conflict [19–22]. However, there is currently a lack of research in both the disaster and heritage literatures about how to balance heritage conservation with humanitarian and development priorities, and how historic urban neighborhoods are transformed by a major disaster like the 2015 Nepal earthquakes.

In this paper we make two contributions to the disaster and heritage literatures. First, we focus on historic urban landscapes[2] and vernacular architectural heritage, much of which is privately owned and used for everyday domestic, ritual, and commercial purposes. The implications of rebuilding such spaces after destructive events are understudied compared to the attention given to restoring prominent monumental sites destroyed by disasters or conflict. Second, we assess the overall impact of a disaster on cultural heritage by considering three main factors: the actual damage caused by the disaster; the decisions made during the planning phase about how to prioritize heritage conservation against other considerations such as risk reduction, economic development; individual household preferences and means; and the practical and administrative challenges of large-scale reconstruction projects.

We analyze how these factors led to a transformation of four historic urban neighborhoods in the Kathmandu Valley: Bungamati, Thecho, Pilachhen, and Harisiddhi.[3] In the next section we review the literature on heritage and disasters to highlight the potential trade-offs and tensions between heritage conservation and standard approaches to post-disaster reconstruction. We then discuss how heritage conservation factored into the reconstruction guidelines developed by the Government of Nepal. We present three analysis sections. The first section assesses the damage caused by the earthquakes to traditional houses in our study area. The second section provides a quantitative assessment of the transformation of historic housing caused by the earthquakes and reconstruction. The third section uses a mix of quantitative and qualitative data to assess how residents prioritized heritage restoration and the main factors that shaped resident perspectives and approaches to heritage restoration. These sections provide a substantive account of how the damage caused by the earthquakes and decisions made during the reconstruction have impacted architectural heritage in Kathmandu's historic urban neighborhoods.

2. Heritage, disasters and reconstruction

Disasters can have significant impacts on cultural heritage [23–25]. This is important because our cultural heritage, from tangible historic buildings, monuments, and artefacts to intangible cultural customs, rituals and traditional crafts, is integral to our identities [26–29]. Heritage is an important source of historical context and informs what we pass on from generation to generation about who we are, what we do, and how we should act [30,31]. Cultural and heritage tourism are powerful drivers for national economies and local livelihoods in many countries – especially in Nepal - and therefore the destruction of cultural heritage can lead to long-term financial losses and livelihood disruptions [1,32,33]. Therefore, the loss of cultural heritage can have negative impacts on individual, communal, and broader societal levels [34–38].

Accordingly, there is a growing body of literature that highlights the importance of preserving and reconstituting damaged cultural heritage to help communities retain cultural, historical, and ritual infrastructure, and sense of place [39–46]. The re-establishment of familiar pre-disaster cultural heritage, customary practices, and traditional governance structures can help disaster-affected persons and communities regain a semblance of normalcy and support recovery and healing [4,47–51]. Some authors have demonstrated that cultural practices and traditional building and subsistence techniques may contain implicit knowledge about resilience – and therefore referencing the past could contribute to future hazard mitigation and sustainable resource management [4,26,52–54]. The practical extension of these arguments is that there is value in restoring or even replacing destroyed heritage sites with new structures that use traditional layouts, dimensions, construction techniques, and materials [55].[4]

[2] Historic urban landscape is a concept developed within heritage studies that acknowledges that the heritage value and spirit of place within heritage neighborhoods is based on the collection of all tangible and intangible heritage resources in an area [73]. Therefore, conservation efforts in such areas needs to focus on entire streetscapes rather than individual structures.

[3] In this paper we focus mainly on tangible cultural heritage consisting of domestic structures. We recognize the importance of intangible cultural heritage (traditional customs, ritual practices, etc.) and its close links with the built environment, but our data do not allow us to present a rigorous analysis of how the earthquakes and reconstruction impacted intangible heritage.

[4] We want to acknowledge that historically, destructive events such as major disasters and conflicts opened up spaces for new forms of built environment, where the preservation of historical structures was secondary to urban development and modernization [74]. Furthermore, there are arguments within heritage studies that restoration should not be the default approach, as destructive events are part of the natural evolution of cultural heritage, and that post-disaster and post-conflict heritage is a contested subject [19,75-80].

It has become common for governments and NGOs involved in post-disaster reconstruction to favor some degree of heritage restoration - at least at a rhetorical level. This has been formalized in the Sendai Framework for Disaster Risk Reduction and other national and international disaster mitigation and management frameworks [56]. However, post-disaster reconstruction is commonly framed in terms of transformation – embodied in the 'Build-Back-Better' mantra embraced by the Government of Nepal after the 2015 earthquakes. Most major post-disaster rebuilding projects propose to build safer and more resilient structures, upgrade infrastructure, reduce pre-disaster vulnerabilities, and support sustainable economic development [57–61]. The 'Build-Back-Better' approach assumes that there were vulnerabilities within the pre-disaster built environments that need to be rectified during reconstruction to enhance resilience. In the context of this paper, the core tension that emerged in Nepal was whether it is possible to build-back-better and safer while preserving historic structures using traditional techniques and materials.

It is important to better understand the extent to which post-disaster heritage conservation or restoration is compatible with the explicitly transformative agenda common to large post-disaster reconstruction projects. To date, we are unaware of published research within either the disaster or heritage literatures about how the impacts of disasters and post-disaster reconstruction transform vernacular cultural heritage within historic urban landscapes. We are also not aware of any studies that systematically investigate how disaster-affected residents within historic neighborhoods prioritize the preservation or restoration of cultural heritage when rebuilding their homes.

We propose that the overall impact of a disaster upon cultural heritage is a function of: 1) the damage and/or disruption caused by the event; 2) how the priorities of heritage conservation are balanced with other priorities such as disaster risk reduction when developing plans, guidelines, and policies for rebuilding; and 3) the preferences, means, and capacity of individual households to navigate the challenges of re-building their homes after a destructive event.

3. Research context and methods

3.1. Historic Newar towns in the Kathmandu Valley

Historic urban neighborhoods in the Kathmandu Valley were originally created by the Newar ethnic group, amongst the oldest inhabitants of the Valley. Historic Newar towns and neighborhoods are characterized by tightly packed multi-story buildings interspersed with small streets and alleyways that meander around open courtyards, ponds, temples and ritual water spouts. Many of the older structures consist of thick load-bearing mud brick walls, layers of open spaces and terraces on the upper floors, and highly distinctive ornately carved wooden doors, window frames, and balconies [4,5,10,26]. The spatial relationships of the built environment commonly reflect familial connections, with multiple branches of an extended family occupying the same piece of property and building often physically connected and/or integrated houses around communal courtyards (Fig. 1). The end result are dense labyrinths of traditional three to five story houses and temples packed tightly against each other, endless narrow, meandering alleys punctuated by ornate ritual water fountains and shrines, and open squares filled with vendors and traditional shaded platforms where older members of the community socialize.

The intangible cultural practices that are central to Newari identity and cultural continuity are carried out amongst these tangible heritage structures. This happens through the many formal festivals and rituals that anchor the Newari calendar, characterized by large gatherings, processions, ever-changing decorations, and offerings and sacrifices within the spaces provided by the tangible heritage of the built environment. The intangible heritage can also be felt in the mundane rhythms of everyday life. The earthquakes affected places where people pray and make offerings, where elderly residents gather and socialize, and where people are married and buried. Additionally, some of the historic settlements are well-known for their populations of traditional artisans, such as wood carvers, potters, weavers and metal workers that serve both local and tourist needs.

