2015 Project for International Contribution to Cultural Heritage Protection

Project for Investigation of Damage Situation of Cultural Heritage in Nepal

Survey of Historic Settlement

June 2016

National Research Institute for Cultural Properties, Tokyo

2015 project for International Contribution to Cultural Heritage Protection

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Preface

This report is the result of an investigation of cultural heritage damage caused by the Gorkha Earthquake on 25 April 2015. The project was commissioned by the Agency for Cultural Affairs and implemented by the National Research Institute for Cultural Properties, Tokyo (NRICPT).

In this project, investigations were conducted from comprehensive viewpoints including architectural history, building structure, urban design, conservation and preservation, and intangible cultural heritage by researchers from Nippon Institute of Technology, the University of Tokyo, Kagawa University, Tokyo Metropolitan University, Tohoku Institute of Technology, and NRICPT, as well as outside experts in cultural heritage conservation.

This volume is the result of surveys conducted in the historic settlement of Khokana that was inscribed on the World Heritage Tentative List.

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1. Outline of Khokana Village and Overview of Damage

1. Outline of Khokana Village and Overview of Damage

This chapter provides an overview of Khokana Village and its current position as a property on the World Heritage Tentative List and the damage from the disaster in Khokana.

1.1. Outline of Khokana Village

1.1.1. Location and administrative districts

Khokana Village is located in the southwestern area of the Kathmandu Valley, approximately six kilometres south of the ancient capital of Patan, in the municipality of Karya Binayak. It is found among the hillocks squeezed between the Bagmati and Nakkhu Rivers. The ridge running from north to south is called Ekantakuna-Tikabhairab Road and Khokana Village covers the area of graded land to the west. As the region's main road, roadside development is being advanced along Ekantakuna-Tikabharaid Road (Fig. 1-1, 2).

Fig. 1-1 Location map of Khokana village (Modified from Google map)

Fig. 1-2 Area map of Khokana village (Modified from Bing map)

Last year, the municipality of Karya Binayak was newly formed from five Village Development Committees (VDC). The Khokana VDC was reorganised into Districts 6, 7, and 8 and 9 of the municipality of Karya Binayak and now continues as an administrative district (Fig. 1-3).

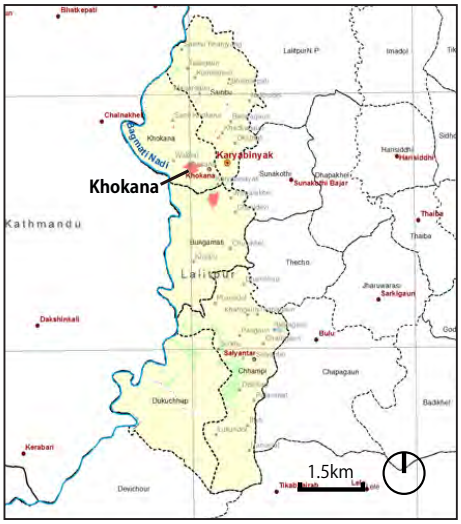

Fig. 1-3 Administrative district of Karya Binayak city[1]

1.1.2. Topographical and geographical features

Khokana Village, which is located in the southwest area of the Kathmandu Valley, previously lay along a former trade route between India and Tibet that flourished during the medieval period and was located in an area through which there was a regular flow of people (Fig. 1-4).

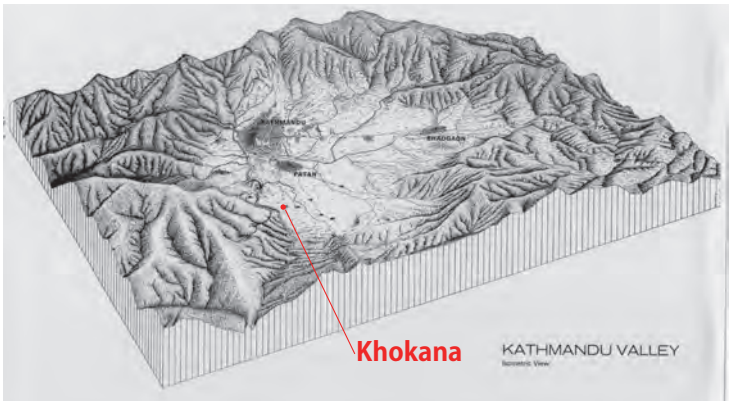

Fig. 1-4 Isometric figure of Kathmandu valley (Quoted from *Kathmandu Valley*) [2]

In Nepal, where the topography differs greatly from the north to the south, it can be observed from past research[3] classifying Nepalese village settlement patterns and vegetation that the Kathmandu Valley is in the 'MAN- MADE TREELESS Zone' (Fig. 1-5), and its settlement pattern is 'Clustered, dispersed, or compact' (Fig. 1-6). Therefore, Khokana Village may be classified as a Nepalese village settlement.

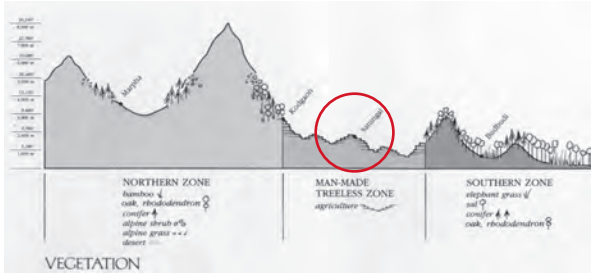

Fig. 1-5 Vegetation classification by geographical features (Quoted from *4 Villages: Architecture in NEPAL*)

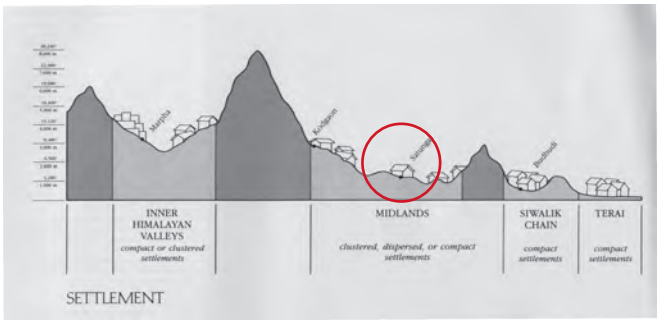

Fig. 1-6 Settlement form classification by geographical feautres (Quoted from *4 Villages: Architecture in NEPAL*)

1.1.3. Population

Based on the 2011 national census, the population of Khokana Village is 4,927[4]. Compared with the 2,546 [5] people recorded in sources from 1969, the population has roughly doubled in the last forty years (Fig. 1-7). Furthermore, data from the time of the 2015 Gorkha earthquake showed the population to be 5,386 [6] ; thus, it may be understood that there has been a trend towards population increase in recent years. We were not able to obtain detailed information by age group.

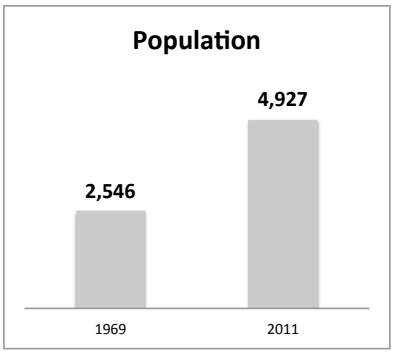

Fig. 1-7 Population trends of Khokana village in recently years

Ninety-seven percent of residents are Newari who engage in agriculture and are called '*Jyapu*'; there are many whose family name is Dangol or Maharjan [7] .

1.1.4. Overview of damage from the April 2015 earthquake and recovery efforts

In Khokana, nine people were killed and twenty-eight wounded (Source: note 6) by the 2015 Gorkha earthquake, which also caused extensive damage to traditional buildings that will be detailed later.

After the earthquake, the Khokana Reconstruction and Rehabilitation Committee (hereafter 'the Committee') comprising politicians, people with academic experience, local NGOs, and others was formed in the village. The Committee is an action organisation promoting self-governing recovery efforts, such as removing rubble and cleaning up, dismantling crumbled buildings, and also writing the proposed future recovery plan[8] . At the time of a November 2015 survey regarding, in part, conditions within the village, the public spaces had been cleaned and several buildings that had been either completely or partially destroyed had been taken down; however, in popularly inhabited areas, the removal of rubble and reconstruction projects have still not yet advanced. Amongst the residents affected by the earthquake, there are people living dual lives, sleeping in temporary residences around the outskirts of the village and returning to their partially destroyed homes during the day.

1.2. Khokana Village as an Item on World Heritage Tentative List

1.2.1. World Heritage Site Kathmandu Valley and items on the Tentative List

Nepal ratified the World Heritage Convention in 1978; the Kathmandu Valley was inscribed on the list of World Heritage Sites the following year. At the present time as at date of report, Nepal has two natural heritage and two cultural heritage sites listed as World Heritage sites and fifteen further sites on the tentative list.

The Kathmandu Valley, which has a total of seven World Heritage properties, including three royal palaces and four religious facilities, became Nepal's first World Heritage site in 1979. Moreover, in the valley, the following four properties are also on the tentative list [9] (Fig. 1-8):

- The early medieval architectural complex of Panauti (1996)
- Khokana, the vernacular village and its mustard-oil seed industrial heritage (1996)
- Vajrayogini and early settlement of sankhu (2008)
- Medieval Settlement of Kirtipur (2008)

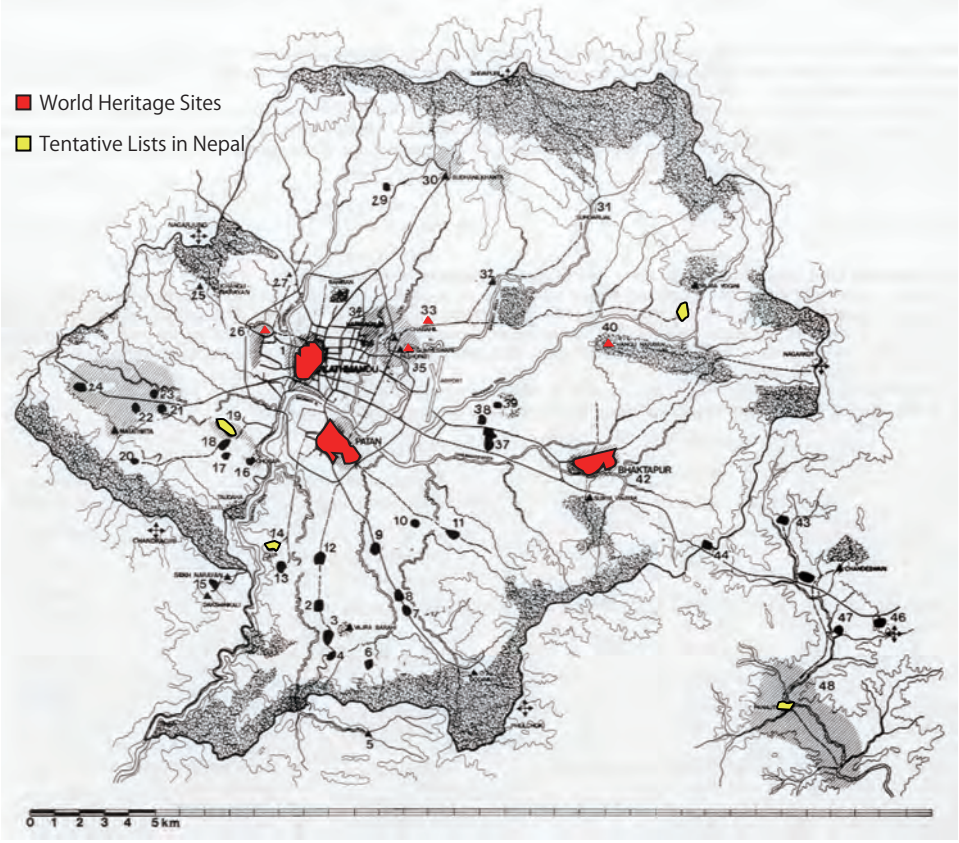

Fig. 1-8 Properties of World Heritage Site of Kathmandu Valley, and on the Tentative List (Modified from the map based on *Newar Towns and Buildings* [10] ; Khokana village is located at No.14 in the map.

1.2.2. Khokana village listed on the Tentative List

Khokana Village was listed on the World Heritage Tentative List in 1996 as “Khokana, the Vernacular Village and its Mustard-Oil Seed Industrial Heritage.” [11]

- Criteria: (i)(iii)(iv)(v)
- Description: Khokana is a unique village which can be taken as a model of a medieval settlement pattern with a system of drainage and chowks. It houses chaityas and a Mother Goddess temple. The mustard-oil seed industry has become the living heritage of the village.

Given the fact that this listing occurred during a comparatively early stage, it cannot be said that registration standards and evaluation of value were carried out sufficiently, but it was positively evaluated for (1)being a representative village formed during the medieval period, (2)being a village having religious temples, and (3) its traditional method of mustard-oil squeezing that is unique to this land.

1.2.3. Nepalese legislation concerning Cultural Heritage Protection

Cultural Heritage preservation in Nepal is managed by the Department of Archaeology under the Ministry of Culture, Tourism and Civil Aviation pursuant to the Ancient Monument Preservation Act, 2013. Considering the tangible cultural heritage related to this research, temples, commemorative buildings and popular residences that have a history of 100 years or longer are defined as ‘Ancient Monuments’ and places where the ‘Ancient Monuments’ are situated are defined as ‘Preserved Monument Areas.’ The properties that comprise the Kathmandu Valley World Heritage Site are protected by these mechanisms.

However, the historical settlements registered in the Tentative List are not covered by the above protections. Ironically, the damage caused to this medieval settlement landscape by the recent earthquake has become the impetus for Nepal’s cultural administration to define these medieval settlement landscapes for the first time as “Historical Settlements” and to establish guidelines for their recovery [12] .

Chapter author: Tomoko Mori

Notes:

Note 1. http://lgcdp.gov.np/phase1/home/map_newmunicipality.php (accessed 2016-02-21)
Note 2. Carl Pruscha, et al.: *Kathmandu Valley vol.1,* Anton schroll & Co.,1975
Note 3. Katherine D.Blair: *4 villages: Architecture in NEPAL*,Craft & Folk Art Museum, 1983
Note 4. Government of Nepal :National Population and Housing Census 2011 (Village Development Committee/Municipality), p.40, 2012
Note 5. Government of Nepal :The physical development plan for the Kathmandu Valley, p.64, 1969
Note 6. Source Email correspondent (Nabin Dagol) (2015-10-02) See data on the population and victims in Khokana vilalge
Note 7. Shovana Bajracharya et al.: KOKANA NI KURASU (Living in Khokana) only in Japanese, P26, Mukudori Shobou, 2008, 11
Note 8. We got Khokana proposal 3rd draft from Nabin Dangol 2015-10-02
Note 9. http://whc.unesco.org/en/statesparties/np (accessed 2016-02-03)
Note 10. Niels Gutschow: *Newar Towns and Buildings*, VGH Wissenschaftsverlag , 1987
Note 11. http://whc.unesco.org/en/tentativelists/844/ accessed 2016-02-03)
Note 12. "Conservation Guidelines for Post-2015 Earthquake Rehabilitation" currently being prepared by UNESCO Office in Kathmandu Domestic Consultant Kai Weise. However, we have learned that these guidelines were a seminar invited by the Archaeological Bureau and the UNESCO Office in Kathmandu, and have not yet been made the official guidelines of the Nepal government.

2. Village Space and Survey of Damage

2. Village Space and Survey of Damage

This chapter describes the spatial analysis and damage condition of Khokana Village.

2.1. Spatial Analysis of Region and Village

2.1.1. Territory and two settlements

The territory of Khokana Village roughly overlaps with the territory of the former Khokana VDC. Its boundaries are fundamentally water boundaries; it is divided from the surrounding region by the Bagmati River to the west, an irrigation canal to the east, and a mountain stream to the south. Because it escapes the erosion from the roadside housing development along the main ridge road (Ekantakuna-Tikabhairab Road), Khokana Village's residents continue their historical way of life and use of the land (Fig. 2-1-1).

The village settlement is divided into the two areas of north and south. The south comprises the former Districts 1-8 (hereafter, 'the Southern Settlement Area'). while the north is the former District 9 (hereafter 'the Northern Settlement Area')[1], with populations of 5,132 and 236 respectively[2]. Over 90% of Khokana's residents live in the Southern Settlement Area, which has a dominant presence.

Fig. 2-1-1 Area map of Khokana village (From Bing map , modified by the author)

2.1.2. Cultural landscape

The majority of Khokana residents belong to the farming caste and make their living through farming. The two settlement regions are set among hillocks and the topography gently inclines in a cone shape towards the Bagmati River, with terraced paddy fields forming a beautiful landscape. The highly douse settlement is built on, which are disadvantageous for a water environment; they buit highly dense settlement and the conic topography is used almost entirely as farmland (Fig. 2-1-2). Double-cropping is practiced there for rice planting and wheat, potatoes, and brown mustard. The 1977 survey report calls the terraced paddy field landscape that spreads from the Southern Settlement Region to the north the 'amphitheater', recording that it is an important element of the Kathmandu Valley cultural tourism[3] . These terraced paddy fields of Khokana Village are a cultural landscape defined as a 'combined work of nature and man'[4] .