3.2. Case study areas

In this paper we present data from four historic Newari neighborhoods in the Kathmandu Valley: Bungamati; Thecho; Pilachhen; and Harisiddhi (Fig. 2; Table 1). They all suffered significant damage during the earthquakes and the reconstruction of each neighbor-

Fig. 1. Example of core area of traditional Newari town in the Kathmandu Valley (Photo P. Daly).

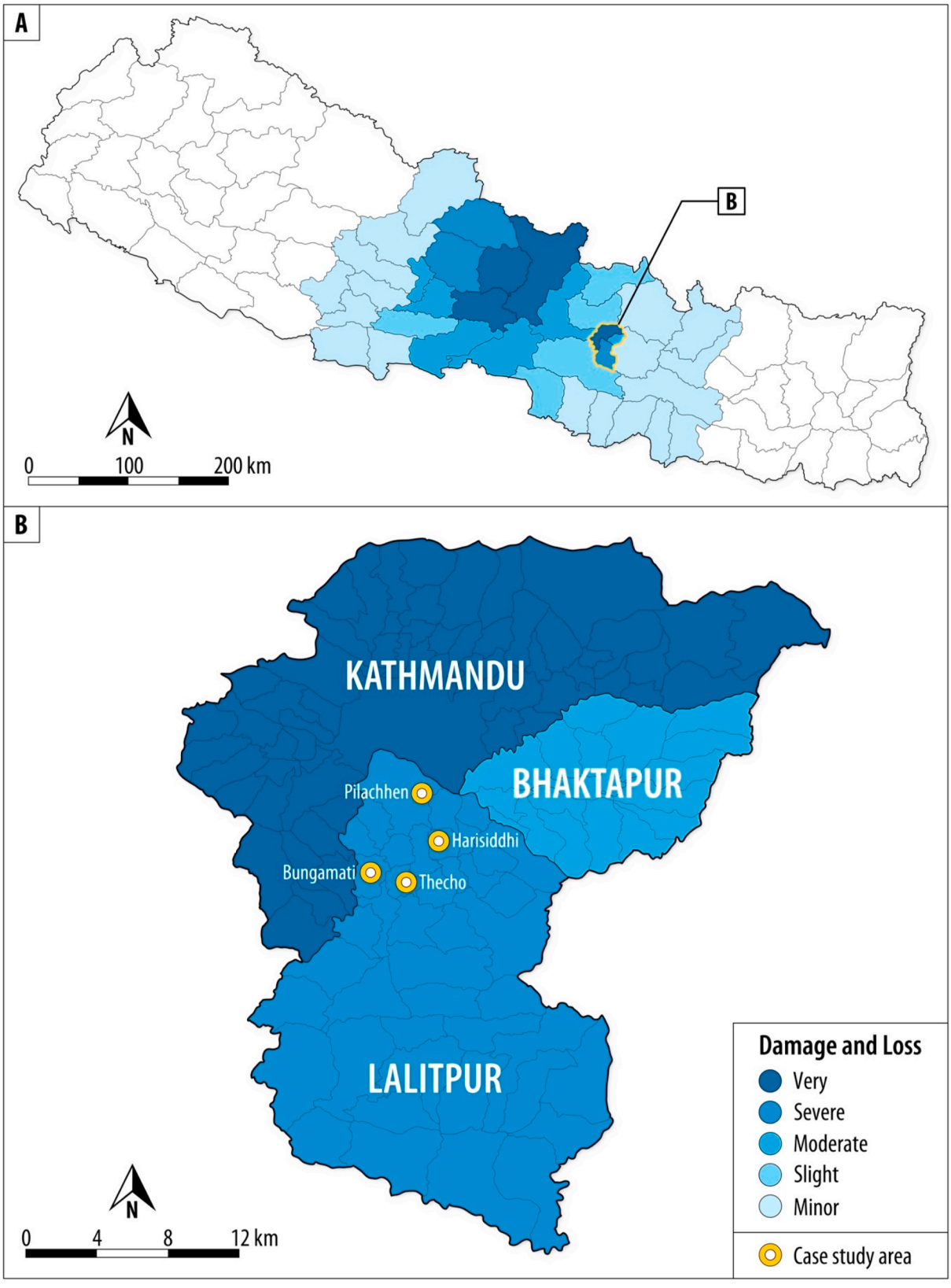
A
B
N
0 100 200 km
B
KATHMANDU
BHAKTAPUR
LALITPUR
Pilachhen
Harisiddhi
Bungamati
Thecho
N
0 4 8 12 km
Damage and Loss
Very
Severe
Moderate
Slight
Minor
Case study area

Fig. 2. Map of the Kathmandu Valley showing the location of our case study neighborhoods. The color coding shows the severity of the damage caused by the April 2015 earthquake (source of data Housing Recovery and Reconstruction Platform Nepal; figure made by M. Ikhsan). (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

Table 1
Characteristics of case study neighborhoods.

Settlement	Pop. Size	Total Houses	Houses Damaged	Key Actors in Reconstruction
Thecho	c. 10,086	2345	303	• Lumanti • Nepal Red Cross • Home Net • Nepal Government
Bungamati	6720	1600	781	• UN-Habitat • Bungmati Area Reconstruction and Development Council • Center for Integrated Urban Development • Nepal Government • Embassy of Sri Lanka
Pilachhen	599	130	103	• Maya Foundation • Pilachhen Reconstruction and Tourism Promotion Project
Harisiddhi	6577	1667	266	• Harisiddhi Reconstruction and Rehabilitation Committee • Harisiddhi Engineers Association • Lalitpur Society for Development

hood was shaped by unique local factors, access to resources, local governance structures, and external partnerships. These neghborhoods have a range of disaster and reconstruction experiences that allow us to develop insights into the challenges facing historic urban neighborhoods after a disaster.

Bungamati is a traditional Newar settlement in the Lalitpur district in the Kathmandu Valley. It had a population of over 6700 people prior to the 2015 earthquakes. It is a dense concentration of multi-story structures on a ridge overlooking agricultural fields and the Bagmati river. It contains several prominent temples, including the Rato Machhendranath Temple which houses the deity of the Kathmandu Valley. Prior to the earthquakes, it was a popular tourist location and a center of traditional craft production. During the earthquakes 781 houses were damaged (Table 1). The Bungamati reconstruction plan, endorsed by UN-Habitat, was framed around heritage restoration to promote tourism. Most of the residents were required to adhere to the government's heritage by-law (discussed in more detail in the next section).

Thecho is a historic Newar settlement located approximately 2 km across the Nakkhu river valley from Bungamati. It had a population of about 10,000 people prior to the 2015 earthquakes. Before the earthquakes, Thecho consisted of a mix of traditional multi-story structures. Unlike Bungamati, Thecho is not a prominent tourist site or center of traditional craft production. During the earthquakes 303 houses were damaged (Table 1). Reconstruction was supported Lumanti, a Nepali NGO. The Thecho reconstruction plan focused on efficiently providing safe and comfortable houses and up-grading municipal infrastructure. No support was provided to residents for heritage restoration.

Pilachhen is a neighborhood within Patan. It is near the Durbar Square which hosts a number of famous heritage sites, including a historic palace that is listed as part of a UNESCO World Heritage site. It had a population of about 799 people prior to the 2015 earthquakes. The built environment before the earthquakes consisted of a mix of traditional multi-story structures. During the earthquakes 103 houses were damaged (Table 1). Reconstruction was supported by a local NGO, the Maya Foundation, which worked with the community to develop and partially fund the Pilachhen Reconstruction and Tourism Promotion Program. This plan focused on restoring cultural heritage to promote tourism and home-stays.

Harisiddhi is a historic village in Lalitpur. Located a mile south of Patan, Harisiddhi, or 'Jala', was once a cultural center of historical significance, as evidenced through oral histories and seen in local inscriptions and architecture. It had a population of 6577 people prior to the 2015 earthquakes. It was not a noted tourist site. During the earthquakes 266 houses were damaged (Table 1). The Harisiddhi Reconstruction and Rehabilitation Committee developed a plan to promote heritage restoration to increase tourism. However, they were not able to secure financial or technical support for heritage restoration.

3.3. Heritage and Nepal's Post-Disaster Recovery Framework

The Nepal government's National Reconstruction Authority (NRA) issued a formal "Post-Disaster Recovery Framework" in May 2016, which outlined the broad principles to govern the reconstruction [62]. The nation-wide reconstruction effort was framed around Building-Back-Better, which prioritized risk mitigation through seismic resistant building codes and planning by-laws as well as community-level economic development. For housing reconstruction, the Nepal government adopted an owner-driven approach where owners were provided with technical support and three tranches of financial support to help with rebuilding.[5] While helpful and widely appreciated, this cash grant program typically amounted to only a fraction of the total cost of rebuilding a house in urban

[5] Under the owner driven model promoted by the Nepal government to rebuild private houses, homeowners whose houses were damaged were eligible to receive up to three tranches of funding from either the government or an NGO, totaling 300,000 Nepali rupees. The release of tranches was contingent upon getting approvals of building plans and progress from local government officials. Within urban areas in Kathmandu, we estimate that the cost of rebuilding a 3-story home following the government guidelines averaged between 3,000,000 and 6,000,000 Nepali rupees.

neighborhoods [63]. The NRA plan advocated for the empowerment of disaster-affected persons and their right to participate in the design, planning, and construction of their homes and commercial properties.

Cultural heritage featured prominently within the Post-Disaster Recovery Plan as seen in this excerpt from the NRA plan:

> "In order to safeguard the cultural continuity of the communities that have been affected by the earthquake, a comprehensive approach will be taken to ensure the rehabilitation of both classified monuments and traditional living environments … The rehabilitation of heritage sites, historic settlements, monuments and traditional houses will ensure cultural continuity *by maintaining the original design, materials, building technology and traditional craftsmanship*. The implementation of the rehabilitation process will include the local stakeholders as far as possible; such inclusion is part of the healing process, which will take time. The reconstruction process will require specific arrangements for the identification, promotion and training of artisans as well as developing strategies for the procurement and production of traditional construction materials." [62] (our emphasis)

The document lists that one of its policy objectives is "To reconstruct damaged cities and ancient villages to their original form, while improving the resilience of the structures" (Ibid). These statements acknowledge the core concerns of both disaster and heritage practitioners.

However, the Nepal Government's initial reconstruction guidelines issued over a year after the earthquakes required that all new houses needed to conform to an updated set of building codes that regulated the depth of foundation and recommended the use of steel-reinforced concrete pillars for multi-story houses [64]. The use of traditional architecture with load bearing walls was discouraged. New row-houses would not be granted building permits and houses couldn't be built on lots of less than 400 sq. m. Neighborhood roads had to be a minimum of 6 m wide. If they were narrower, the government would dismantle encroaching houses. All of these measures were based on engineering and planning perspectives that prioritized disaster risk reduction. Homeowners who did not adhere to the building codes could not get official approval from the government needed to verify their houses were legal. Additionally, the government could demand that illegal houses be demolished at the owner's expense.

These regulations were immediately criticized by stakeholders in historic urban neighborhoods as it would not have been possible for people to adhere to the regulations and rebuild historic urban neighborhoods in anything resembling the form they existed before the earthquakes. In response, the government issued a heritage by-law in September 2016, which exempted selected historic urban neighborhoods from some of the provisions of the building code. The by-law stipulated that streets in some historic neighborhoods could remain as they were and that rebuilding could restore row-housing. Historic towns that requested to be recognized as 'heritage towns' to be exempt from some of the building regulations were required to adhere to the heritage by-law.

The new heritage by-law provided an official vision of how houses in historic urban neighborhoods should be re-built. New houses had to conform to the following points, as detailed by the Ministry of Urban Development (2019):

- The interior of the house can be decorated according to one's will, but the exterior needs to be brick.
- The vertical limit of the house is not to exceed 35 feet.
- The building cannot be more than four floors high.
- Room height cannot be taller than 8 feet.
- All four walls have to be built using locally made 'traditional' bricks. The bricks are not to be plastered and are to be left in their 'natural' state.
- The doors and windows have to be made out of wood and must follow traditional design. They all have to be perfectly aligned in their placement.
- Only one-third of the terrace can be an open space. The rest has to be covered under a slanted roof.

4. Methods

The data presented in this paper come from a program of research on disaster governance, community mobilization, and post-disaster reconstruction that we conducted in the Kathmandu Valley from 2016 to 2021 [5,63,65]. The project reviewed relevant documents and plans related to the overall national-level rebuilding, as well as specific plans for rebuilding our case study neighborhoods. In 2019, the project conducted an extensive in-person survey of 1453 households that were damaged in the earthquakes. We worked with local government officials to identify all houses in each of our case-study neighborhoods that were registered by the government as officially damaged by the earthquakes. The project hired teams of local enumerators, working with local facilitators, to conduct a quantitative survey based on a questionnaire (Table 2). We targeted the head of household for the survey, but it was common for other family members to be present and provide information.

To gain further insights into how the reconstruction unfolded in real time, we selected a sample of households in each case study area that we periodically revisited for ethnographic observation over five-years to monitor housing reconstruction. We put all households into three categories based upon the status of rebuilding their homes at the start of our survey in late 2016: 1. Households that had made substantial progress rebuilding before we started our investigation. 2. Households that were just started to rebuild around the time our survey started; and 3. Households that had not started rebuilding before the start of our survey. We targeted a minimum of 5 households from each group, from each case study settlement. We conducted initial in-depth interviews and then regular follow-up interviews both in person and over the phone. We also maintained regular correspondence with our subjects through text messages and phone calls so they could notify us in real-time about their progress and challenges faced during rebuilding. We analyzed the transcribed interviews from 162 respondents, identifying the main topics discussed. Most of the interview data used in this paper was obtained between 2018 and 2019. We present insights from the qualitative data in section 5.3 and provide respondent profiles and an extensive collection of excerpts from interviews to support the claims made in this paper [SI Table 1; **SI Appendices 1 – 10**].

Table 2
Questions from the quantitative survey used in this paper.

Theme	Data Collected
Damage	How did the earthquakes affect your house? • Completed destroyed • Partially destroyed/not habitable • Partially destroyed/habitable • Minor damage
Change of Housing Stock	Type of house before/after the earthquakes & after rebuilding • **RCC**: Houses that were built using steel-reinforced concrete frames that do not have significant heritage components. • **Traditional Brick and Mud with load-bearing walls:** Houses built in tradition Newar architectural style with a structure supported by load-bearing brick walls and Newar-style exterior components such as carved wooden window and door frames and balconies. • **Steel-Reinforced Frames with Traditional Brick Exteriors:** Houses built with steel-reinforced concrete frames with non-loadbearing brick walls with traditional-style exterior brick façades that contain at least some elements of cultural heritage. • **Mixed:** Houses that use mixed construction materials and mixed building typologies: i.e. ground floor is RCC, with additional floors built with load bearing brick and cement/mud mortar or steel frames and/or cement boards and/or other prefabricated materials (such as gypsum boards). How many stories was your house before the earthquakes? How many stories is your house after rebuilding?
Cost	Estimate cost to rebuild. Source of financing.
Resident Priority	When rebuilding your house, how did you prioritize the following? Please rank: • Earthquake Safety • Cultural Heritage • Comfort • Commercial utility
Regulations	How appropriate was the rebuilding plan, including house design, mandated or recommended by the government, NGOs, or community, for you as well as for the wider community? How important is it for people to follow the building codes and by-laws promoted by the government?
Challenges	What were/are the main challenges faced rebuilding your home?