Furthermore, the temple at the centre of the settlement and the Shikari temple on its western edge are important ritual spaces, and rituals are traditionally performed along a fixed route from the settlement. There is a crematorium on the Bagmati riverside and ashes are released into the river after cremation. The route for funerals is well-established, and particularly in the South Settlement Area, which has three

Fig. 2-1-2 Cultural landscape of Khokana village (Taken by author on 5 Dec. 2015)

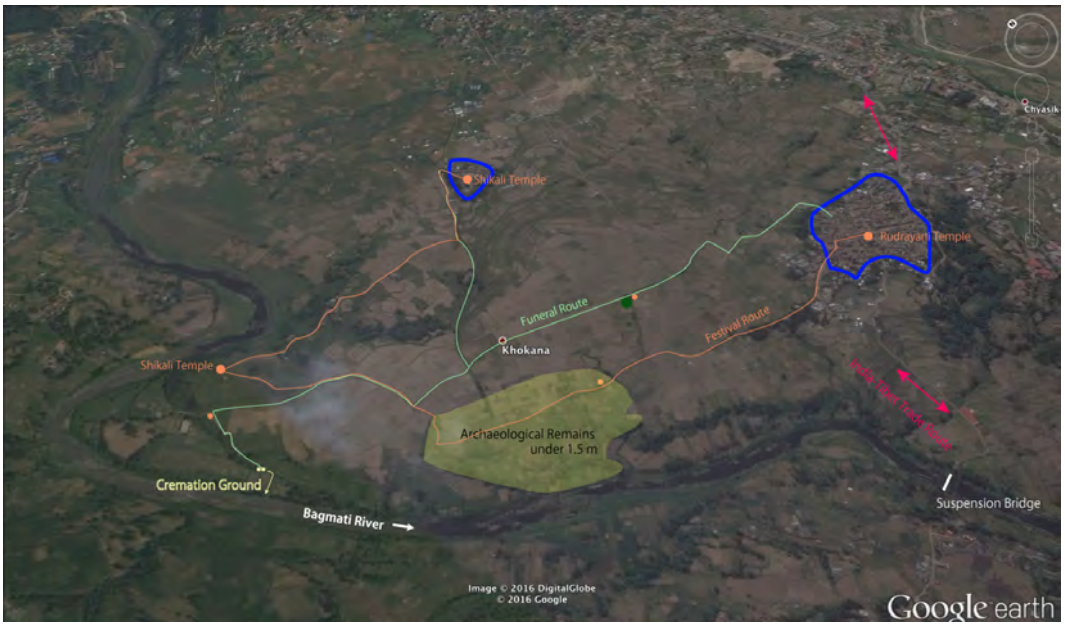

Fig. 2-1-3 Territory of Khokana village main temples main route etc. (From Google Earth modified by the author)

entrances, the routes and entrances are divided into outward and return journeys. In the northwest, there exist burial remains that are thought to be the ruins of a village. The artefacts in the ground make it unsuitable as cultivated land, so it remains wilderness; however, there are stone places of worship and stone statues interspersed across the land, so it is an important religious space. It has already been noted that Khokana Village lay on the medieval Indian-Tibetan trade route; it is also believed that this route ascended from India to the Bagmati River, entered the Southern Settlement Area, passed along the ridge road, and headed towards Patan (Fig. 2-1-3).

At present, several houses have been established on the new residential land along the farm road, and a steel tower runs across the terraced paddy fields. This terraced paddy field landscape, which was once called an 'amphitheater', is undergoing a process of unfortunate changes.

2.1.3. Water source (Rajkulo)

The water source for the village's paddy fields lies approximately eight kilometres south of the village and is said to be a tributary of the Rajkulo (meaning 'King's canal') built by the Malla Kings during the medieval period[5] , but we have not conducted a detailed investigation during this research period.

Fig. 2-1-4 Rajkulo to the Patan palace (Quoted from Nepali Times , modified by the author)

The Rajkulo is an irrigation system supplying water to watering places and ponds of the three royal palaces of Kathmandu, irrigating water between them; it existed as an irrigation canal circulating water throughout the Kathmandu Valley. However, there are no records of who commissioned the construction of the Rajkulo; with few sources existing following rapid urbanisation, the whole story has not been made clear [6] .

Fig. 2-1-4 [7] illustrates the Rajkulo route to the Patan palace. While it is limited to the periphery of the city, part of the Rajkulo still exists and, with the support of the Indian government, an NGO[8] had carried out the first stage of a restoration project by 2009, reconstructing it as far as Teku, five kilometres from the royal palace. When it is completed, it will be possible to supply water to 40,000 people and 450 hectares of farm land. However, the article detailing these figures also records that the project is at an impasse due to insufficient funding, though we have not been able to confirm the latest developments regarding this project.

Further understanding and reconstructing the Rajkulo is not only a measure to solve the urban

sector issues of Kathmandu, which suffers from water shortages, but should also be re-evaluated culturally as an important system supporting the prosperity and life culture of the Kathmandu Valley. We wish to make collecting information about the Rajkulo and the understanding of its current state an issue for the future.

2.1.4. Irrigation system

Regarding water derived from a water source, we surveyed the irrigation system in Khokana Village[9] . The majority of the main canal, which is called a tributary of the Rajkulo, is maintained as a concrete canal and exists as a boundary of the Khokana Village territory. At present, large-scale residential land development is progressing on the graded land from above this main canal to the mountain ridge road. As the water environment of the land at the top of the irrigation canal, just outside the territory of Khokana Village, is disadvantageous for farm land, it was inevitable that it would be converted into residential land following urbanisation.

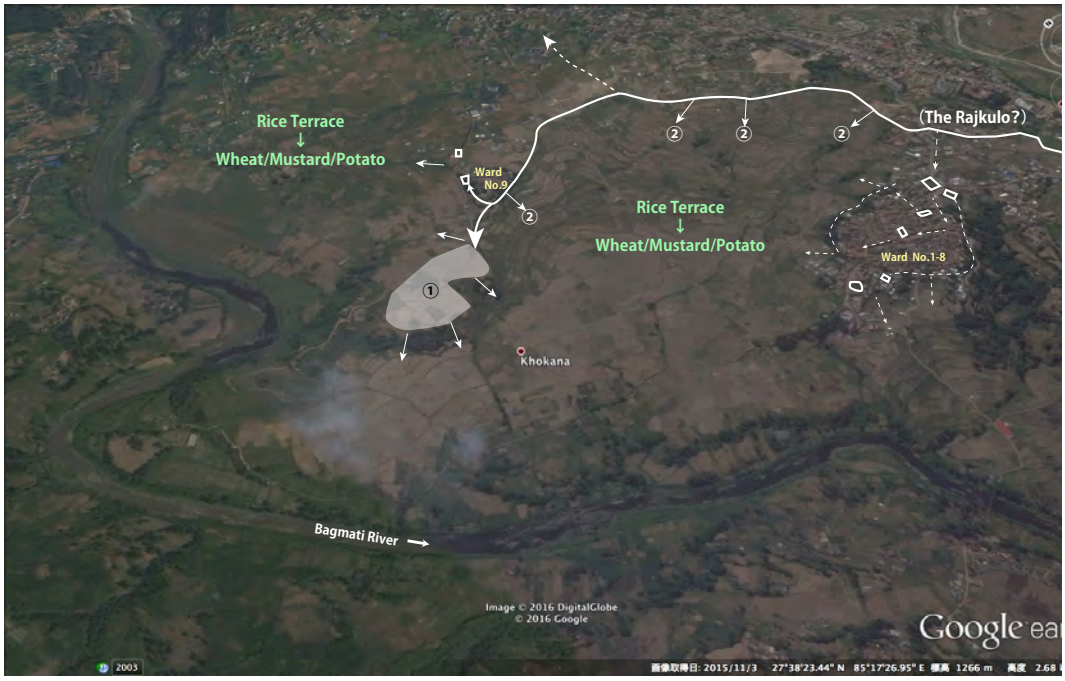

Fig. 2-1-5 Territory of Khokana village : Irrigation system (From Google Earth, modified by the author)

The main canal supplies water through the tributary, which has been skilfully designed to use the natural slope of the conic topography toward the river and the natural depression of the land to reach the terraced paddy fields spread below. Towards the terraced paddy fields lying even further to the north of the slightly elevated Northern Settlement Area, the canal bifurcates and distributes water to each settlement area. The tip of the ridge (① in Fig. 2-1-5) has the function of a water intake facility. When watering the fields before rice planting, the water gate is first opened for four days and nights and water running through the main canal accumulates here. When water volume reaches capacity, it is released all at once, managed by the village residents. Biannually, before and after rice planting, the sections to be managed by the Northern and Southern Settlement Areas are decided, bottom dredging is conducted collaboratively for one week.

The two residential settlements on elevated ground also draw in water bifurcated by the main canal, which flows through the reservoir. In the Southern Settlement Area, sophisticated knowledge and technology is employed to use the elevation differences within the settlement areas, construct reservoirs at key points to distribute water throughout the settlement through culverts, and establish canals around the perimeter of the settlement area to release water into the terraced paddy fields spread below.

It is clear from the above that, similar to the Rajkulo irrigation system in the Kathmandu Valley, there is also a sophisticated irrigation system inside the territory of the village.

Section author : Tomoko Mori

Notes:

Note 1. See 1.1.1.
Note 2. Source Email correspondent (Nabin Dangol) (2015-10-02) See data on earthquake dead for April 25 2015
Note 3. UNESCO, UNDP: Master plan for the conservation of the cultural heritage in the Kathmandu Valley, 1977.3
Note 4. UNESCO, World Heritage Center: The Operational Guidelines for the Implementation of the World Heritage Convention, 2008
Note 5. Source Email Correspondent (Nabin Dangol) We received the “Khokana proposal 3rd draft” (2015-10-02)
Note 6. Kapil Bright: Renovating Kathmandu’s ancient canals, ECS Nepal, 2011.7
Note 7. Mallika Aryal: Reviving Patan’s rovyal canal, Nepali Times, No. 273, 2005.11
Note 8. Environment and Heritage Conservation Nepal (EHCN)
Note 9. On December 5, 2015, we conducted an onsite survey with the help of three guides Nabin Dangol, Jeevan Dangol and Buddhi K. Dangol from the village and also conducted a hearing survey.

2.2. Spatial Analysis of the Southern Settlement Area

2.2.1. Overview of the southern settlement area

As detailed above, the Southern Settlement Area is the centre of Khokana Village. To the east, Khokana Road is a branch road of the Ekantakuna-Tikabharaib Road and as a main connecting road to the village, it is kept in good repair. The bus towards Kathmandu City stops on Khokana Road, and the road heading southeast continues on to Bungamati Village (Fig. 2-2-1). The west side of the settlement lies on a trade route headed towards the Bagmati River. Along the river, there are suspension bridges for pedestrians, but it is impossible for automobiles to cross. Inside the settlement area, there are sizable vehicles, but they are few in number, with many motorbikes moving unpredictably around the streets.

In the settlement area, the remains of three gates (*Dhoka*) serve as entrances. At present, the dhoka near the bus stop towards the east is the main entrance to Khokana; sited there is a restaurant establishment on the first floor of a modern building, and the area is crowded with people coming and going. The north dhoka connects to the route for funerals and the west dhoka leads into the route for ritual processions.

The Rudrayanee (Rudrayani) Temple soars above the centre of the settlement area. An example of Nepalese architecture, it is a three-story Hindu temple that forms a central ritual space of the village, together with the adjacent pagoda, pond, watering place (*Hiti*) and rest place (*Pati*), and the Kwoe Lachhi Chowk down towards the west. The street running east to west is the central axis joining these two points. In comparative terms, there are many traditional Newar-style dwellings nearby that, together with the Rudrayanee Temple, convey the visage of the medieval period. However, intermittently, one can see the modernisation in building styles and overbuilding.

Fig. 2-2-1 The southern settlement area of Khokana village (From Bing map, modified by the author)

2.2.2. Roads

The Table in Fig. 2-2-2 (Right side) indicate the actual measurements of the road width. That the east-west axis (hereafter, the Main street) is the main street in the settlement area can be seen from its width. The main roads (marked red on the map) are all connected inside the settlement area, and the three entrances are located on branch roads breaking off in a key shape from the Main street. Alongside the roads paved with brick and stone, connected houses form the townscape. The boundary between the public space of the roads and private land is clearly marked by the pavement, and it can be inferred from facts such as the presence of a uniform building line (the so-called 'setback': Fig. 2-2-3) that there are unwritten laws concerning architecture in the settlement area. As noted above, the irrigation system relies on roads and culverts; it can also be seen that a planned division of street blocks has been implemented. Since the earthquake, the roads have been clogged with support materials to prevent buildings from collapsing, and there are, consequently, areas through where automobiles cannot pass (Fig. 2-2-4).

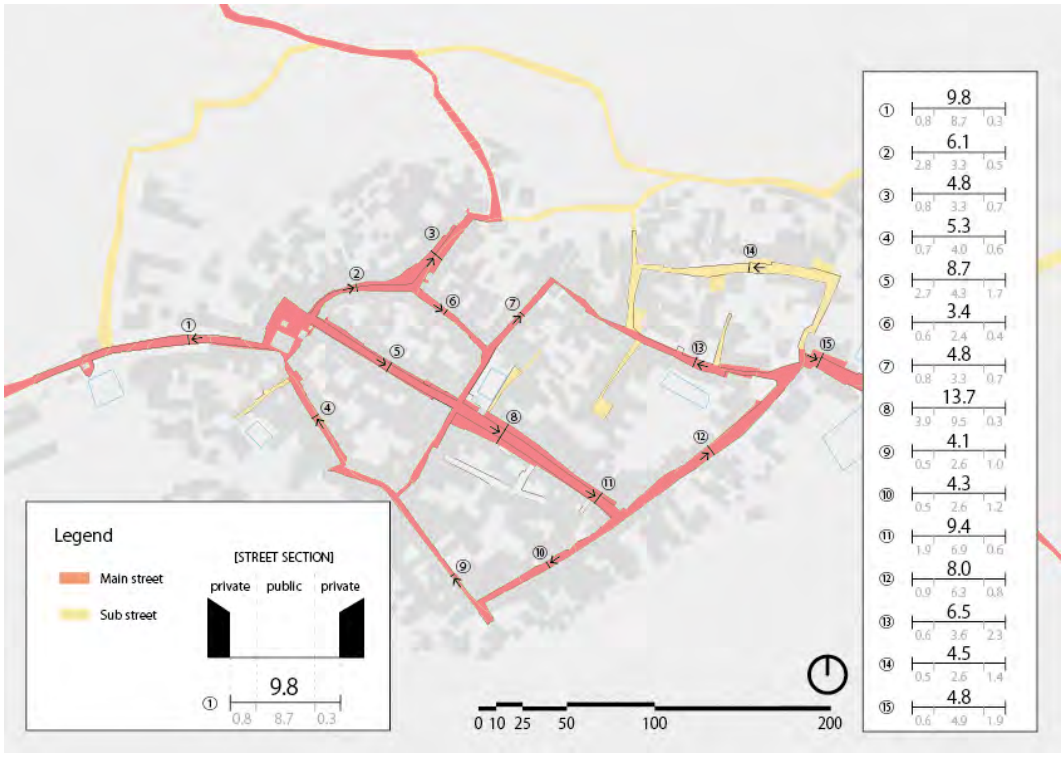

Fig. 2-2-2 Streets and its width in the southern settlement area

Fig. 2-2-3 Main street that connects Rudrayanee Temple and Kwoe Lachhi Chowk

Fig. 2-2-4 Photo from the infront of Rudrayanee Temple

2.2.3. Plaza

The plaza combines a small shrine, a well, a rest space, and a watering space with the space of the road. Here one can find various life activities, such as prayers, farm work, laundry, and daily conversation, in addition to courtyards that have now been turned into rubble storage spaces (Fig.s 2-2-7, 8, and 9). At a festival held during the survey (November 25: Full Moon), a divinity was taken out from the Rudrayanee Temple down the main avenue; the festival was held with Kwoe Lachhi Chowk, featuring a musical band marching through the settlement area (Fig. 2-2-6).

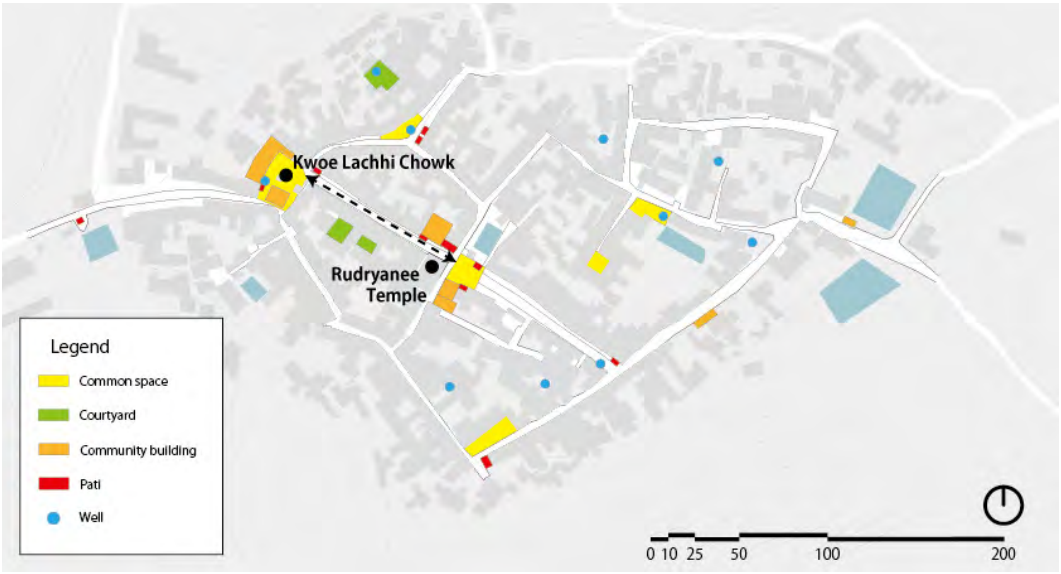

Fig. 2-2-5 Open spaces in the southern settlement area

Fig. 2-2-6 Kwoe Lachhi Chowk at the festival (Taken on 25 Nov. 2015)

Fig. 2-2-7 Washing aside of the well (Taken on 23 Nov. 2015)

Fig. 2-2-8 Sun drying (Taken in Nov. 2015)

Fig. 2-2-9 Remains of debris from the earthquake at a courtyard (Taken in Nov. 2015)

2.2.4. Religious space

As one of the features of Khokana Village listed on the World Heritage Site Tentative List is the fact that it enshrines both Chaitya (Buddhism) and the goddess Rudrayani (Hindu) (Fig. 2-2-10). There are enshrined gods and pagodas everywhere (Fig. 2-2-11). Gods are also enshrined (Fig. 2-2-13) in the remaining space, and their number is uncountable. There was earthquake damage to the village's religious architecture. The small shrine at Kwoe Lacchi Chowk was rebuilt before the autumn festival with donations from and the cooperation of the residents (Fig. 2-2-12). It is understood that the Rudrayanee Temple is scheduled for repairs by the Department of Archaeology.