5. Results

5.1. Direct impacts of the earthquakes on cultural heritage

The official damage assessment conducted by the Nepal Government determined that the earthquakes damaged or completely destroyed over 781 domestic and commercial spaces in Bungamati, 703 in Thecho, 266 in Harisiddhi, and 103 in Pilachhen (Table 3).

Table 3
Extent of damage by pre-earthquake housing type in the four case study settlements. Summary by building type and damage level shown in Fig. 4.

	Total Destruction	Uninhabitable	Habitable	Minor Damage	N/A	Total
Bungamati (N = 781)						
Mixed	16	11	8	7	0	42
RCC	6	14	42	40	2	104
Concrete Frame with Traditional Façade	10	7	31	13	4	65
Traditional Brick & Mud	425	40	36	5	12	518
N/A	18	4	9	2	19	52
Total	***475***	***76***	***126***	***67***	***37***	***781***
Thecho (N = 303)						
Mixed	2	0	1	0	0	3
RCC	2	6	14	40	0	62
Concrete Frame with Traditional Façade	5	11	5	34	0	55
Traditional Brick & Mud	120	31	15	17	0	183
Total	***129***	***48***	***35***	***91***	***0***	***303***
Harisiddhi (N = 266)						
Mixed	1	0	0	0	0	1
RCC	5	2	1	0	0	8
Concrete Frame with Traditional Façade	2	0	0	0	0	2
Traditional Brick & Mud	240	9	1	0	0	250
N/A	5	0	0	0	0	5
Total	***253***	***11***	***2***	***0***	***0***	***266***
Pilachhen (N = 103)						
Mixed	1	0	0	0	0	1
RCC	0	3	17	6	0	26
Concrete Frame with Traditional Façade	0	0	16	0	0	16
Traditional Brick & Mud	20	10	28	2	0	60
Total	***21***	***13***	***61***	***8***	***0***	***103***
Total for All Area	***878***	***148***	***224***	***166***	***37***	***1453***

Some of the houses collapsed during the earthquakes, but many were partially damaged and remained standing and largely intact. During the initial damage assessment, government engineers and architects identified still-standing structures that were unsafe for habitation due to structural damage. Some owners dismantled these buildings, leaving vacant lots while waiting for reconstruction. Some of the damaged structures were left standing, abandoned and propped up with make-shift wooden braces and in some cases still used/occupied in spite of regulations (Fig. 3).

Out of the 1453 damaged houses in our study areas, 878 were totally destroyed (Table 3). All of these houses needed to be demolished and re-built. A total of 148 houses suffered extensive damage, could not be used, and needed to be demolished. A total of 224 houses needed significant repairs but inhabitants were still able to use the structures. A total of 166 houses suffered minor damage (although some of these structures were replaced by new houses).[6]

We assessed the basic construction techniques for all of the damaged structures (Table 3). Almost 70% of the houses in the four neighborhoods that were damaged were made using traditional construction techniques and materials (structures made from load-bearing mud and brick walls) - with many of these structures dating back generations. About 10% had traditional exteriors but utilized non-traditional materials and techniques for their core structures, and 20% did not have much or any traditional components or could not be identified during the survey.

Almost 90% of the traditional mud brick structures with load bearing walls that were damaged by the earthquakes suffered catastrophic or substantial damage that required complete demolition (Table 3; Fig. 4). In contrast, 25% of buildings with traditional exteriors over non-traditional steel-reinforced concrete frames, and 20% of RCC structures damaged by the earthquakes, suffered catastrophic or substantial damage. Our data show that the earthquakes caused significant damage to the traditional housing stock that made up a substantial portion of the cultural heritage in all of our case study areas and a high percentage of pre-earthquake houses built with traditional materials and techniques suffered catastrophic damage that required complete demolition and replacement with new structures.

5.2. Changes in housing stock

We collected information from each household about the type of their house before the earthquake and type of the house after reconstruction to analyze changes in house stock that resulted from adhering to building codes, the heritage by-law (for Bungamati), and communal/household preference. We created alluvial plots for each neighborhood to show changes in building types from before the earthquakes to after the reconstruction (Figs. 5–8). Before the earthquakes approximately 70% of the houses that suffered some level of damage across the four neighborhoods were traditional structures made from bricks and mud with load bearing walls, with 9% traditional exterior over steel-reinforced concrete framed structures, and 14% reinforced concrete slab with little to no traditional elements. After the reconstruction, only 8% of the rebuilt houses were traditional mud brick structures with load bearing walls, 38% had some level of traditional exterior elements over a non-traditional frame, and 38% were reinforced concrete slabs with little to no traditional elements. At an aggregate level the data demonstrate a notable reduction of traditional houses which used load bearing walls. This was partially offset by an increase in the number of houses with steel-reinforced concrete frames with some degree of traditional-style Newari brick façades.

We created an alluvial plot comparing the number of stories in each house before the earthquakes and after reconstruction and found a notable overall reduction in the amount of 3 and 4 story homes (which reflect traditional use of space in multi-generational homes) and an increase in the amount of 1 and 2 story homes (Fig. 9). Our interviews suggest that many of the 1 and 2 story houses were built to provide short-term shelter and their inhabitants hope to build additional stories or even new homes when they have the resources to do so. Taken together, this represents a significant transformation in the housing stock away from traditional building techniques and materials and, to a slightly lesser degree, away from traditional aesthetics in these historic urban neighborhoods. There are distinct patterns of changes within the individual neighborhoods.

Bungamati: Approximately 66% of the houses in Bungamati that experienced some level of damage were traditional mud brick with load bearing walls and 8% had reinforced concrete frames with traditional style exterior façades. Only 7% of the rebuilt houses were traditional mud brick with load bearing walls and 56% were reinforced concrete frames with traditional facades (Fig. 5). The rest of the new houses were either reinforced concrete structures with no traditional elements or undetermined at the time of our survey.

Thecho: Approximately 79% of the housing stock in Thecho that was damaged during the earthquakes were either built using traditional methods or contained traditional elements (61% of which were mud brick with load bearing walls and 18% reinforced concrete frame with traditional facade). After the reconstruction, only 32% of the rebuilt houses reflected traditional styles (6% mud brick structures with load bearing walls and 26% reinforced concrete with traditional façade). The amount of reinforced concrete houses with no traditional elements increased from 21% before the earthquakes to 64% after the reconstruction (Fig. 6).

Harisiddhi: Approximately 95% of the housing stock in Harisiddhi damaged by the earthquakes were traditional structures (almost all of which were mud brick structures with load bearing walls). After the reconstruction only approximately 7% of housing stock either used traditional building techniques and/or included some elements of traditional culture (with only 3% mud brick structures) (Fig. 7). Almost all of the post-reconstruction houses in Harisiddhi are made from reinforced concrete slabs and most of

[6] Our analysis is based on official levels of damage recorded by the local governments during the post-disaster damage assessment that was used to determine which households were eligible to receive government funds for re-building. We are confident that the official totals that we correlate with our categories of catastrophic and substantial damage are generally accurate as residents were motivated to ensure they were listed as 'earthquake victims' to received assistance. However, it is likely that official totals of minor damage are under-reported as many houses had superficial damage but there was no benefit to recording it. Therefore, we believe that totals of houses with minor damage represent a low-end estimate.

Fig. 3. Example of historic building in Patan damaged by the earthquakes and supported by wooden braces. (Photo P. Daly).