Fig. 2-2-10 Chaitya and Rudrayanee Temple (Taken in Nov. 2015)

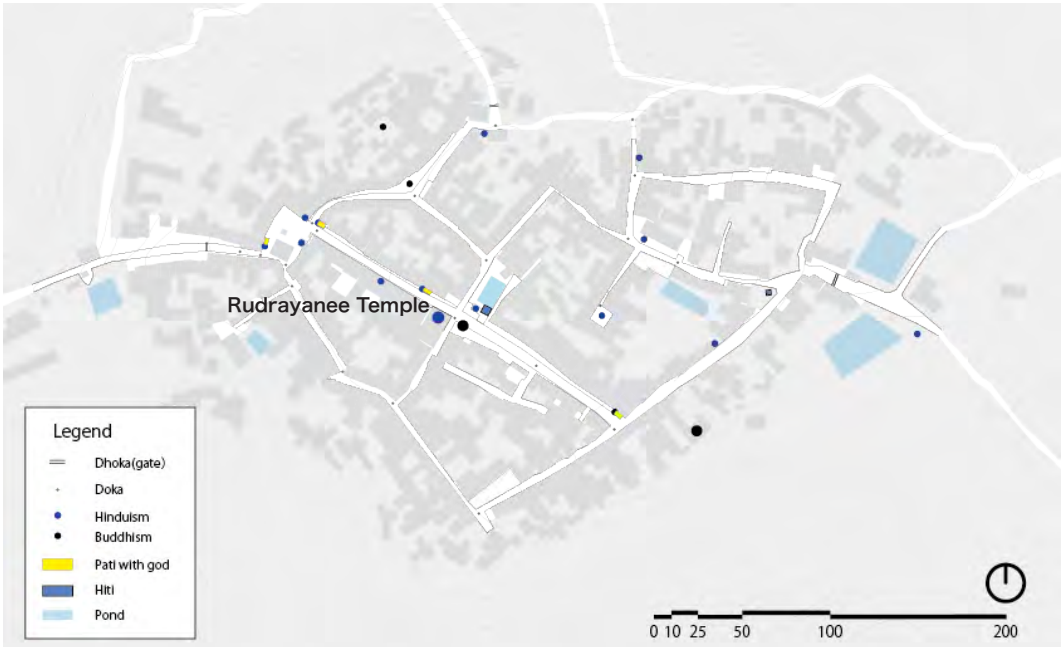

Fig. 2-2-11 Religious spaces in the southern settlement area

Fig. 2-2-12 Rebuilt small shrine (Taken in Nov. 2015)

Fig. 2-2-13 Pati hosting a god statue (Taken in Nov. 2015)

Belief pervades the villagers' daily lives. Every morning, there are people who purify their houses and purify the road nodes, called *Doka*; in the evenings, you can occasionally hear the performances of music bands. It may thus be said that the entire village is a religious space.

2.2.5. Overview of changes

Among the drawings of the settlement area obtained during this survey is one source[1] (Fig. 2-2-14) that was printed in 1969. In this research, we attempted to use this source to compare its details with the present situation (Fig. 2-2-15) to apprehend the changes in the settlement area. As outlined above, recent years have seen the population increase to approximately double its 1969 size. When comparing this drawing with the present situation, the expansion of the settlement area is clear. We were able to confirm three main trends to this expansion:

(A) new residential development on the settlement peripheries;
(B) extensions inside the residential block; and
(C) extensions to the settlement perimeter.

Subsequently, to confirm the changes in the neighbourhood's landscape, we compared a photograph[2] from the 1970s (Fig. 2-2-16) to the present conditions (Fig. 2-2-17). In the photograph from the 1970s, the Rudrayanee Temple soars in the centre and the traditional tiled-roof houses ranged and formed streets. Today, modernised buildings feature prominently and there are newer buildings whose heights rival that of the Rudrayanee Temple. It is apparent that, during the 1970s, there was a plantation in the courtyard space inside the residential block. It may be surmised that, unlike the current trend towards overbuilding, there were once courtyard spaces with access to sunlight. In addition to modernisation and overbuilding, the recent earthquake has complicated issues in the village.

Section author : Tomoko Mori

Notes:

Note 1. Goverment of Nepal: *The physical development plan for the Kathmandu Valley*, 1969
Note 2. Gutschow Neils: *Architecture of the Newars, A history of building typologies and details in Nepal, documentation drawings by Bijay Basukala, Vol.1, the early periods*, Serindia Publications, 2011

Fig. 2-2-14 The southern settlement area in 1969 (From Note. 1)

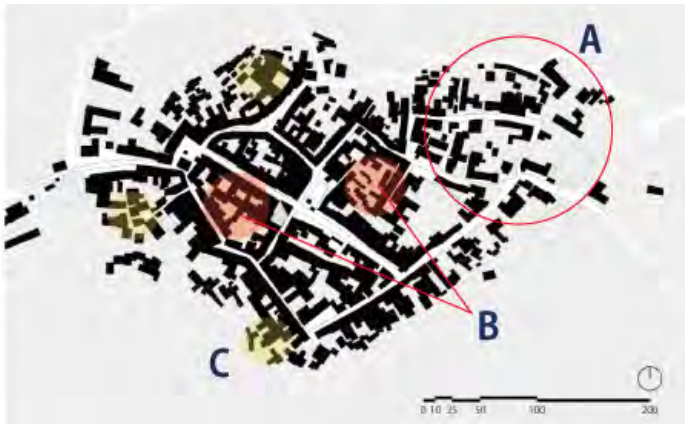

Fig. 2-2-15 The southern settlement area in 2015

Fig. 2-2-16 Aerial Photo of southern settlement area in 1973 (From Note. 2)

Fig. 2-2-17 Photo from North-west of Rudrayanee (Taken on 6 Dec. 2015)

2.3. The Mustard Oil Industry in Khokana

2.3.1. Overview of the survey of mustard oil

Unless otherwise noted, the contents of this section are based on interview surveys conducted with two managers of mustard oil mills in November 2015[1]. As these were limited interview surveys conducted with two individuals through interpreters, it is necessary to corroborate them with documentary records in the future.

2.3.2. Mustard oil in the Kathmandu Valley

Mustard oil is a cooking oil for daily use not just in Nepal, but also in northern India and Bangladesh. It is manufactured by heating and pressing leaf mustard seeds and is also used for massaging small children, applied to the skin and scalp to prevent dryness, and for religious ceremonies[2]; it thus may be called a product that is intimately connected to life.

Khokana is well known as a producer of mustard oil. On the World Heritage Site Tentative List, it is designated by the title 'Khokana, the vernacular village and its mustard-oil seed industrial heritage'. The description of the value of mustard oil highlights that 'It houses chaityas and a Mother Goddess temple. The mustard-oil seed industry has become the living heritage of the village'[3].

The farming villages of the Kathmandu Valley and particularly the peripheries of Khokana have long cultivated leaf mustard in addition to rice, and mustard oil manufacturing has traditionally been performed in each farming family household. Because, in comparison with transporting the seeds that are the raw material for this product, mustard oil is comparatively light and high in value, there have been periods during which it was used to pay taxes to the ruling lords of the Kathmandu Valley.

2.3.3. The history of mustard oil production in Khokana

The village of Khokana established its policy of intensifying mustard oil manufacturing as its main industry during the agricultural off season, when there is less farm work to do, approximately 400-500 years ago. In terms of individual endeavours, commonly owned mills with equipment were established and mustard oil manufacturing was started. With each stock having the value of 50 pice, by issuing approximately 150 stocks per mill (for example, Gabu mill had 142 stocks, while Nhu mill had 152 stocks) and raising funds, a mill building and instruments for heating and pressing were established.

In terms of the whole village, there were at one stage at least four mustard oil mills. The exact period in which these mills were established is unclear, but according to the interview surveys, Gabu mill is the oldest, with Kutu and Nhyabu mills being constructed later, and Nhu mill is the newest.

Before the mustard oil mills were established, each family used the leaf mustard seeds produced on farmland around the perimeter of the village as raw materials. However, with the establishment of the mills and the improved efficiency of pressing work, production quantity increased and the raw materials

produced on farmland around the perimeter of the village were no longer sufficient for its residents' needs. Consequently, people in the village began to collect leaf mustard seeds from the entire Kathmandu Valley. We were told that barter exchange was sometimes used to obtain raw materials by carrying the Khokana mustard oil to faraway villages a 2-3-day walk away. At that time, leaf mustard was widely cultivated in the Kathmandu Valley, together with rice growing; however, because Khokana intensified and increased the efficiency of mustard oil production through mills, it became widely known as a producing area for mustard oil.

At the time the mills were established, rules concerning their use were created and investors held the rights to alternate in using them. Consequently, each farming household used the mill system by collaborating with relatives and acquaintances, using the mills to squeeze the seeds they had produced on their own, distributing them as mustard oil to collaborators, and each of them taking the mustard oil home with them. Nowadays, squeezers that can be operated by just one person have been introduced, but at the time the mills were created, human weight was used to squeeze oil from the seeds, a job that we were told required 15-16 people; working as a community comprising mainly family and relatives was the general rule. It is unclear whether investors and the groups that performed the pressing work were related to each other through geographical ties in the village.

2.3.4. The location and history of each mill

As detailed above, at least four mustard oil mills of a relatively large scale were constructed in Khokana and used by investors. The location of each mill is illustrated in Figure 1. According to our interview surveys, the ages of the mills in descending order are as follows:

- the mill at the village entrance is the oldest (the main users are the residents of Districts 2 and 3);
- it is followed by the mill within the Main street (part of District 5 and Districts 7 and 8), and the mill to the north of the village (District 1 and part of District 5) as third oldest; and
- finally, the mill that we interviewed is the youngest (Districts 4 and 6).

The mills are positioned along paths that enter the village from outside. Mustard oil squeezing requires many people and we were told that because there were many people at the mill during the evening, placing mills at the village entrance was also for security purposes. We also heard the opinion that because mustard oil produces a distinct smell when it is heated, the mill had to be located at the edge of the village.

2.3.5. The decline and revival of the mustard oil industry

Partly because mustard oil requires considerable work to extract, when cheap vegetable oil came to be imported from countries such as India, Khokana's mustard oil industry severely declined. Around thirty years ago, Khokana's mustard oil mills closed and its buildings were left to stand empty. To raise the mills' efficiency, equipment improvement and, in particular, the purchase of a presser was necessary. However, because each mill had many investors, decision-making for new investments proved to be

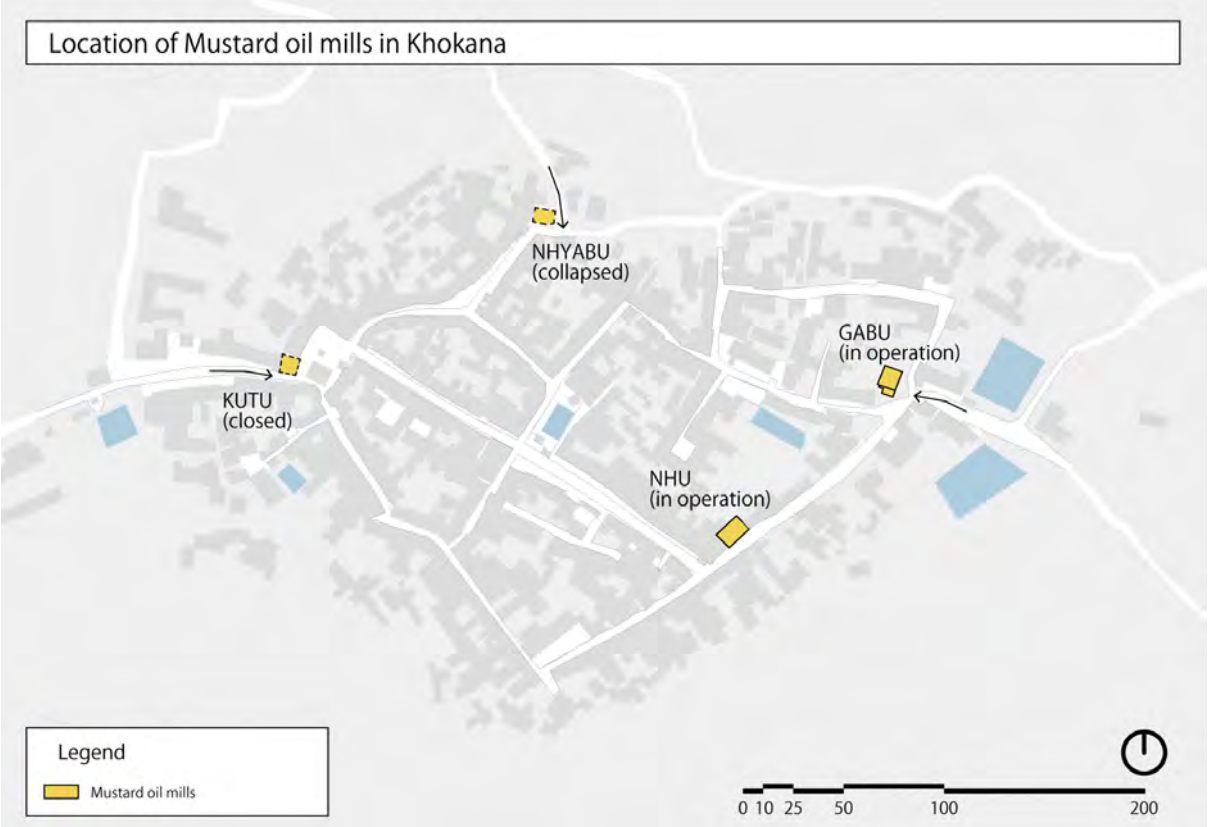

Fig. 2-3-1 Location of main mustard oil mills in Khokana (Yellow) and main route into the village (Arrow)

Fig. 2-3-2 Gabu mill (In Operation, the portraits on the above of buildings are victims in Khokana by the earthquake)

Fig. 2-3-3 Kutu mill (Closed)

Fig. 2-3-4 NHU mill (Closed)

Fig. 2-3-5 Nhyabu Mill (Collapsed)

impossible, leading to the closure of the mills.

In 1999, through support from UNESCO's Kathmandu office, two mills were restored and restarted their operations. At the Gabu mill, a new management team of several people was formed, and production was restarted after borrowing the entire mill from all its investors and recruiting new mill operators. The Nhu mill is now run through a cooperative union of investors, but the mill's operation is conducted by the members who responded to our interview survey.

Whilst they were once gathered as raw materials throughout the Kathmandu Valley, including the villages surrounding Khokana, the majority of the mustard seeds processed in the village is now sourced from outside the region. Raw materials are imported domestically from areas outside the Kathmandu Valley, such as the Terai plains region close to India, and from abroad, from India, Europe, and elsewhere. The leaf mustard seeds cultivated around Khokana are still used intermittently today, but it has been recognised that the use of compost on surrounding farmland has decreased and been replaced by chemical fertilisers, resulting in the impoverishment of the land. Whereas previously 7-8 litres of oil were squeezed from 25kg of raw materials, in recent years, this has decreased to 4.5-5 litres.

Today, the residents of Khokana and neighbouring villages, searching for high quality oil, still purchase mustard oil directly from the mills, and deliveries are also made to some of the department stores in Patan.

2.3.6. The process of mustard oil production in Khokana (the example of Gabu mill)

The raw material of mustard seeds is first roughly ground and carried to a giant oven with the surface of the seed with the mustard colour inside. Inside the oven, workmen continue carefully mixing the seeds and continue to heat them until their unique and aromatic scent emerges. The unique aroma that fills the mill is produced from this heating of the raw materials.

The heated seeds are stuffed into a flat and tightly woven basket, gripped between two large wooden beams about 40cm in length, and squeezed. Of the two beams, the end of one is fixed in place beforehand, and the end of the other is held by a vice-like device with a large handle about the length of a person's spine. After depositing the seeds into the woven basket and inserting them between the beams, a workman uses all of his weight to turn the large handle and thereby squeeze the seeds.

The bottom of this traditional squeezer is formed in a dug state, so that the brown-coloured mustard oil that oozes out of the woven basket collects in the container of this dug state part of the basket. The top of the woven basket opens widely and the bottom is a sharp-edged pentagon, with one part designed to gather oil effectively. According to the owner of the mill, the squeezing method is traditional and is still employed despite the fact that it requires much work because it greatly improves the quality of the oil.

After the first squeezing process, the pomace is like a hardened cake inside the woven basket, but it is then finely crumbled a second time and deposited into the next squeezer, which is mechanical. The oil squeezed from a mechanical squeezer is strong coloured and somewhat poor in quality, but because squeezing oil solely according to traditional methods would be economically infeasible, the Khokana

Fig. 2-3-6 The grinding mill for mustard seeds

Fig. 2-3-7 Compressor using the traditional technique

Fig. 2-3-8 The way of compressing using the weight of the workman

Fig. 2-3-9 Mechanical compressor used for second squeeze

Fig. 2-3-10 Cooker heating grinded -mustard seeds

Fig. 2-3-11 Putting roaseted -seeds into the compressor

Fig. 2-3-12 Squeezed mustard oil (First squeeze)

Fig. 2-3-13 Crushing pomace of first squeeze

product is a mixture of the oil generated by the first squeeze using traditional methods and the product of the second squeeze by machines.