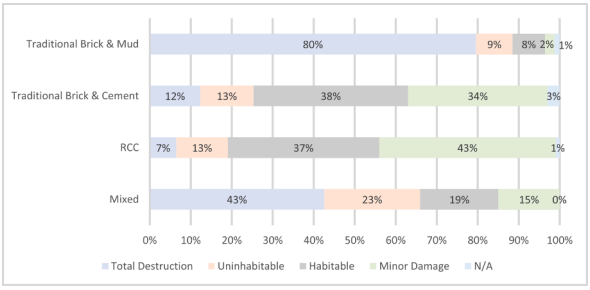

Fig. 4. Extent of damage by pre-earthquake housing type for all houses in all four case study areas by type of house construction (by percent). Counts by case study area shown in Table 3.

these do not contain extensive exterior elements that reflect traditional heritage (89% RCC after the reconstruction as compared with 3% before the earthquake).

Pilachhen: Approximately 74% of the housing stock in Pilachhen damaged by the earthquakes had some traditional aspects (with 58% mud brick with load bearing walls and 16% reinforced concrete with traditional exterior). After the reconstruction, approximately 44% of the housing stock either used traditional building techniques and/or included at least some elements of traditional culture (with 27% mud brick with load bearing walls and 17% reinforced concrete with traditional exterior) (Fig. 8). Fifty-five percent of the rebuilt houses are reinforced concrete without traditional elements (up from 25% before the earthquakes).

5.3. Resident perspectives on preserving heritage

In our survey we asked respondents to rank the importance of the following factors when rebuilding: earthquake safety, cultural heritage preservation, comfort, and commercial utility (using the home for economic purposes such as small-scale production or retail). Seismic safety was overwhelmingly the most important factor for residents in all neighborhoods (Figs. 10–13). This was followed by comfort when considering factors ranked first or second. Bungamati was the only neighborhood where cultural heritage was ranked second. In all of the other neighborhoods, heritage preservation was generally ranked lower than both seismic safety and comfort, but above commercial utility.

We asked residents if they approved of the government building codes and by-laws (Fig. 14). Less than half the residents in Bungamati approved, but with an additional 12% stating they would have approved if the government provided financial support to help them adhere to the by-laws. There were significantly higher levels of approval in the other three areas, with 84% of residents in Thecho, 74% in Pilachhen, and 66% in Harisiddhi agreeing that the building codes and by-laws were appropriate and should be followed. We believe that the lower approval rate in Bungamati reflects the added expense and administrative burdens required by the heritage by-law – as residents in Bungamati were the only ones out of our four case study neighborhoods that were required by community mandate to incorporate heritage components into their houses.

The qualitative data we obtained from our interviews aligned with the results from our quantitative survey but present a more nuanced view on how residents perceived heritage preservation. We found that while safety and comfort were generally their main concerns, many residents expressed some level of interest in retaining aspects of Newari tradition in their post-earthquake houses and neighborhoods and were in theory supportive of some degree of heritage restoration [**SI Appendix 1**]. The most commonly cited reason for restoring heritage, especially in Bungamati, was to attract tourists [**SI Appendix 2**]. There was a general consensus that for Bungamati to recover it is vital to re-energize the tourist sector and the main driver for this is rebuilding the traditional aesthetics of the settlement. On a smaller scale this was mentioned in the other settlements, especially in Pilachhen, which aspired to capitalize on heritage tourism after the reconstruction.

A number of interviewees across the four neighborhoods expressed their preference for traditional Newari houses based upon factors unrelated to tourism [**SI Appendix 1**]. Some respondents cited the value of heritage conservation for cultural identity and cultural continuity. Several respondents said they preferred living in traditional mud brick houses as opposed to the new concrete and

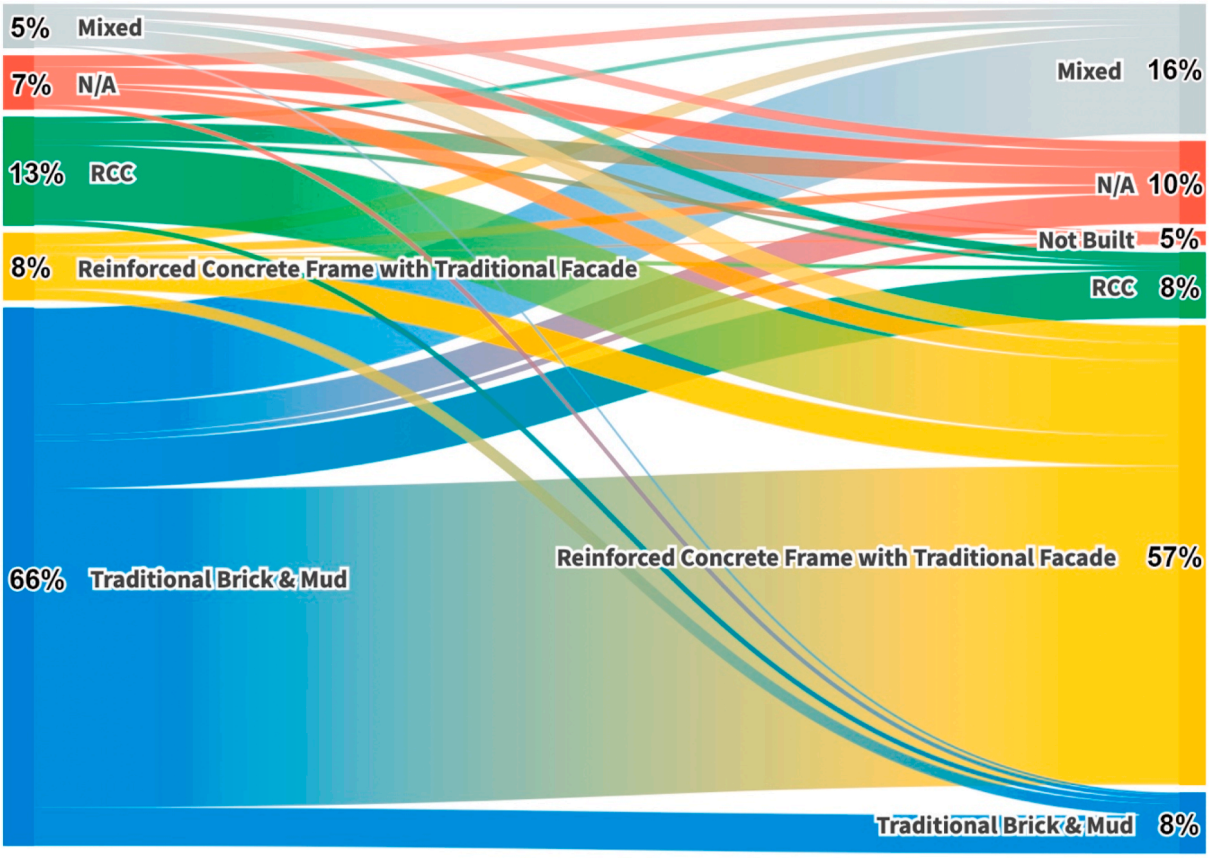

Fig. 5. Alluvial chart of changes of housing type for Bungamati. The left side of the plot shows the pre-earthquake housing composition. The right side of the plot shows how each damaged house was transformed during the reconstruction. Houses were it was not possible to determine the category of house construction were identified as N/A. A small number of houses at not started construction (Not Built) at the time of the survey.

brick houses built after the earthquake because the former provided a more comfortable living environment – cooler in the summer and warmer in the winter. This was especially the case for older residents, some of whom claimed that they felt physically worse in 'modern' housing. A number of respondents complained about the limit on the maximum number of stories they could build. It is common for traditional Newari houses to be between 3 and 5 stories and to include extensive terrace and outdoor space for drying laundry, storing grain, etc., but residents could only legally build 3.5 stories and were not allowed to have as much open roof space as is common in traditional Newar houses [SI Appendix 3]. This divided some large, extended families that lived in the same house before the earthquakes.

A number of respondents told us that it was important (or that they felt social pressure) to have a traditional Newari-style house with elaborate and intricate carvings on doors and window frames because an adjoining house had done so, their house was near a prominent heritage site such as a temple, or their house lined a prominent square or public space [SI Appendix 4]. Several respondents said it was important to have some traditional elements in their post-earthquake houses because of the need to host formal cultural events, and for some families, their future obligations to literally host the local deity in their homes.[7] Out of the households in Harisiddhi which opted for a heritage-based design when rebuilding their homes, most included someone responsible for organizing, conducting, or participating within cultural and religious festivals and/or ritual activities. Such residents felt obliged to have a traditional house that reflected their involvement in traditional cultural practices.

While we found many residents expressed some interest in restoring cultural heritage, most of our respondents told us that it was challenging to incorporate heritage elements into their post-earthquake houses. The main reason was the additional costs [SI Appendix 5]. We received estimates from residents and local contractors that incorporating traditional elements onto the exterior of a house could add up to 30% to the total cost of rebuilding. The materials and configurations specified in the heritage by-law for the Newari outer facades, window frames, and doorways cost more than pre-fabricated aluminum frames with the same functionality. Many residents in Bungamati reported that they would have used non-heritage materials to save money if they could have gotten away with it, even if they preferred the traditional wooden versions.

[7] In some of the Newari settlements there is a tradition that families host the local community deity for one year in their house. The deity, usually in the material form of a statue, must stay within the traditional core of the settlement and the host family is obligated to carry out a range of rituals related to the process.

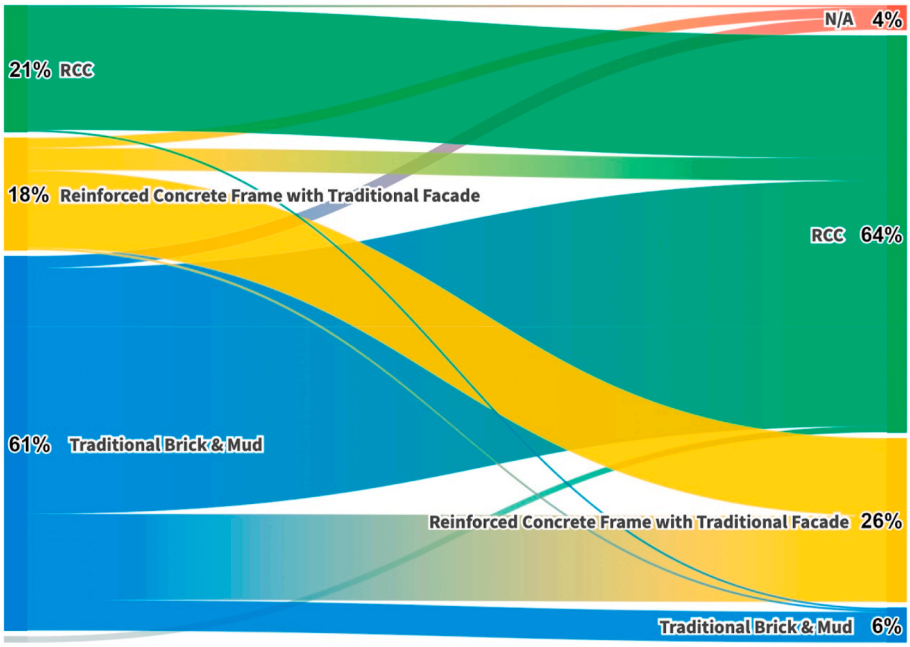

Fig. 6. Alluvial chart of changes of housing type for Thecho. The left side of the plot shows the pre-earthquake housing composition. The right side of the plot shows how each damaged house was transformed during the reconstruction.

Fig. 7. Alluvial chart of changes of housing type for Harisiddhi. The left side of the plot shows the pre-earthquake housing composition. The right side of the plot shows how each damaged house was transformed during the reconstruction.

That is exactly what most of our respondents in the other neighborhoods did where it was up to individual households to decide whether to include heritage components. People acknowledged it would have been nice to have traditional carved wood window frames, doors, and balconies but it was a luxury that they could not afford [SI Appendix 5]. Many of the residents outside of Bungamati opted for non-heritage windows and doors – effectively eliminating two of the most visible markers of traditional Newar architecture. A number of respondents in Bungamati told us that the costs needed to adhere to the heritage by-law was one of the reasons why they had yet to start rebuilding.

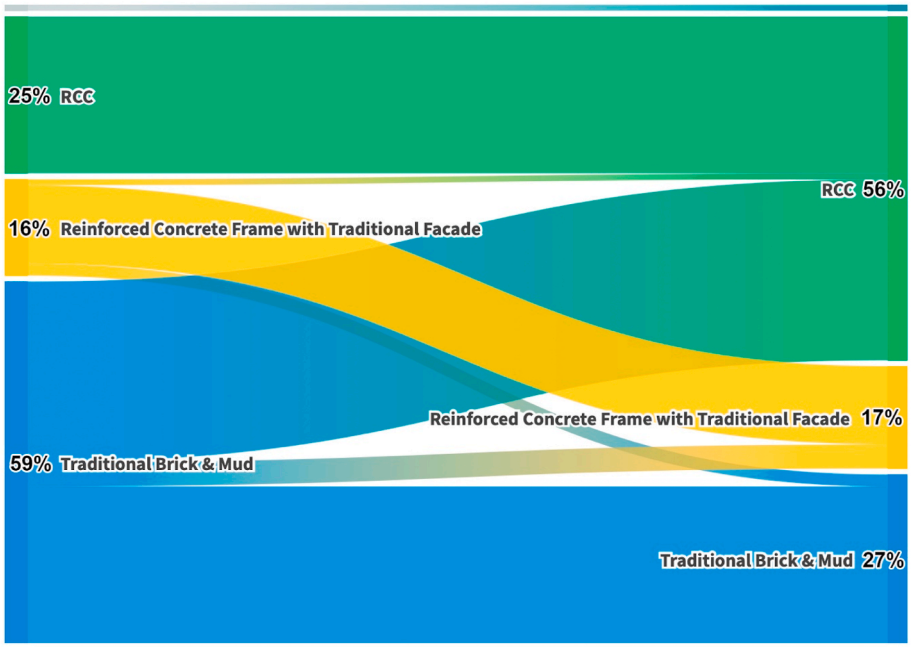

Fig. 8. Alluvial chart of changes of housing type for Pilachhen. The left side of the plot shows the pre-earthquake housing composition. The right side of the plot shows how each damaged house was transformed during the reconstruction.