2.3.7. Possibilities and issues for Khokana mustard oil

As this section has summarised, the production of mustard oil was originally an overwhelmingly local industry that started from processing raw materials produced from farmland around the village using labour during the agricultural off-season. The residents of Khokana promptly established commonly owned mills, conducted oil squeezing efficiently, and succeeded in making the production of mustard oil a primary industry of the village following farming. The trading centres for raw materials spread as far as the surrounding farming villages of the Kathmandu Valley, but as may be seen in the barter trade of raw materials and oil, production and consumption may be interpreted to have been a continuous industry that was self-consumed within a certain region.

In recent years, however, with the advance of urbanisation in the Kathmandu Valley, the majority of raw material production became reliant on areas outside the Kathmandu Valley. Mustard oil produced with modern equipment and other cheap vegetable oils circulate on the market and Khokana mustard oil produced with traditional methods is uncompetitive in terms of price. The high quality of Khokana's mustard oil is widely recognised, but that quality is highly dependent upon traditional squeezing methods that require manpower, making it difficult to compete in the same arena with general vegetable oils produced in factories.

It will be necessary to consider how to raise Khokana mustard oil's added value and develop it into an economically sustainable traditional industry by sharing with consumers both the scenery of the terraced paddy fields, where leaf mustard has long been cultivated, and the realities and merits of a manufacturing process that requires human hands (traditional squeezing methods). Simultaneously, it is also important to encourage the regional residents themselves, who are the biggest consumer of Khokana mustard oil, to understand their local mustard oil industry. A hint as to how to achieve this may be hidden in the origins of the mustard oil mill, in which village residents have used the equipment in shifts and helped one another to squeeze oil.

At present, there are only two mills in operation, but as noted above, each mill is located near to the village entrance, so that in terms of the village structure also, the former sites of mills are located in important positions. Establishing a simple facility for promoting understanding of traditional industries that support Khokana's development, through means such as the understanding of mustard oil production using buildings and land and experiencing traditional squeezing, may be a useful means of deepening the understanding of traditional industries among visitors and residents.

Section author : Takefumi Kurose

Notes:

Note 1. Dates interview surveys were conducted: Gabu Mill 2015/11/24, Nhu Mill 2015/11/25
Note 2. Luke C. Mullany et al., Traditional Massage of Newborns in Nepal: Implication for Trials of Improved Practice, Journal of Tropical Pediatrics, 51 (2): 82-86, April 2005
Note 3. UNESCO, World Heritage Centre, Tentative Lists, quotation from the section on Khokana, http://whc.unesco.org/en/tentativelists/844/, last checked on February 26, 2016

2.4. Water Irrigation Circumstances and Water Quality Analysis

2.4.1. Introduction

Water is indispensable to the maintenance of healthy living and healthy social activities, and accessibility to water impacts on people's ways of living, village history, and the creation of culture and tradition. Conversely, human activities can also negatively impact on drinking water and the water environment. In this survey, we inspected the actual circumstances of water irrigation in Khokana and conducted a survey of the quality of water that is intimately connected to people's ways of living.

2.4.2. Survey method

In Khokana, where there are no sewage treatment facilities, there is a risk of water pollution from microorganisms originating in faeces and of the spread of water-related infections arising from it. Therefore, in this survey, we used colibacilli and coliform groups, which are widely used as indices of faecal pollution in water, as the measurement targets. Their characteristics are listed in Tab. 2-4-1.

Tab. 2-4-1 The Characteristics of Coliform Groups and Colibacillis and their Meaning as an Index

Coliform Groups	The aggregate of colibacilli, including bacteria. Stipulated as operational definitions of aerobic or facultative anaerobic bacteria groups that decompose lactose and generate acid and gas within 48 hours at 36±1°C, or bacteria groups that contain β-glactosidase. As some soil bacteria also fit this definition, the detection of colibacillis does not necessarily indicate fecal pollution, but because in general these bacteria increase as the sanitary environment worsens with the generation of microorganism pollution, it is widely used as an index of microorganism pollution. In Japan, coliform groups are specified as the environmental standard for water environments.
Colibacilli	Gram-negative bacteria that live mainly in the intestinal tracts of warm blooded animals and are released into the environment together with feces. They are subsumed under coliform groups, and it cannot be identified whether their origin is human or animal. Excluding some special types, colibacilli are not pathogenic, but because it strongly suggests recent (roughly within a few days) fecal pollution, it is widely used as an index of microorganism pollution. From the perspective of guaranteeing the microbiological safety of drinking water, the World Health Organization's drinking water guidelines and Japan's sewerage water quality standards both specify the non-detection of colibacilli.

Over the two-day period of 22-23 November 2015, a total of 14 water samples were collected from the village, including eight test samples of tap water, three test samples of pond water, and three test samples of well water. There was no rainfall during the period when the water samples were collected.

Test samples were inserted into sterilised syringes, with the tap water left unaltered, while the pond and well water was diluted by 10-10,000 times with a sterilised phosphate buffering solution. According to necessity, diluted test samples were conducted through DISMIC filters and cultivated for 24 hours at 37°C after adding the colibacilli selection medium-ColiBlue24®Broth (Millipore). Following the protocol for the selection medium, the density (CFU/mL) within 1mL of the original test sample was calculated by making the colonies that turned blue after culturing the Colony Forming Unit (CFU) of the colibacilli and the sum of colonies that turned blue or red the CFU coliform group. Measuring the same test samples, in two series we measured their average value. Fig. 2-4-1 illustrates examples of the appearance of a colony after culturing.

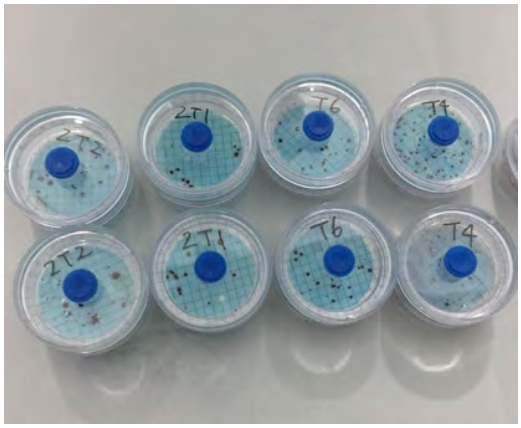

Fig. 2-4-1 Examples of the appearance of a colony after culturing

2.4.3. Results and considerations

Tab. 2-4-2 shows the coliform group and colibacilli densities of each test sample. For the tap water test samples, despite the high possibility of it being used for drinking, coliform groups tested positive in all eight samples, and six of the eight test samples were positive for colibacilli, revealing that the microbiological pollution of the water supply tanks shared by the village is serious.

Tab. 2-4-2 Density Levels of Coliform Group and Colibacilli for Each Test Sample [1]

Sample ID	Coliform Group (CFU/mL)	Colibacilli (CFU/mL)	Origin	Use and Surrounding Circumstances
T1	12	0.5	Faucet	Water tank by the side of the road, donated, plastic
T2	10.5	0.5		Common use water tank (for drinking), plastic
T3	23.5	4		Common use water tank (for drinking, bathing, laundry), concrete
T4	74	13		Common use water tank, concrete, next to the marsh (P2) at the center of the village used for ritual ceremonies
T5	30	5		Common use water tank, concrete
T6	33	0		Water tank for earthquake victim camp, donated, plastic
2T1	13	0		Common use water tank, concrete
2T2	15	4.5		Common use water tank, concrete
P1	610	0	Pond	Village entrance, algae generation
P2	350000	35000		Pond at the center of the village used for ritual ceremonies, algae generation
P3	165000	0		Pond immediately proximate to surrounding houses, dark brown
W1	420	240	Well	In the plaza mainly used for vegetable washing
W2	108	0		Intersection, mainly laundry
2W1	1765	125		In the residence site, domestic water used for non-drinking purposes

T1 and T6 are plastic water supply tanks (Fig. 2-4-2) that are surmised to have been donated in response to the earthquake damage, but both were positive for coliform groups, suggesting the need for appropriate maintenance management methods. In the pond test samples, colibacilli density was markedly high in the pond (P2) located at the centre of the village and used in ritual ceremonies, leading to the proximate presence of faecal pollution being surmised. The tap water from the supply tank (T4) installed next to this pond (P2) was polluted with the highest density levels of colibacilli among the tap water test samples, emphatically verifying the inferior quality of the sanitary environment surrounding the pond. At the time the water samples were taken, abnormal levels of algae were proliferating (Fig. 2-4-3) in this pond (P2), and contamination by not only faecal matter but also nutrient salts originating in domestic wastewater, such as nitrogen and phosphate, was also strongly suspected. By contrast, while high density levels of coliform groups were detected for the test samples of the other ponds (P1 and P3), colibacilli was not detected, suggesting the possibility of little direct inflow of faeces. Among the well water test samples, W1 and 2W1 had high colibacilli density and faecal pollution was strongly suspected. According to the residents, this well water is not used for drinking, but the concerns they raised about the risk of microbiological infection through water splashing in daily life activities, such as washing vegetables and laundry (Fig. 2-4-4), should not be ignored.

Fig. 2-4-2 Water tank located in earthquake victim camps (T6)


Fig. 2-4-3 The pond located in the center of the village, in which the ritual is performed (P2)


Fig. 2-4-4 Washing vegetables by the well located in the plaza (W1)

2.4.4. Conclusions and suggestions

This survey has indicated the extent of the microbiological pollution of tap, pond, and well water in Khokana Village. As noted above, while the detection of coliform groups and colibacilli does not, without more, necessarily mean there is an immediate risk of infectious disease, considering the fact that high density levels of colibacilli were also detected for tap water that is supposed to be used for drinking, we consider that there is an urgent need to implement immediate remedial measures. It is also desirable that the marked faecal pollution and abnormal algae proliferation in the pond used as a symbol of the village for ritual ceremonies be improved immediately. Specific measures that may be deployed include separating domestic wastewater (particularly polluted water) from the water environment, primary treatment of sewage water through septic tanks, and implementing sanitary education.

Section author : Kumiko Oguma

Notes:

Note 1. Capital alphabet "2"of Sample ID means that is picked on second day of research, 23, Nov. 2015, the others are picked on the first day of research, 22, Nov. 2015.

2.5. Earthquake Damage Conditions in Khokana

2.5.1. Survey overview

The contents of this section are based on the on-site survey conducted in November 2015 (observing and interviews with residents) and the comparison of aerial photographs taken before and after the earthquake.

As will be detailed further in the next section, many buildings in Khokana Village were damaged; even in cases where residential houses have not been completely destroyed, there are many homes which, due to safety problems, are impossible to live in. Consequently, many residents have constructed and are living in temporary dwellings inside and around the village. In this section, by comparing aerial photographs from before and after the earthquake and conducting an on-site investigation, we have identified the places where temporary housing has been constructed and examined the (temporary) changes to the village structure.

2.5.2. Conditions in Khokana during the earthquake

Because the earthquake on 25 April 2015 occurred during the day, many residents were out doing farm work and thus escaped the damage from collapsed buildings; however, those who were inside buildings (particularly the elderly and children) were victims of this damage (as stated above, the victims comprised nine dead and 28 wounded). The local youth club is said to have taken a leading role in performing rescue work. At the time of the disaster, people in the village feared the collapse of buildings and evacuated to the wide main street. There were also many people who evacuated to the safer bus park where there are no surrounding buildings. On the day of the earthquake, there was a health club being run by the youth group and we were told that around 200 people evacuated there.

After the earthquake, an emergency meeting was held in the community. After nightfall, refugees were moved to schools and factories on the edge of the village judged to be undamaged and safe. The disaster victims were divided into several groups and were mainly assigned to refuge shelters according to their communities.

2.5.3. Construction of temporary residences

Around one month after the earthquake, individuals and communities were allotted shelter spaces and materials. In many cases, temporary residences were constructed by the residents themselves with building materials such as zinc-coated steel mainly provided by the Nepal Government and NGOs (such as the Fondation de France). We were told that there are two types of land on which these temporary residences have been built: fields owned by disaster victims or their relatives and land borrowed from others by paying land rent.

Through this survey, it became clear that temporary residences were mainly built on vacant land

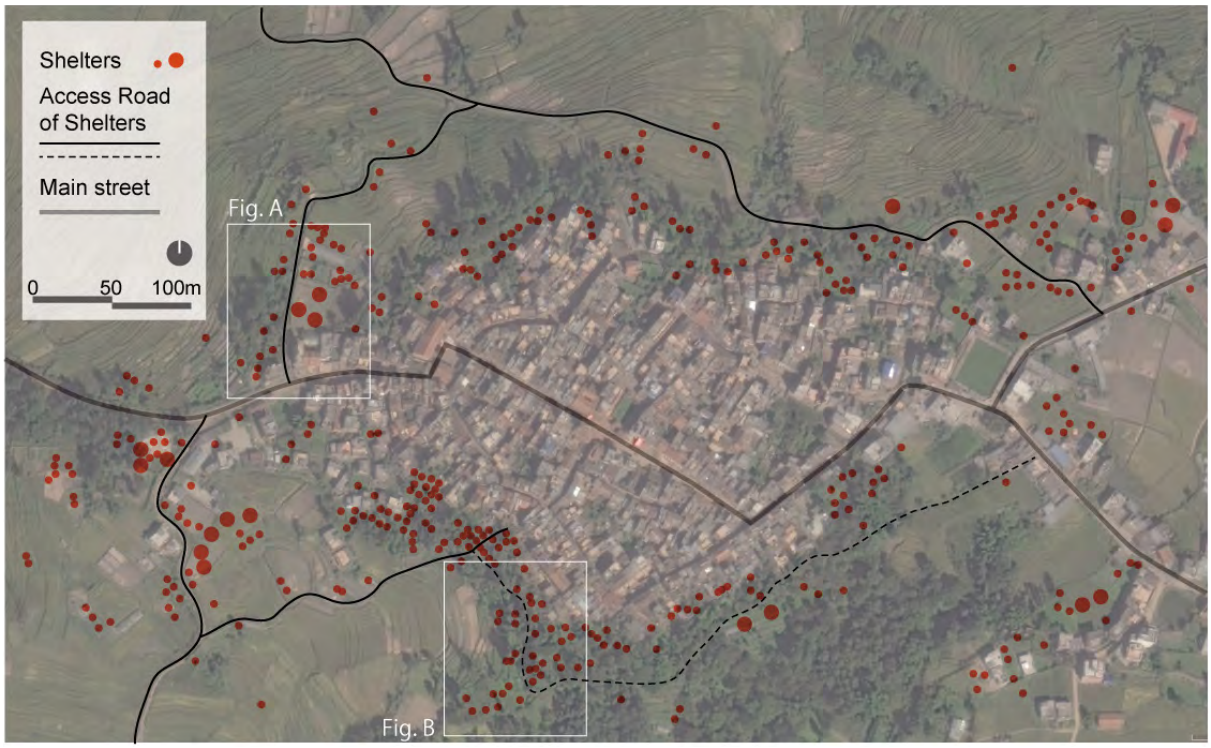

Fig. 2-5-1 Distribution of the shelters in the periphery assumed by aerial photograph before (Taken on 25 Oct. 2014) and after the disaster by Google Earth

Fig. 2-5-2 Shelters in the periphery of the village (Partially enlarged view of Fig. A)

Fig. 2-5-3 Shelters in the periphery of the village (Partially enlarged view of Fig. B)

Fig. 2-5-4 The larger area for temporary housing at the vacant lot of the west side of the village (The road on the right side of this photo is a part of the ringroad)

Fig. 2-5-5 Temporary housing in the northern settlement (The trees on the back side of the photo surrounded the village before the disaster)

in and around the village. In particular, the majority of temporary residences are constructed on the edge of the village, where the risk of secondary damage due to buildings collapsing is small. Based on the comparison of aerial photographs taken before and after the earthquake and the on-site investigation, the temporary residences are indicated as having been constructed around the village after the earthquake in Fig. 2-5-1.

2.5.4. Issues Surrounding Changes in the Structure of the Village due to the Earthquake and the Recovery

Over 300 temporary structures are thought to have been constructed after the earthquake around the perimeter of the village alone. Many of these are built on vacant land for farming or farming related work around the village where there is comparatively little incline. Furthermore, part of the forest land surrounding the village is being used for temporary residences, and the extent of this forest land is consequently decreasing. Consequently, the clear division between the village and the terraced paddy fields is being lost, and the temporary residences are temporarily expanding the territory of the traditional village. In addition, the farm roads outside the village are being extended as access roads to these temporary residences around the perimeter of the village, forming a ring road around the village. It is possible that the temporary residences will become permanent residential land; in our opinion, it is necessary to consider implementing rule-making for future development of the area surrounding the village.

Section author : Takefumi Kurose

2.6. Investigation on the Transformation of Townscape: Case Study of the Townscape along Nyala Dan Street

2.6.1. Background

Khokana is a small town with a population of 5,000 people located 10km southwest of Kathmandu. Low-rise brick houses, of mainly three stories, form its townscape. Khokana, which is surrounded by terraced paddy fields and where peasant *Zaat*[1] people called '*Jyapu*' live, has a pastoral scenery with drying farm products such as red peppers and radishes under the eaves.

Despite being added to the World Heritage Tentative List with the designation 'Khokana, the vernacular village and its mustard-oil seed industrial heritage' in 1996, the recommendation process of Khokana to the World Heritage List has made no progress for a long time. Moreover, there is no legal protection of its townscape[2] . Since the 2000s, the division of the land, extension and renovation of houses, and construction of high-rise houses of reinforced concrete have been carried out to such a remarkable extent that the vernacular townscape valuable as World Heritage has been radically transformed. In 2015, when the large-scale earthquake struck the Gorkha District, the maintenance of the traditional townscape became a more critical situation as the old houses were damaged or collapsed much more than the latest buildings of reinforced concrete.

According to the residents, every house but four collapsed in Khokana in the earthquake of 1934. After that disaster, the new townscape of Khokana was reconstructed from ruins. Khokana has a long history , however, its townscape may be considered fairly new because even the oldest buildings there were constructed only 90 years ago, except the four buildings which did not collapse during the disaster of 1934. On reflection, we could say that Khokana's townscape has a history spanning three or four generations.

After the 1934 earthquake, it is considered that almost all of the village's houses were similarly reconstructed in their pre-disaster form. The situation after the 2015 earthquake is different from that of 1934 because reinforced concrete houses and damaged traditional houses have remained intact. This time, the village itself needs to be rehabilitated. 'The Khokana Reconstruction and Rehabilitation Committee', a local private organisation mainly formed by young people, has devoted efforts to rehabilitate the traditional townscape at the opportunity after the disaster. Khokana residents, however, had already transformed their townscape before the 2015 disaster, with extension of their living spaces, changing their lifestyle, and extension or reconstruction of their houses using reinforced concrete. Considering this situation, it is difficult to realise the rehabilitation of traditional townscapes without taking into consideration their demands for living spaces.

The Khokana Reconstruction and Rehabilitation Committee intends to rehabilitate the traditional townscape. This does not mean directly rehabilitating that townscape by restoring the existing historical buildings, but also involves creating new houses in a traditional style. For example, the Committee conveyed to us their opinion that the traditional style buildings constructed before the 2015 disaster – those built in a similar but different style to the originally traditional houses of Khokana – were ideal (cf. Fig. 2-6-2). Therefore, it is necessary to share the future image of the townscape and special design of Khokana not only with professionals and voluntary organisations but also with the local residents.

Fig. 2-6-1 A proposal for Khokana Reconstruction and Rehabilitation, the local Committee

Fig. 2-6-2 Houses built in Newar style apparently different from traditional houses in Khokana

2.6.2. Objectives

We need to begin the rehabilitation process from the present situation that the village is characterised first by the co-existence of traditional houses and contemporary high-rise housing and second by the great earthquake that struck in 2015. In examining the future vision for the rehabilitation, we first need to focus on the evolutional process of Khokana's townscape, from the spatial situation of reconstruction after the 1934 disaster, through to the 1996 townscape when Khokana was evaluated as a World Heritage candidate, and finally to the current townscape. We will not consider single houses that have been already divided, but focus instead on the original housing units and their lots, as reconstructive units. We will also focus on the spatial composition and the common use not only of the houses but also of courtyards and through passages, to enable us to show the future vision of the rehabilitation of the village with its spatial characteristics.

The objectives of this investigation are to comprehend a) the transformation of the townscape after the 1934 earthquake and b) the spatial transformation of traditional houses according to the actual demands of residents or changes in the life stage of each family in order to plan the rehabilitation of the traditional townscape. In essence, we are going to clarify:

1. the causes of the transformation of townscape; and
2. the units of the housing lots that should be considered as one for planning the rehabilitation of the traditional living space and its transformation

The findings of this investigation could provide guidelines for the reconstruction, restoration, and formation of the townscape for its future rehabilitation.

2.6.3. Situation of the investigated site

Nyala Dan (*Nayajho*) Street is one of the most important streets of the Khokana townscape, from Shree Rudrayani Temple, located in the centre of Khokana, to Kwelachhi Chok. However, with recent reconstructions along this street, the townscape has changed significantly in comparison with that in the aerial photograph of 1973 (cf. Fig. 2-6-3). Exacerbating this situation, the existing traditional houses were damaged by the April 2015 earthquake. Aside from Shree Rudrayani Temple, the common facilities, and

Fig. 2-6-3 Aerial photo in 1973 (Quoted from reference 1, p.146)

Fig. 2-6-4 The investigated site (Quoted from Google earth, taken on 8th June 2015)

Pati (small arbour) at the end, all the buildings in the investigation site are used for housing even there are stores on the ground floor. During the field survey, occupation of most of the traditional houses was prohibited by the government according to the extent of damage, and those houses need to be restored or rebuilt urgently. Thus, it is difficult to restrain the reconstruction of traditional houses into contemporary ones without establishing any regulations. There is anxiety that the future townscape could be quite different from the former one on World Heritage Tentative List.

2.6.4. Strategy

In this investigation, we studied on prior research and related documents, collected photographs from websites, and conducted a field survey (comprising interviews and drawing floor plans of the houses).

1. Analysis of photographic documentations

We collected dated old pictures and aerial photographs from websites and compared traditional houses on them with those on the site at present, and then analysed the transformation of the townscape.

2. Field survey

From 2 to 6 December 2015, we interviewed residents of Nyala Dan Street about the changes of use of houses and courtyards, family compositions and other relevant issues using interview sheets (cf. Appendix -1). Subsequently, we took photographs inside the houses and surveyed and drew their floor plans, complemented by explanations from the residents about the uses of and their changes to their homes.

There are 38 houses which remained even with heavy damage after the 2015 disaster along Nyala Dan Street; we interviewed the residents of 18 of these houses. We also interviewed the residents of four houses (all of which are recorded on the 1969 map) which front the courtyard in order to understand the changes at the rear of the street. We interviewed in the morning and evening because the residents are engaged in farming during the day. The houses and the dates of the investigation are detailed in Tab. 2-6-1. A Nepalese interpreter (Japanese-Newari) assisted this field survey.

Fig. 2-6-5 Interview inside of the damaged house

Fig. 2-6-6 Investigation of the inside house

Tab. 2-6-1 List of the houses and residents

There are some houses whose ownerships are divided into more than two. For this investigation, we assigned building numbers according to the owners and these numbers of buildings (A) are different from the ones of "disaster damage condition survey"(B).

Investigation number	Building number (A)	Building number (B)	Date of investigation	Name (Interviewee)	Age	Occupation of householder	Number of family
1	S05-b	-	2. Dec. 2015	S. L. Maharjan	80	Magician	4
2	N08	A011	2. Dec. 2015	N. G. Tuladhar	66	Retired	3
3	N19	A004	2. Dec. 2015	B. K. Maharjan Apa	60	Carpenter	6
4	S15	D004	2. Dec. 2015	H. N. Dangol	73	Retired	2
5	S14-b	-	3. Dec. 2015	M. K. Dangol	59	Farmer	6
6	N13	D006	3. Dec. 2015	J. B. Maharjan	80	Retired	5
7	N12	A008 East half	3. Dec. 2015	R. Maharjan	38	Carpenter	4
8	S16	D003	3. Dec. 2015	S. K. Dangol	33	Bike repairer	3
9	S09	D009	4. Dec. 2015	H. L. Maharjan	70	Farmer	3
10	S10-b2	-	4. Dec. 2015	J. B. Dangol	46	Farmer	2
11	N01	A018	4. Dec. 2015	A. Maharjan	42	Farmer	6
12	N07	A012	5. Dec. 2015	K. Maharjan	59	Farmer and Shop owner	9
13	S03	D015 East half	5. Dec. 2015	A. Maharjan	22	Farmer	7
14	S05	D013	5. Dec. 2015	K. Dangol	42	Famer and Carpenter	5
15	S08	D010	5. Dec. 2015	S. K. Dangol	48	Office worker, grocery shop owner	5
16	N04	A015	5. Dec. 2015	G. Dangol	76	Farmer	6
17	S12-b	-	5. Dec. 2015	D. A. Maharjan	29	Artisan (Metalist)	2
18	N05	A014	6. Dec. 2015	S. L. Dangol	68	Gardener (Florist)	8
19	N14	A006 West part	6. Dec. 2015	G. L. Dangol	46	Farmer and driver	4
20	S13	D006	6. Dec. 2015	S. Maharjan	40	Craft artisan	4
21	N18	A005 East half	6. Dec. 2015	S. B. Maharjan	59	Farmer	5
22	S18	D001	6. Dec. 2015	H. B. Dangol	47	Farmer	5

Buildings located at the backside of the street

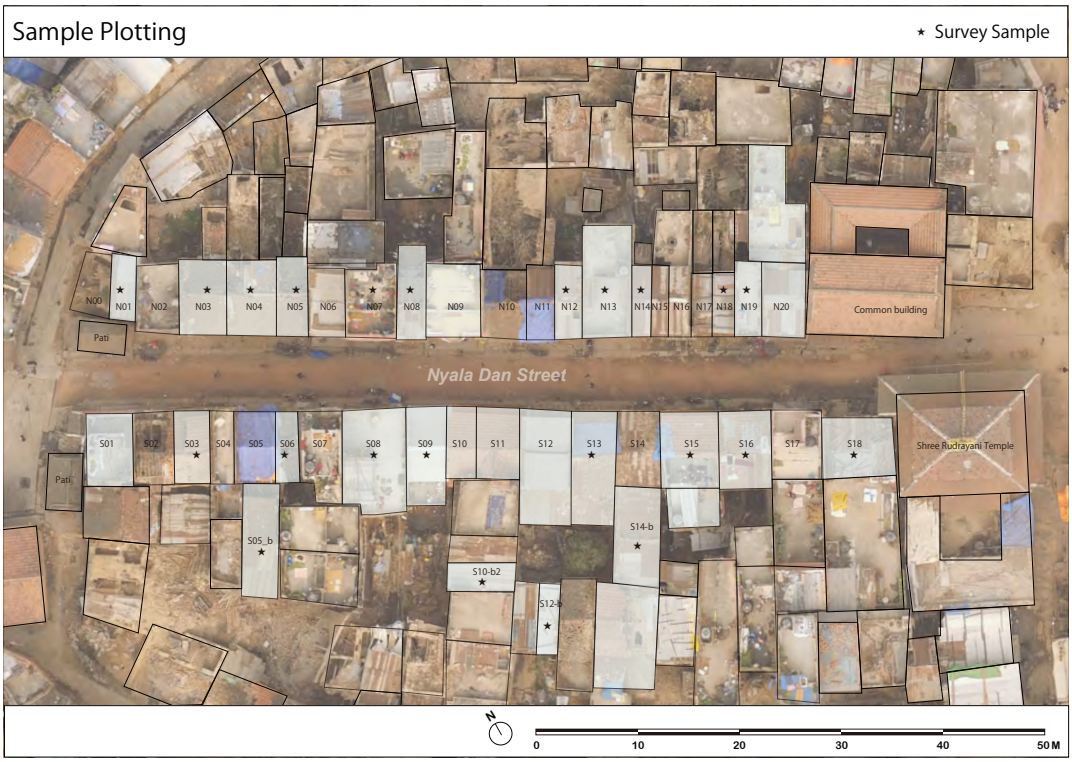

Fig. 2-6-7 Investigated houses (Houses marked with★ are investigated, houses painted in white are surveyed inside)

This research was conducted by the following two researchers (with the assistance of the interpreter):

Hiroki Yamada (Associate Fellow, Japan center for International Cooperation in Conservation, National Research Institute for Cultural Properties, Tokyo)

Naoaki Furukawa (Visiting Researcher, National research Institute for Cultural Properties, Tokyo/ Project Assistant Professor, Faculty of Urban Environmental Sciences, Tokyo Metropolitan University)

2.6.5. Analysis of transformation of townscape along Nyala Dan street

1. Analysis of documents

We arranged the site plan of Khokana prepared in 1969 (Fig. 2-6-8) and aerial photographs from 2003 published on the Google Earth website in chronological order, then analysed their morphological changes over periods of 10 years (cf. Appendix-2 'Aerial photographic documentation of Khokana sorted by 10 year periods').

The site plan drawn in 1969 shows the roof shape of each building and, we understand, the whole spatial structure of Khokana, including the crossroads at the centre and the situation of houses with courtyards. This plan is consistent with the aerial photograph of 1975, so we consider the source of investigation of 1969 to be reliable. We thus superimposed this plan on the current aerial photograph and

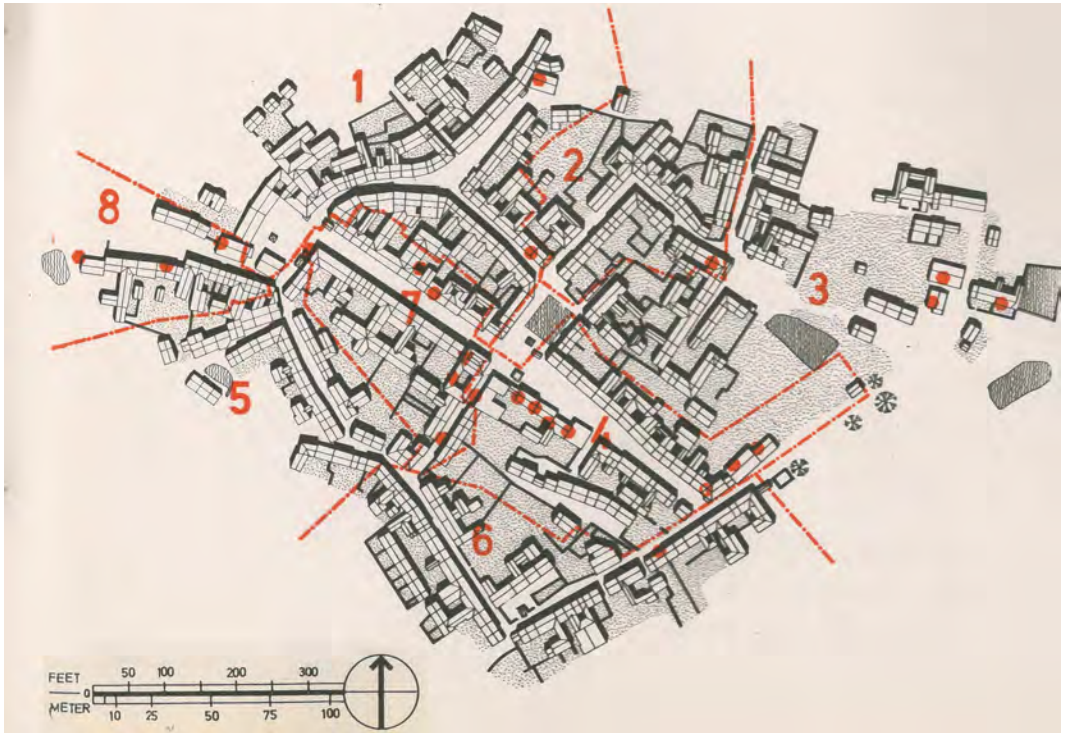

Fig. 2-6-8 Site plan in 1969 (Quoted from reference 2, p.65)

compared the arrangement of houses and courtyards. We were able to recognise the approximate position of houses which were extended or renovated after 1969, although there were some size differences between the plan and the aerial photograph.

Fig. 2-6-9 Site plan in 1969 (Quoted from reference 2, p.65)

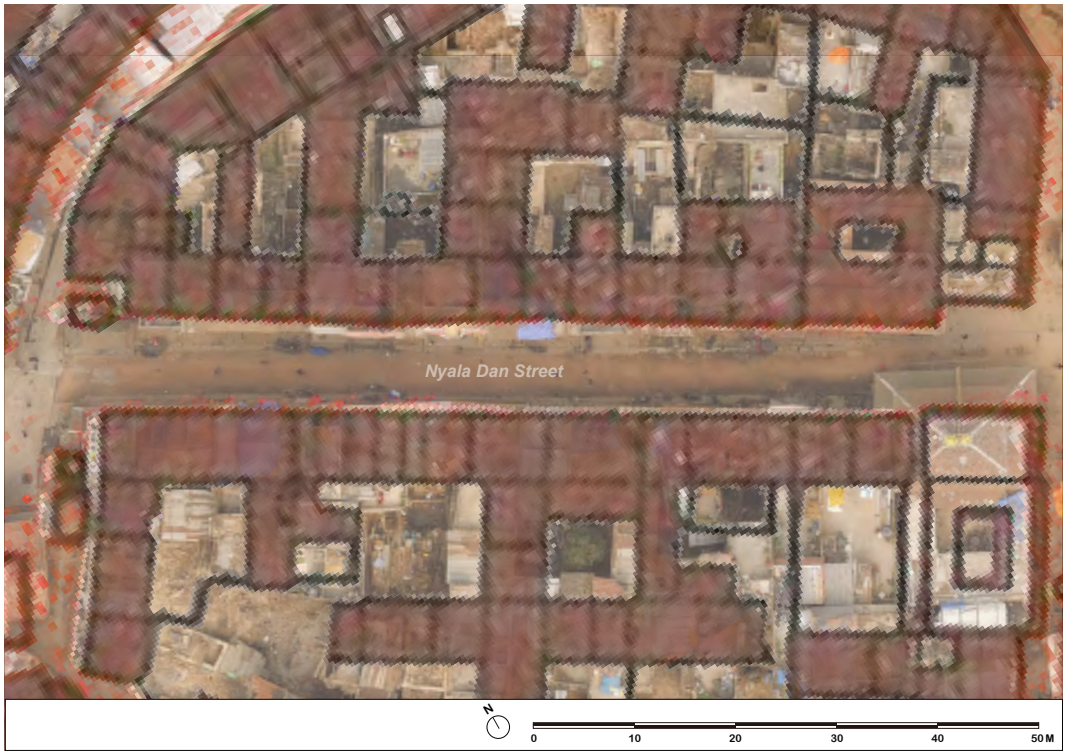

Fig. 2-6-10 Comparison of the map of the year 1969 (Quoted from reference 2, p.65) with present condition

- The aerial photograph taken in October 2003 is the oldest of those published of the site on Google Earth. At that time, there were only two houses on the street, N02 and N07, which had flat roofs. The incline of the roofs of houses N14, N15, and N16 changed because of extension works. Judging from the roof shapes in the aerial photograph, there are no extension works on the south side of Nyala Dan Street.
- In comparing the aerial photograph (Google Earth map) of 2003 with that of 2007, we see the changes of the roof shapes of N01, N06, and N19 on the northwest side. Conversely, there were no remarkable changes of roof shapes on the south side of the street even eight and half years ago.
- We see some changes to the roofs of N13, N20, S01, S04, and S07 in the aerial photograph of 2010. At that time, most of roofs of houses at the rear from the street had already been changed from tiled roofs into flat roofs.
- We see that the houses N09, S08, S12, and S17 have been rebuilt and their roofs have been changed in the aerial photograph of 2014, which is the latest one before the 2015 disaster.