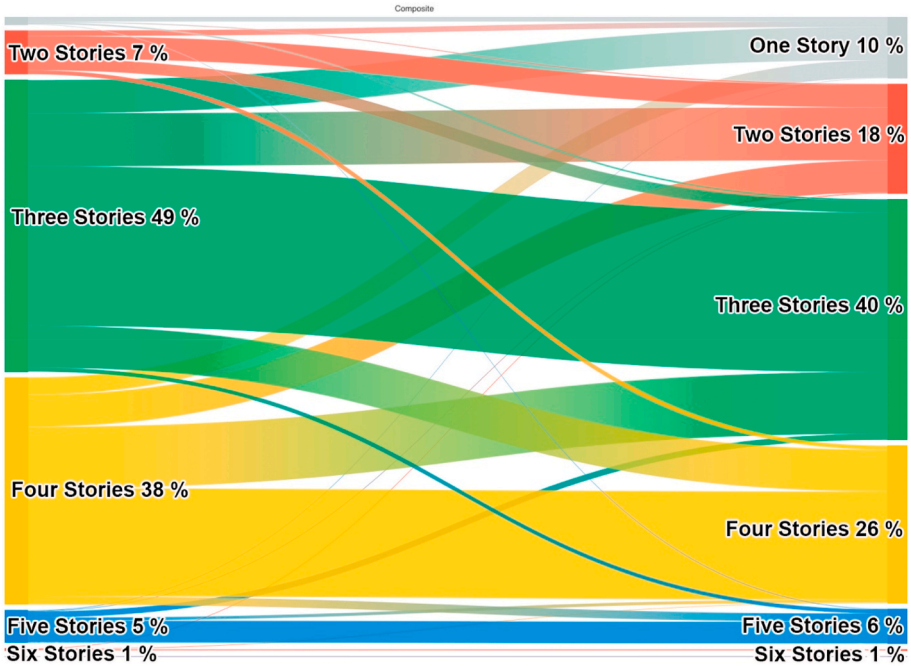

Fig. 9. Alluvial chart showing the changes in the number of floors from the pre-earthquake structure (left side) to the rebuild structure (right side). This figure is a composite showing the total changes for all four settlements.

Many of our respondents in Bungamati complained that the stringent, detailed and highly specific heritage by-law made it difficult to get their building permits approved and added additional burdens to an already complicated approval process [SI Appendix 6]. Some respondents in Bungamati were unaware of the exact heritage specifications because not everyone had access to or a detailed understanding of the provisions of the building codes or the heritage by-law. Somewhat ironically, the regulations on the size and design of window frames and doorways in the heritage by-law prevented some people from reusing the old traditional window frames or doors they salvaged from the ruins of their pre-earthquake homes – resulting in waste, increased cost, and discarding actual relics that

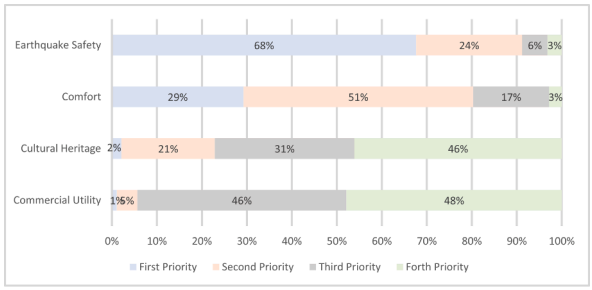

Fig. 10. Resident ranking of how they prioritized safety, heritage preservation, comfort, and commercial utility of post-disaster housing for Thecho (by percent).

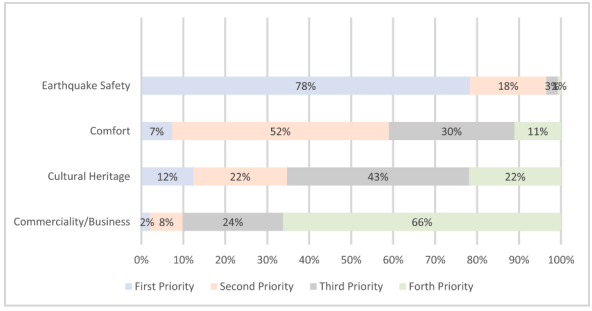

Fig. 11. Resident ranking of how they prioritized safety, heritage preservation, comfort, and commercial utility of post-disaster housing for Bungamati (by percent).

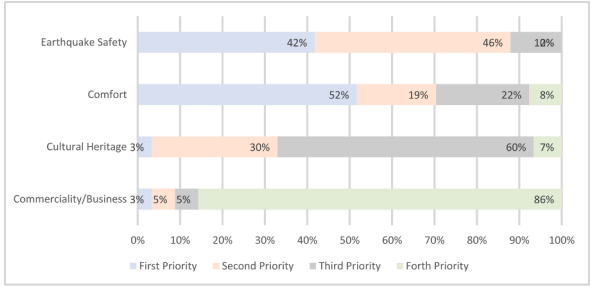

Fig. 12. Resident ranking of how they prioritized safety, heritage preservation, comfort, and commercial utility of post-disaster housing for Pilachhen (by percent).

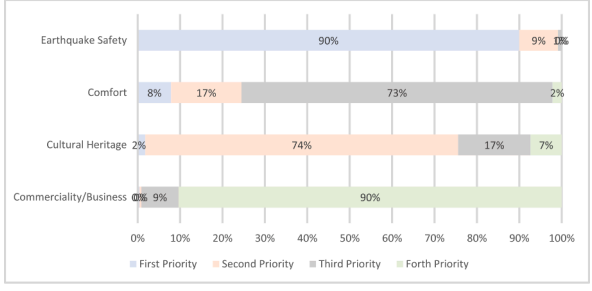

Fig. 13. Resident ranking of how they prioritized safety, heritage preservation, comfort, and commercial utility of post-disaster housing for Harisiddhi (by percent).

arguably contained significant authentic heritage value and direct links to the pre-earthquake aesthetics of the neighborhood [SI Appendix 7]. This is because the heritage by-law had standardized and specific instructions on the number and size of windows, for example, and these standards often did not align with the composition of pre-earthquake traditional structures.

6. Discussion

Our analysis shows that the earthquakes and the reconstruction transformed the architectural heritage of historic urban landscapes within the Kathmandu Valley. While many communal and monumental heritage sites, such as temples, museums, and palaces, have been restored in ways that at least reflect their pre-earthquake exterior aesthetics, a number of factors have led to changes in the

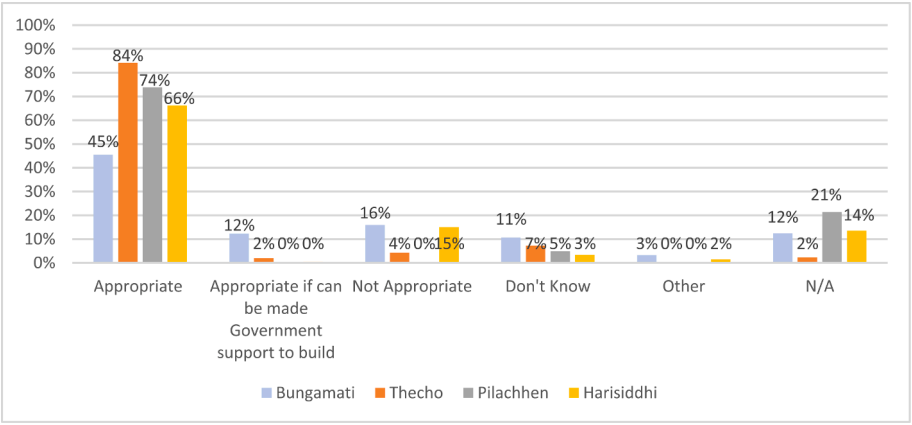

Fig. 14. Resident perceptions on whether the building regulations for their settlement were appropriate.

stock of traditional houses. The seismic safety building codes reduced the construction of multi-story houses using traditional load bearing walls – the most prevalent type of traditional-style house in historic urban neighborhoods before the earthquakes. It is likely that the changes that we see in our study areas occurred to some degree across many of the historic urban areas in Nepal [64]. The limits on building height and regulations about roof types marked a change away from traditional uses of domestic space. A combination of communal agreement in Bungamati and selective resident efforts in the other neighborhoods led to the construction of new types of houses that had 'modern' structural components covered in some degree of traditional decorative features.