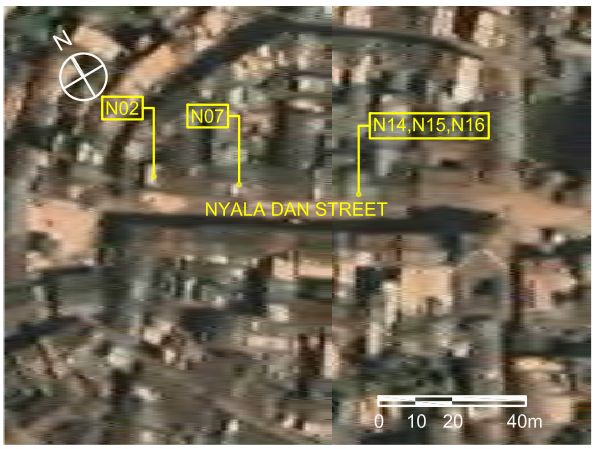

Fig. 2-6-11 Photo taken on the 21st Oct.2003, from Google earth

Fig. 2-6-12 Photo taken on the 22nd Mar.2007, from Google earth

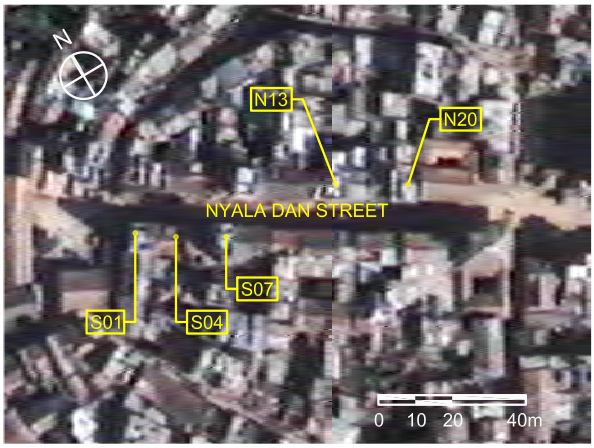

Fig. 2-6-13 Photo taken on the 26th Jan.2010, from Google earth

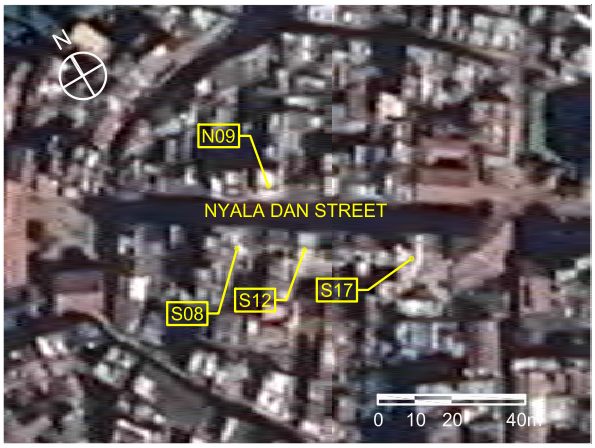

Fig. 2-6-14 Photo taken on the 28th Dec.2014, from Google earth

We analysed the transformation of the townscape along Nyala Dan Street based on photographs taken at eye-level. We sourced old photographs data from websites (www.Flicker.com) that we can obtain the date of each photograph and the identity of each photographer, except Fig. 2-6-15. We observed that rebuilding has increased rapidly and the townscape has changed remarkably in recent years, as demonstrated in the attached photographs.

Concerning the landscape in the 2007 photograph, we found that No.7 was rebuilt and the townscape around the street has quite changed from earlier images. However, the harmonic view of the village, with the mountain range in the background, was maintained in the 2007 photograph comparing with 2014 photograph.

In this way, we visually reconstructed the process of the townscape's transformation using the photographs taken at eye-level from the time when digital cameras became widespread until the 2015 disaster.

Fig. 2-6-15 View from the open space at the west end to the east. This photo was probably taken in the 1990s when the roof of bldg. no.2 changed into the flat one. (source unknown)

Fig. 2-6-16 View from the west end (bldg. S02) to the east, on the 8th January 2005 (photographer: Elke Selter)

Fig. 2-6-17 View from in front of bldg. S17 to the east, on the 14th April 2007 (photographer: Reza Karriem)

Fig. 2-6-18 View from the centre of the street (bldg.S15) to the east, on the 2nd August 2014 (photographer: DNT)

Fig. 2-6-19 View from bldg. No3 to the east, on the 23rd March 2007 (photographer: Gabri+Sil)

Fig. 2-6-20 View from the east (temple) to the southwest, in 2008 (source: unknown)

Fig. 2-6-21 View from the centre of street (bldg.S18) to the east, on the 6th December 2015

2. Field survey: History of extension and renovation of houses depending on the change of family structure

In general, it is considered that the townscape of traditional houses along Nyala Dan Street was rehabilitated after the 1934 disaster, then these houses were divided into small narrow houses by repeated property distribution to children or brothers, or transfer to strangers; furthermore, they were also extended or renovated. In this investigation, we clarified through interviews the reasons why the houses and their lots have been segmented and extensions or renovations of those houses have been conducted.

On investigating the transition of each house, we had difficulty establishing the original housing units and their site boundaries if those houses were rebuilt after being divided. Consequently, we examined the shapes of the original houses and compared them with those of the current houses based on the roof shapes identified in the aerial photograph taken in 1973. Incidentally, in addition to the tracings of the original houses noted above, we obtained information about the limits of each original house and its boundary through the interviews.

Fig. 2-6-23 shows the chronicle of renovation and rebuilding based on the changes of facades along the street, according to interviews with local residents. Concerning the extension period, we roughly

divided it into four periods according to the social, economic, and technical tendencies: the first period is from the 1934 disaster until 1972, the second is from 1973 to 2003, the third is from 2004 to the 2015 disaster, and the fourth is from that disaster until now. The extensions and renovations before 2003 (marked in green and red: Building nos. S10, S11, S15, S16, N02, N08, N12, N14, N15, and N16) are identified as small scale, from three storeys to three and a half storeys (to extend the height of the third floor) or four

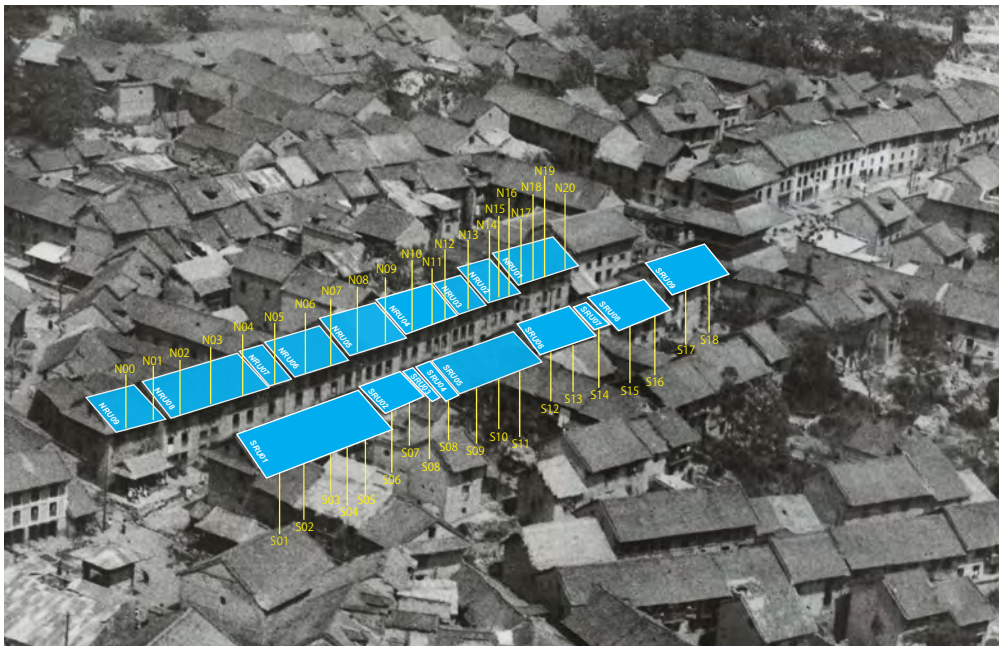

Fig. 2-6-22 Segmentation of the houses by roof shape in 1973 (From reference 1, p.146) with present condition

Fig. 2-6-23 Chronicle of façades along Nyala Dan street, western district (Chronicle of Extension/ Rebuilding)

storeys (to add the flat roof); conversely, those conducted after 2004 (marked in violet) are identified as rebuilding on a large scale and demolishing existing houses. After rebuilding, the houses are three to five storeys with a staircase on the top, but the height of each floor is larger; therefore, the houses total heights are much higher than those of the traditional houses. The rebuilt houses have flat roofs and the set back penthouses are built there. Furthermore, water storage tanks have been placed in many of those penthouses.

Fig. 2-6-24 shows the transformation of housing units (SRU and NRU), each of which is considered as one unit, by examining the aerial photograph of 1973. Most transformation cases show that the houses are divided vertically and then extended or renovated. Another case also shows that two housing lots (SRU03 and SRU04) were unified and then a new house (S08) was constructed there. We see only one case in which small lots were unified on this investigation site. However, it is possible that more housing lots will see several small lots being unified in the future. Consequently, it is necessary not only to restrain the segmentation of building lots but also to lead several small lots together to establish appropriate building lots.

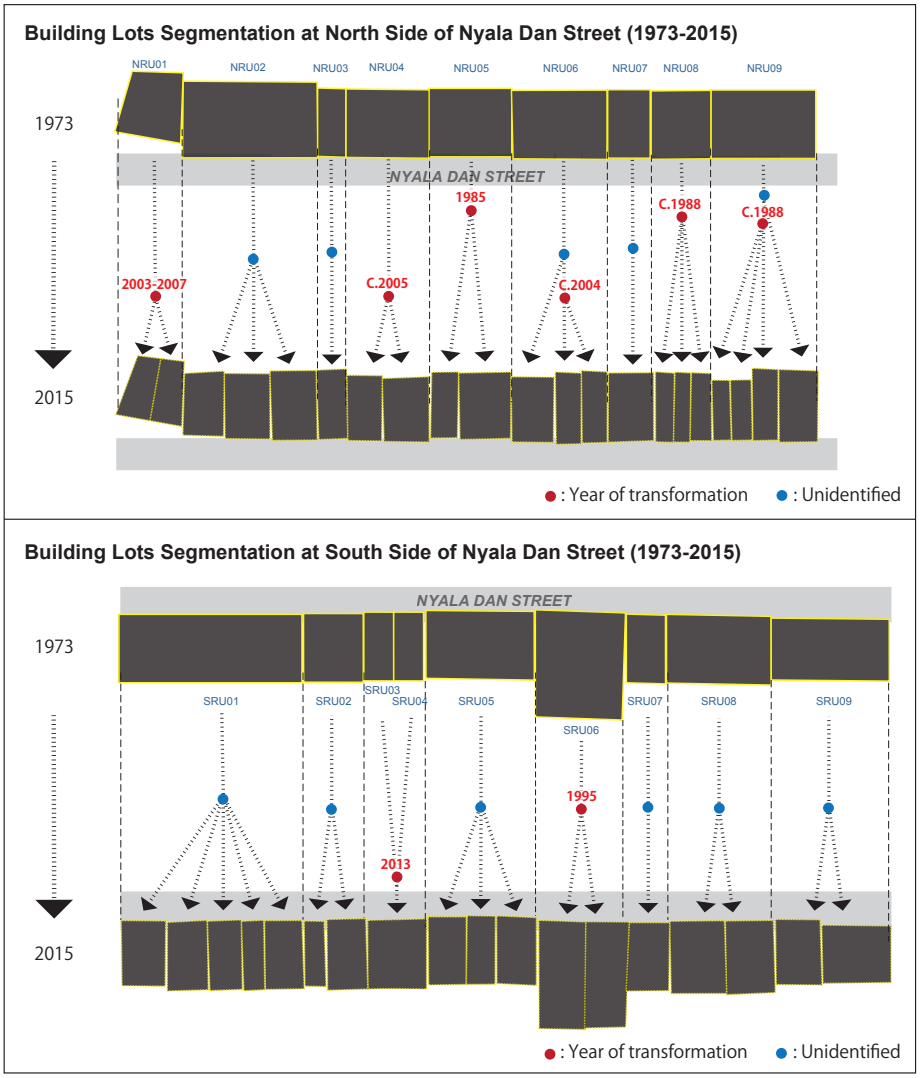

Fig. 2-6-24 Segmentation of housing lots along Nyala Dan street

Tab. 2-6-2 Vertical transformation of architectural forms (Building extensions in the horizontal direction are examined separately)

Number of Building Unit 1973 (*from photograph of 1973, reference 1)	Number of floors (*from photo of '73)	Transition of segmentation pattern of until current architectural forms (cf. commentary of table below)	Number of Building Unit 2015	Number of floors	Year of transformation	Note
NRU01	3	▸ segmentation-unchanged	N00	3	–	Demolished by 2015 EQ
	3	▸ segmentation-extension	N01	4	?(2003-2007)	
NRU02	3	▸ segmentation-extension	N02	4	?(1973-2003)	
		▸ segmentation-unchanging	N03	3	–	
		▸ segmentation-unchanging	N04	3	–	
NRU03	3	▸ unchanging-unchanging	N05	3	–	
NRU04	3	▸ segmentation-rebuilt	N06	4	2005	
		▸ segmentation-rebuilt	N07	4	2005	
NRU05	3	▸ segmentation-extension	N08	3.5	1989	
		▸ segmentation-rebuilt	N09	5	2009	
NRU06	3	▸ segmentation-unchanging	N10	3	–	
		▸ segmentation-unchanging	N11	3	–	
		▸ segmentation-extension	N12	4	2000	
NRU07	3	▸ unchanging-extension-1	N13	4	2007	
NRU08	3	▸ unchanging-extension-2	N14	3.5	1988	
		▸ unchanging-extension-2	N15	3.5	1988	
		▸ unchanging-extension-2	N16	3.5	1988	
NRU09	3	▸ segmentation-unchanging	N17	3	–	3F collapsed by 2015 EQ
		▸ segmentation-unchanging	N18	3	–	3F collapsed by 2015 EQ
		▸ segmentation-extension	N19	4	2008	
		▸ segmentation-extension	N20	3.5	2011	
SRU01	3	▸ segmentation-rebuilt	S01	5	2007	
		▸ segmentation-unchanging	S02	3	–	
		▸ segmentation-extension	S03	3.5	2005	
		▸ segmentation-extension	S04	4	2009	
			S05	3	–	
SRU02	3	▸ segmentation-unchanging	S06	3	–	
		▸ segmentation-rebuilt	S07	5	2005	
SRU03	3	▸ unification-rebuilt	S08	3	2013	
SRU04	3	▸ unification-rebuilt				
SRU05	3	▸ segmentation-unchanging	S09	3	–	
		▸ segmentation-extension	S10	3.5	1971	
		▸ segmentation-extension	S11	3.5	1971	
SRU06	3	▸ segmentation-extension	S12	4	2013	
		▸ segmentation-unchanging	S13	3	–	
SRU07	3	▸ unchanging-unchanging	S14	3	–	
SRU08	3	▸ segmentation-extension	S15	3.5	1985	
		▸ segmentation-extension	S16	3.5	1995	
SRU09	3	▸ segmentation-rebuilt	S17	5	?(2010-2014)	
		▸ segmentation-unchanging	S18	3.5	1988	3F+3.5F collapsed by 2015 EQ

Transformation pattern of architectural forms (Vertical direction only)	
▸ unchanging-unchanging	Without segmentation and extension (unchanging-unchanging)
▸ unchanging-extension-1	Without segmentation, but extended house (unchanging-extension-1)
▸ unchanging-extension-2	Not to segment, but to extend house and to divide interior spaces (unchanging-extension-1)
▸ segmentation-unchanging	Without segmentation, but extended and divided the interior spaces (segmentation -unchanging)
▸ segmentation-extension -1	Segmented and extended the floors with keeping structure of from the ground floor to the second floor (segmentation- extension-1)
▸ segmentation-extension 2	Segmented and extended the floors with keeping structure of from the ground floor to the second floor. Divided interior spaces also. (segmentation-extension-2)
▸ segmentation-rebuilt	Segmented, demolished and rebuilt (segmentation-rebuilt)
▸ unification-rebuilt	Unified the two lots and rebuilt after demolishing small buildings (unification-rebuilt)

2.6.6. Transformation of houses and its factors

1. Spatial transformation corresponding to the change of use of rooms on each floor

In the preceding section, we examined the segmentation and extension of houses to accommodate separate living of households. In this section, we examine the relation of changes of spatial use inside the house to spatial transformation. We conducted interviews on the use of each room, but it was possible neither to conduct detailed investigation of the spatial use, nor to take detailed measurements inside the buildings. Concerning the Newari traditional house, we assumed the spatial image at the time of the construction, with reference to the writings of N. Gutschow *1) and R. Ranjitkar *4) and the papers of Prajapati and Ms.Taniuchi *5.6.7).

Regarding the basic use of the general house in Newari style, the workshop, warehouse, and animal shed are situated on the ground floor, living spaces are on the first floor and the second floor, and the kitchen is situated in an attic. Concerning spatial use, that of the kitchen and the lavatory has rather changed.

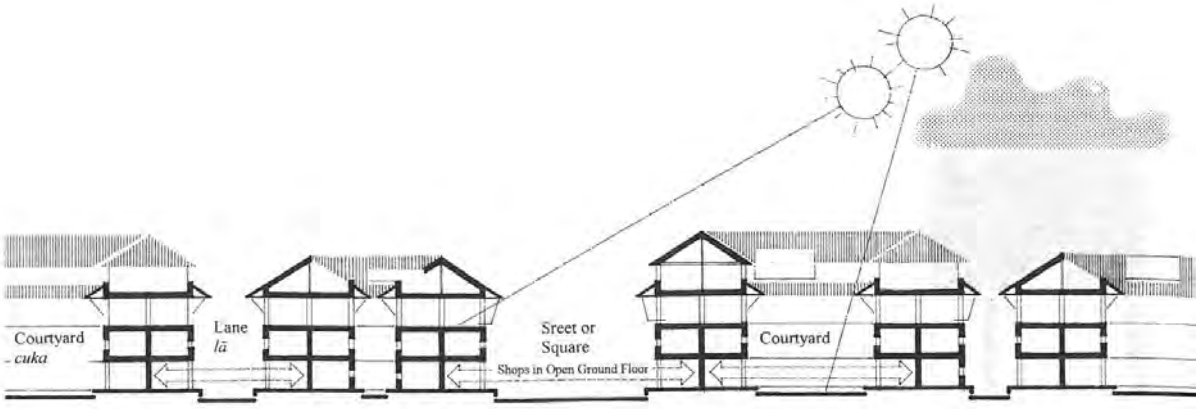

Fig. 2-6-25 Characteristic arrangement of Newal architecture (Drawing G.Auer, 1972) (Quoted from reference 1, p.172)

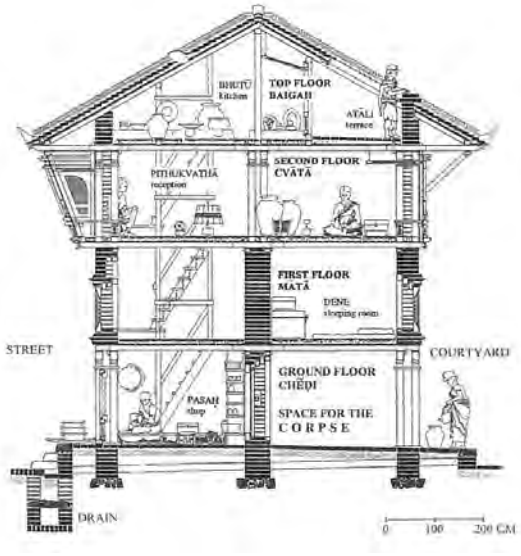

Fig. 2-6-26 Section of Newari house (Drawing G.Auer, 1972) (Quoted from reference 1, p.172

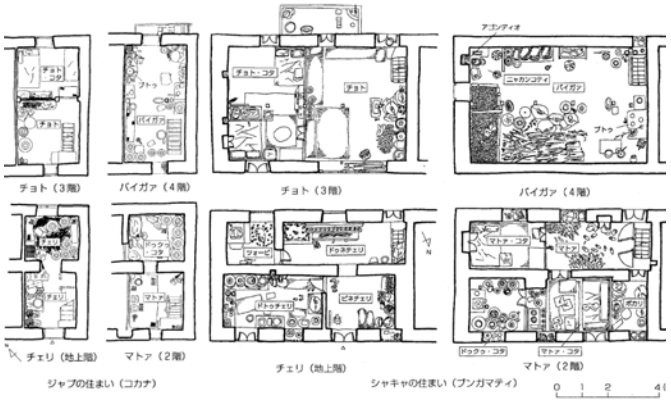

Fig. 2-6-27 Life style of Newari people (Quoted from reference 5)

2. Spatial changes of Kitchen

Regarding the spatial expansion of the kitchen, there are lots of cases of the floor height of the third floor being raised or expansion of the floor (N14); in both cases, the houses' facades change. As kitchen utensils have recently become used for discharging smokes (as cassette cooker), we observed that some houses have installed small kitchens on the second floor. Even in the new high-rise houses, there are kitchens and watering places on the top floors like those in traditional houses, and residents occupying the same buildings share these rooms(S01).

Fig. 2-6-28 Extension of kitchen in traditional house (façade of N14)

Fig. 2-6-29 Inside of extended room on the third floor (N14)

Fig. 2-6-30 Façade of traditional house maintained (N05)

Fig. 2-6-31 Inside of traditional house kitchen. Tiled roof is posted over low walls of 60cm high. (N05)

3. Additional installation of lavatories

There were some cases in 1990 (around 25 years ago) that lavatories were installed on the ground floor under the staircases (N14, and others). Furthermore, there were common lavatories in the houses (e.g. S03) which different households shared because it was inefficient to install one in each household. In 2003 (around 12 years ago), there were some cases of lavatories being installed in the courtyard with the support of World Vision (e.g. S15).

4. Common use of passages

Along with the extension of houses, we see some spaces (workshops, animal sheds, and others) in the first floor were shared more with several households as through passages to the houses of inner part (S05, N16). We also saw the rooms whose spatial usage changed even though whose main use didn't.

Fig. 2-6-32 Installation of cooking stove on the 2nd floor (N19)

Fig. 2-6-33 Common kitchen is always installed on the top floor (left back) (S01)

Fig. 2-6-34 Installation of lavatory under the stairs (N14)

Fig. 2-6-35 Installation of common lavatory in the courtyard (S15, rear side)

5. Changes from tiled roofs to flat roofs

Some outdoor uses brought inside of the houses have influenced the spatial changes of the townscape. As the main industry of Khokana has been agriculture, it has needed sunny and flat spaces for drying cereals. These spaces are called *'layebo'* in the Newari language and are very important to village life. The residents living on the north side of the street use spaces facing the street in front of their houses. Conversely, those living on the south side (as we see at the rear of S14) use the sunny courtyard located on the south side as a workspace for drying cereals because the street side of their houses does not receive much sunshine. However, over recent years their courtyards (as spaces for drying) have become significantly smaller with the extension of housing. The reason to install a rooftop floor (that is, to change from a sloped tiled roof to a flat roof) is the need for more workspace, substituting for the shrinking courtyards. It is considered that the tendency of having flat roofs is influenced by the necessity of access to consistent sunlight, as an alternative to using the sunny courtyards for drying cereal and washing clothes, and providing a suitable position for water tanks on top of the houses In fact, all new high-rise houses in the village have flat roofs. Incidentally, the more they construct high-rise houses, the more residents living around them have to rebuild because they need to retain sunny spaces for themselves. Moreover, one of the factors behind the widespread change to flat roofs is that they probably need personal spaces for each family to use, rather than outside common spaces, to reflect the change from extended families to nuclear families.

Fig. 2-6-36 Rearside of southern houses used for sunbathe or farming (*Layebo*)(S14 rearside)

Fig. 2-6-37 They drying cereals on street in front of sunny northern house (Outside of the investigation site)

Fig. 2-6-38 Flat roof extended relatively at the initial stage of townscape transformation inside investigation site (view to N02 from N07).

Fig. 2-6-39 Drying cereals in the sun on the roof floor (N13)

6. Other cases of renovation

Although we cannot identify it as a common characteristic, there are various renovation cases due to the necessity of life. In the case of Building S11, engraved pillars, which are very important elements for the historical succession of traditional house, are reused without documentation at different position. We need to investigate this matter in detail in near future.

Fig. 2-6-40 Courtyard becomes smaller as houses around were extended in reinforced concrete in the inside courtyard (rearside of S15)

Fig. 2-6-41 View of narrow courtyard (Fig.2-6-40) from upper floor (rearside of S15)

Fig. 2-6-42 Window faced to the courtyard was filled with bricks for extension (S14b)

Fig. 2-6-43 Beams of different members were poasted in line. Some of them were put on the former renovation. (S10b02)

Fig. 2-6-44 Example of installation of brick post for reinforcement (S11)

Fig. 2-6-45 Engraved pillar reused as a beam of the ground floor (S11)

2.6.7. Transition of housing arrangements

Although each courtyard has its own boundary, they have typically been used as a semi-public space. This space, though, has become smaller gradually from 1934 to the present day because of extensions and rebuilding around them. Most of the courtyards simply became storage spaces for materials after the 2015 disaster.

The through passage which leads from the main street to the rear is a very important urban space not only in Khokana but also throughout towns in the Kathmandu Valley. As shown by Building N07, the through passage (*"Galli"* in Newari) is installed again even though houses on both sides of it have been rebuilt. Furthermore, there are common spaces in wellhole style. (void space called *"Dhalipwa"* in Newari), used as drainage spaces for rainwater and the water from life activities, between neighbouring houses. According to the interviews, there are some unwritten rules stipulating that those spaces need to be maintained even when the houses are rebuilt. These rules are still respected at present: for example, there is a common well left at the courtyard at the rear of building N08.

This report has already indicated that the number of courtyards in the investigated site has been decreasing remarkably in this decade. Fig. 2-6-46 shows, in chronological order, the transformation of outside spaces including courtyards caused by extensions and rebuilding.

There are several through passages leading to courtyards or houses behind streets in the investigated site. Each of them has different uses or conditions. As the doors to some of these passages were locked, we could not investigate all of them. However, we show some of the passages that we were able to investigate as they are important factors for examining the future spatial structure of Khokana (Fig. 2-6-47 ~53).

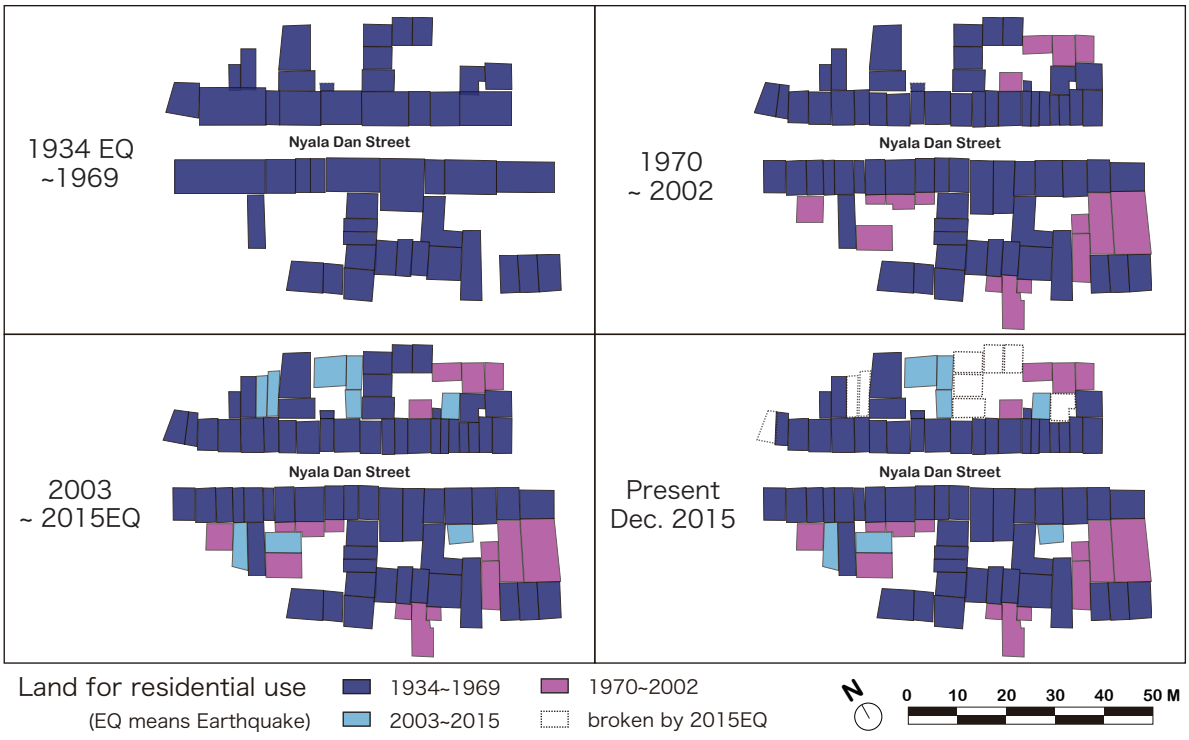

Fig. 2-6-46 Transition of courtyards with extension of housings

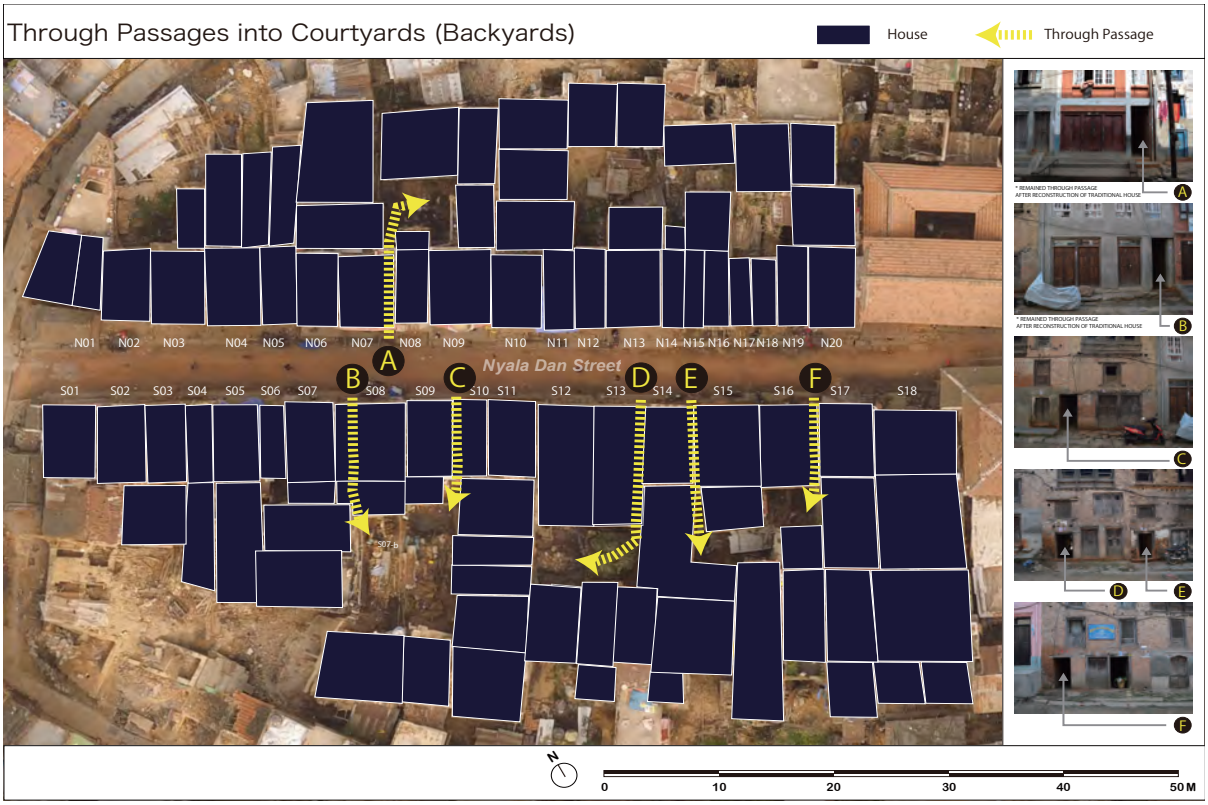

Fig. 2-6-47 Situation of through passage of the inside investigated site

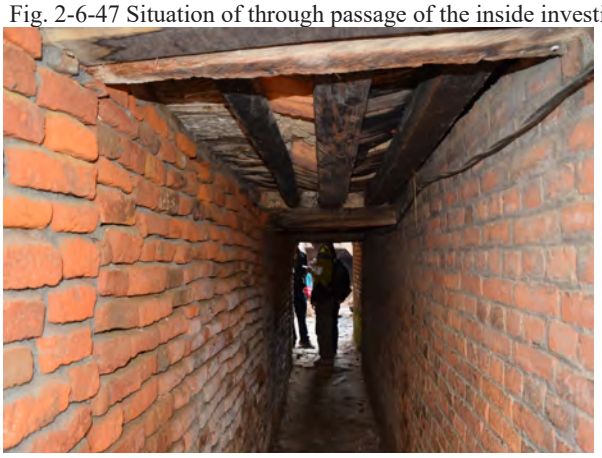

Fig. 2-6-48 Through passage (*Galli*) (S03)

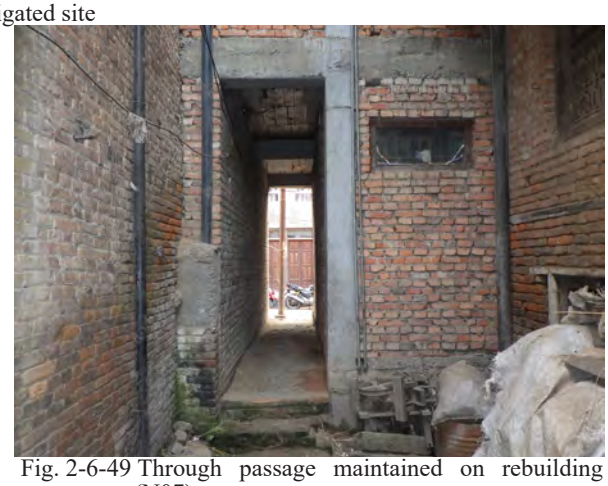

Fig. 2-6-49 Through passage maintained on rebuilding (N07)

Fig. 2-6-50 Example of through passage whose space was composed of houses on both sides (S09-S10).