However, our findings show that there was a net reduction in even the appearance of Newar tradition in all neighborhoods, with this especially pronounced in the neighborhoods that did not adhere to the heritage by-law. In the other settlements, a number of residents told us that the earthquake and reconstruction caused significant changes to the historic cores. The costs of rebuilding forced many residents to either delay rebuilding, or to sell off ancestral land. It was common for families with land in surrounding agricultural areas to build new and bigger houses there, as their plots in the center of the historic neighborhoods were small and difficult to build on.

We found that many residents in all the neighborhoods saw some value in preserving cultural heritage, but generally prioritized seismic safety (by a considerable margin) and personal comfort over restoring heritage. Attracting tourists was the most common reason people felt it was important to rebuild at least some of the architectural heritage of their neighborhoods, with this especially pronounced in Bungamati. In all of the settlements, practical issues like costs limited the inclusion of traditional elements into post-earthquake houses by households that otherwise might have preferred to include at least some traditional elements in their new houses.

At the start of this paper, we proposed that the potential for heritage to be transformed by a disaster is a function of the extent of damage, decisions made during the planning, and challenges faced by residents during implementation:

Damage: The extent of the physical damage caused by the earthquakes to historic houses led to a major transformation of traditional housing stock. The earthquakes disproportionately impacted old traditional houses that were built with mud brick with load-bearing walls. The majority of traditional structures suffering catastrophic structural damage and therefore needed to be demolished and replaced with new houses. We proposed that the more extensive the damage to cultural heritage, the greater the potential for transformation. In all of our case study neighborhoods this proved correct. For many of the damaged traditional houses, repair was not an option and therefore residents needed to build new houses. Many of the traditional houses that defined the heritage in these historic neighborhoods before the earthquakes were replaced by new structures – a sub-set of which included some traditional decorative features on the exterior of steel-reinforced concrete framed structures.

Several studies have championed the resilience of traditional building techniques and advocated incorporating them within post-earthquake homes in Nepal [10]. These studies note that historic buildings were much more heavily damaged than 'modern' buildings – but argue this was more a function of unregulated vertical construction and poor maintenance than flaws inherent within traditional forms of architecture [1,6]. We appreciate that there are lessons about resilience embedded into the built environment of heritage structures [66]. However, both local residents and stakeholders involved in the reconstruction saw that older traditional buildings were responsible for much of the loss of life and property that occurred during the 2015 earthquakes. This led to the understandable perception amongst many residents that traditional load bearing walls were not likely to be safe from future earthquakes.

Planning: We proposed that planning how to rebuild historic urban neighborhoods would be shaped by how perspectives about heritage preservation, disaster risk reduction, and development/humanitarian concerns were prioritized. We found a curious pattern at both the national and neighborhood level where initial plans acknowledged the value of preserving cultural heritage during the reconstruction and empowering residents to decide how best to rebuild their homes. Three of the neighborhoods focused on the potential economic value of rebuilding in a manner that retained at least some of the traditional heritage aesthetic of the pre-earthquake neighborhoods to support heritage tourism, home-stays, and traditional artisans. These heritage-centric plans were promoted by a range of external stakeholders, such as UN-Habitat.

However, as planning shifted from the rhetorical to operational, the formal guidelines and building codes issued by the Nepal government prioritized seismic safety over heritage preservation. The building codes discouraged traditional multi-story mud brick structures. We found high levels of support from residents for seismic safety, even when it came at the expense of heritage restoration; a sentiment that has been expressed in other historic towns in Nepal [8]. Our interactions with residents and government officials indicate that rebuilding was influenced by the urgency to re-house people as quickly as possible, as safely as possible.

The communal mandate to rebuild according to the heritage by-law in Bungamati led to a much higher percentage of post-reconstruction houses having some traditional components. From a conservation perspective, adherence to the heritage by-law helped Bungamati retain the exterior aesthetics of a heritage town. The post-reconstruction neighborhood looks and feels like a historic urban landscape and it is likely that this will become more pronounced as time goes by and the new structures start to weather and age. However, the requirements in the heritage by-law that all houses conform to very specific standards has reduced the diversity and texture that defined heritage structures in Bungamati before the earthquakes. In the other three communities, the lack of communal agreement and resources left the decision to include traditional elements into their new houses largely to the discretion and means of individual households.

Implementation: While the conceptual plans in three of our neighborhoods aimed for heritage preservation, the actual levels of restoration were dependent upon the commitment of local residents and reconstruction committees and access to resources. The additional costs needed to build Newar façades, balconies, and window/door frames put pressure on the residents in Bungamati who were required to follow the heritage by-law and was the main factor that prevented residents in the other settlements from choosing to incorporate heritage elements into their new houses. There were some issues with obtaining materials,especially timber needed for traditional wood-work because some of the kinds of wood used in traditional houses is difficult to obtain or now are protected resources [67]. Residents in Bungamati had to deal with added layers of administration to get their houses built. Surprisingly, we did not hear from many residents that they were not able to add heritage components because of lack of traditional crafts-persons. This has led to a clear reduction in the stock of traditional houses.

7. Conclusion

The rebuilding of historic urban neighborhoods after the 2015 earthquakes provides useful conceptual and practical insights for understanding the relationships between disasters, risk reduction, and heritage preservation. First, seismic risk reduction was prioritized by the government and local residents more than cultural heritage. We found that disaster risk reduction was viewed from an engineering perspective that valued modern rather than traditional building technologies and materials. In Nepal, the formalizing of disaster risk reduction through building codes was at least partially mutually exclusive with conserving or restoring traditional architectural heritage. Heritage was effectively relegated to decorative components on the exterior of houses. Furthermore, the highly specific prescriptions within the heritage by-laws limited the agency of residents to shape heritage based upon their values and aesthetics. The end result in Bungamati is an essentialized vision of heritage that represents the arbitrary standards produced by an administrative process rather than more diverse and organic textures of pre-earthquake traditional houses. Second, only neighborhoods and individual households with the means to do so and/or ability to mobilize resources were able to rebuild traditional-looking structures. The case in Nepal makes it clear that concerted political will, cohesive resident agreement, and generous external support are needed to carefully restore historic urban neighborhoods damaged by a disaster or conflict. In the absence of all three, heritage preservation becomes a luxury for a relatively small number of affluent or especially motivated households.

It is interesting to note that regardless of the outward aesthetics, all of the traditional-style houses built after the earthquakes are modern buildings. They lack the building technology, materials, interior use of space, and diversity of decorative features common in the pre-earthquake traditional housing stock. Therefore, many of the private heritage sites in Kathmandu's historic urban neighborhoods can no longer be considered cultural heritage if the criteria values material authenticity and temporality. Rather, the heritage value of these sites now comes from their aesthetics and the extent to which the new parts of the built environment facilitate the intangible cultural practices integral to Newar identity. While some might critique the lack of material authenticity, it is too soon to determine how these new ‘heritage’ structures will be perceived by both residents and visitors. As Piazzoni has argued, “rebuilt urban fabrics can respond to people's desires more than scholar may realize” [55]. p. 251).

Kathmandu's historic towns now join the list of heritage sites that have been rebuilt after a disaster or conflict, such as the historic center of Warsaw after the Second World War, the Mostar Bridge, or the Sungnyemun gate in South Korea [68–72]. All of these sites have been discussed extensively in the heritage literature and are recognized as World Heritage Sites by UNESCO in part because their reconstruction is part of their stories of perseverance and resilience. Future monitoring is needed in the historic urban neighborhoods in the Kathmandu Valley to see how the composition, cohesion, and development of these ‘new’ historic neighborhoods is affected by the earthquakes and reconstruction and the earthquakes and reconstruction become part of their heritage.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijdrr.2023.103564.

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