Fig. 2-6-51 Common open ceiling space for such as drainage (*Dhalipwa*)(S05)

Fig. 2-6-52 After the disaster of 2015, lots of materials in the courtyard disturb its use. (Courtyard at the back of S08 and S09)

Fig. 2-6-53 The well used to be shared by residents around (N08).

2.6.8. Extensions due to the increasing number of people in households and segmentations of housing lots due to distribution of properties

It was clarified in the interviews that after proprietors' deaths, their extended families are separated by each household and house occupied, resulting in the housing lots being divided. The housing outlines have been changing specially in this century depending on the incomes of each family or ages and jobs of their members and they extend their houses or rebuild especially after the division of households when their children grow up.

For example, we investigated Building N08 to explore segmentation of housing lots caused by separation of the household. First, the interviewee and his cousin divided the original building (NRU05) into N08 and N09 to distribute the property about 30 years ago. They then extended N08 at the rear, adding a lavatory (Ground floor), storage (First floor), and a flat roof as their children grew older. Subsequently, a house for the interviewee's relatives was built in the spacious courtyard of the rear eight years ago. A collective house sharing an entrance for the families of the second son and third son was then built six years ago. As the interviewee's house was seriously damaged by the 2015 earthquake, he now lives in his third son's house.

In summary, the original houses and their lots of 1934 have since been divided due to the separation of every household. This enables us to trace the original unit's transition into the different houses of the present day through this research.

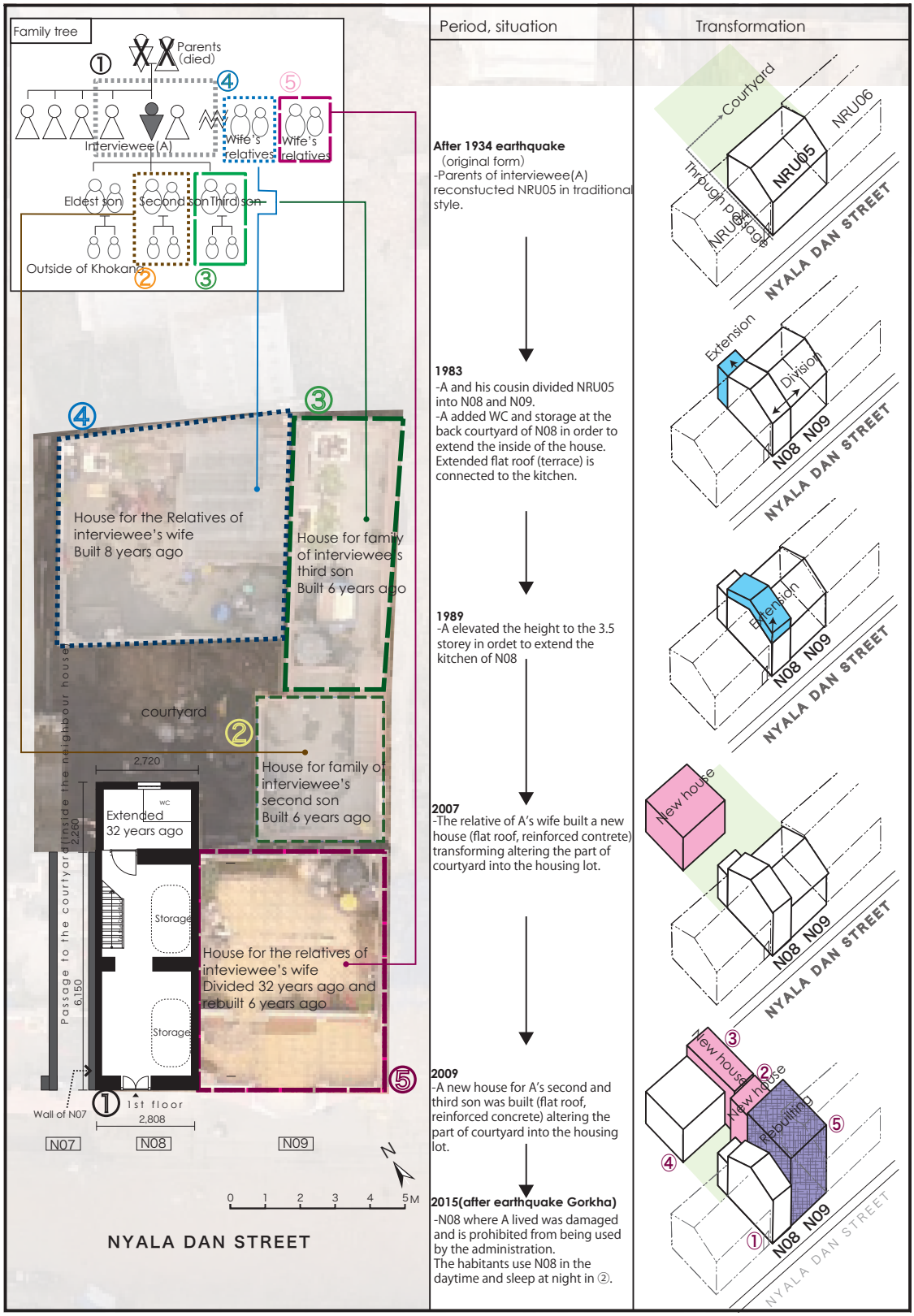

Fig. 2-6-54 Example of segmentation of housing lot by every household (N08)

2.6.9. Lifestyle of neighbouring of the relatives

The preceding paragraph shows that the relatives of the interviewees came to neighbour each other through extensions or rebuilding of their own houses. Fig. 2-6-55 illustrates how the relatives live in each household. We can see in this figure that many relatives live closely, though each family has their own house, as we have seen in the earlier paragraph. In this investigation, it was impossible to conduct a field survey of all the houses along the street and its rear. However, it is necessary to understand the ensemble of such families, houses, and the building lots as those detailed in the earlier paragraph to consider the future rehabilitation plan. We conducted this field survey only along Nyala Dan Street. However, we need to understand the distribution of each Zaat – the base of the Nepal society – in the whole village of Khokana. Therefore, in addition to the perspective of city planning, that of the immaterial culture or ethnological knowledge strongly demands future research.

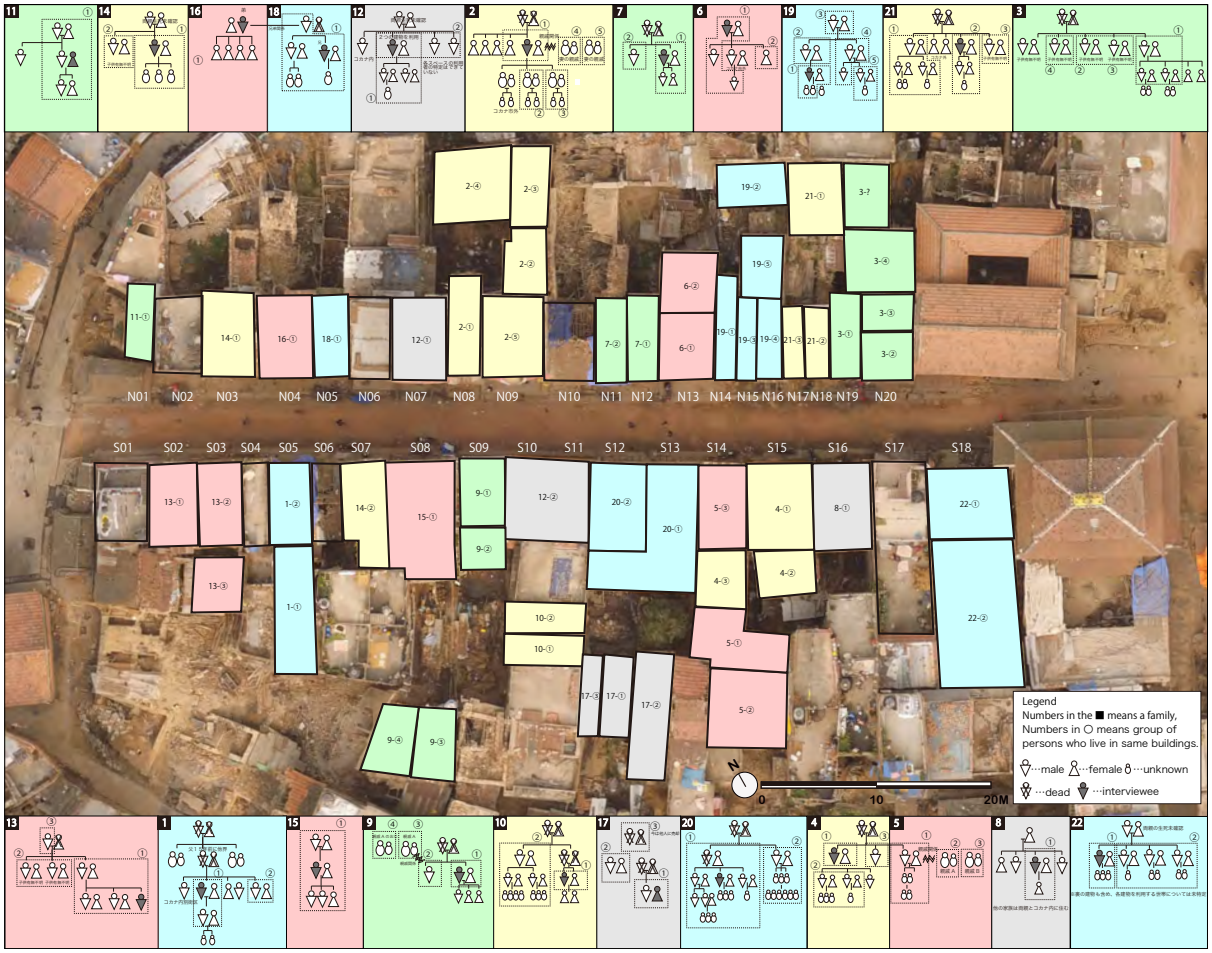

Fig. 2-6-55 Situation of neighbouring of the interviewees' relatives/families (distribution of owners or users of investigated houses)

2.6.10. Conclusion

1. Summary of investigation

(1) Causes of transformation of the townscape

We grasped the transition of the changing townscape along the target site (Nyala Dan Street) and of block patterns (e.g. courtyards) inside. We then identified the causes of those changes as follows: population increase, changes of family structures, and the division of the extended family by every household (nuclear family, etc.), which has influenced the division of existing houses and properties or the extension and/or renovation of houses. Furthermore, lifestyle changes pressured residents to extend their living spaces, especially the kitchen, and this is another factor in the transformation of the townscape. Further, the changes of spatial use of agricultural facilities (e.g., workshops and animal shed), such as for drying cereals, are related to the changes of the buildings' interior spaces or façades.

(2) Housing lots that should be considered as integrated units for rehabilitation of traditional living spaces and their transformation

First, the ownership and management unit of houses or housing lots have changed remarkably since 1934. However, even after the segmentation of housing properties or their rebuilding, the households of the same relatives live closely and they generate living arrangements, such as sharing spaces for agriculture and stock farming. Moreover, as for the outside, there are some unwritten rules concerning sharing spaces with the neighbourhood and maintaining through passages.

The current outlines of houses and lots are quite different from those of 1934; consequently, we cannot surmise their past situation from the present. However, by conducting research interviews, we have been able to deduce the property boundary of each household, the past shape of the buildings or their sites around the common courtyards, and the traditional way of living, such as with relatives. That leads us to consider the units that should be planned together for rehabilitation of traditional living spaces.

2. Recommendation for the future Khokana

(1) Design guidelines which can accommodate the demands of residents on living spaces

Through the field survey, we have clarified that the demands of residents for extension of living spaces, such as kitchens, lavatories, or sunny flat roofs exclusive to dry farm products, have accelerated the transformation of houses. It is necessary to avoid restraining those demands on the basis that they are not the historical customs of Khokana, but instead to formulate design guidelines which can accommodate these demands upon houses. Otherwise, if we now rebuild traditional houses ignoring residents' demands, they would inevitably, in the future, be changed into unpleasant houses for the townscape.

(2) Succession of the structure of village (ex. the past land use, housing layout)

The current architectural forms or boundaries of their lots have already changed from the traditional and vernacular urban spaces which were previously evaluated as candidates for World Heritage Site status. Thus, if we set the traditional townscape as our goal of rehabilitation, we should study the rehabilitation planning considering the original housing and lots, rather than the current ones. As we develop this research content, we need to clarify the family structures, the original lots, and information on the rights of the land as fundamental details for the planning development.

Furthermore, it is desirable that traditional spaces are rehabilitated by respecting and continuing the renovation of the spatial composition of past courtyards, public spaces along the street, and through passages. For example, the houses built at the rear of the street 30-50 years ago have structural problems, and outside lavatories that were constructed for the hygienic solutions could be installed inside. Relocating these outside lavatories would lead the rehabilitation of the courtyards and the traditional structure of Khokana.

(3) Study on new residential area corresponding to the increase of population

By 1969, more than one generation had passed since the reconstruction after 1934. In consideration of this, the townscape of 1969 had already changed because of the increase in population. In 1996, when the village was listed on the tentative World Heritage list, there were alternations of generations and increasing in population; after that point, the rapid reconstruction began.

The population of Khokana has increased from 2,546[3] in 1969 to 5,368 [4] in 2015 in statistics. Among the 2015 population, 618 people are aged from 0 to 10 years old. When this young generation have their own families in Khokana, their houses will need to be rebuilt. If we consider the former traditional townscape as the ideal image, the village holds already surplus population now. It is important to avoid uncontrolled expansion of the village and to maintain the cultural landscape of agriculture periphery of Khokana. Therefore, we should now examine not only how to rehabilitate the village but also how its population will increase in the future. We should also expect the construction of a new residential area so that some of increasing residents can live outside the centre of Khokana.

3. Future investigations (future issues)

(1) Survey of lifestyle with the relatives, on the basis of occupation

It is necessary to develop a rehabilitation plan for the collapsed or damaged houses in Khokana in order to maintain the local community. It is advisable, in addition, that the village be rehabilitated preserving the current residents' lifestyle of Khokana as much as possible, including the neighbouring of relatives, sharing a kitchen, and having meals together, all of which we clarified in this investigation. If a new residential area is to be constructed, the local community still needs to conduct its plan taking into account each resident's occupation and the relation of the residential area to farmland. To plan a residential area appropriate to the residents' lifestyles, we need to conduct a more profound and detailed investigation on the residents' occupations and lifestyles.

(2) Detailed investigation of traditional houses in Khokana

One of four traditional houses which escaped the collapses caused by the earthquake is situated on Nyala Dan Street (S10 and S11). Like other houses, this house has suffered significant transformation; however, the stones piled up before 1934 remain in the foundations, carved timbers remain inside, and the original courtyards are kept in good condition. There is also the altar inside which an image of a Goddess was previously placed. This house is thus the public space of the residents. As it is very important for the history of Khokana, it is advisable to investigate it more profoundly, with the perspective of conservation and restoration.

Fig. 2-6-56 House which has remained from before 1934 (partially extended)

Fig. 2-6-57 Stone showing the existence of God set in front of the entrance to the backyard (Pikhalaku)

(3) Making mechanisms to both rehabilitate the townscape and conserve the terraced paddy field in parallel

We cannot say that the living culture of Khokana would be truly rehabilitated even by renewing or restoring the traditional houses and recapturing the beautiful townscape. The living culture unified of village and terraced paddy field around it, life and production should be protected in Khokana.

Although the important historical houses could be conserved, restored, or rebuilt using outside funds, most of the other houses and the rest of the townscape cannot seemingly be rehabilitated without self-supporting endeavours.

The farmer on his 60s, who worked on a farm, said during his interview, 'I am afraid that the next generation might not succeed the land which I inherited from my ancestors and that none of them is in charge of the terraced paddy field in the future because most people of the same generation as my son (30s or 40s) are not farmers'. He also revealed, 'there are some people whose sons sold a part of the terraced paddy field to others and allotted the profit for living expenses'.

Most of the terraced paddy fields in Khokana are under the direction of more than one Guthi[5] . However, we saw several cases of farmland being converted into housing lots. Farmland is the property of the residents (farmers) and is directly related to the rehabilitation of the townscape, as it will generate the funds for the conservation and rebuilding of houses. Consequently, one of the most important issues is how to manage the farmland for the protection of the whole landscape of Khokana.

Thus, we need to examine whether only continuous land use as a terraced farm for agriculture leads directly to the protection of the cultural townscape. During the field survey, we found that a person outside Khokana rented land from a farmer living in Khokana and began to engage in agriculture. However, he built plastic green houses on the terraced paddle field and these houses adversely affect the vernacular landscape of Khokana. This case shows what preservation of the cultural landscape of Khokana's terraced paddle fields depends upon. It is not sufficient to simply keep using the terraced paddle fields as farmland only: they also need to be managed appropriately.

Considering the investigation detailed above, it is necessary to examine how to preserve the landscape of the terraced paddle fields, which is tightly linked to the rehabilitation of the townscape. This may involve, for example:

① conducting further interviewing surveys of the stakeholders (mainly Guthi) who possess and manage the terraced paddle fields about its present state affairs and the future issues;

② exchanging opinions with people of the next-generation who will later manage the terraced paddle fields; and

③ examining the approach to collect funds for rebuilding farmers' houses, except for the sale or leasing of farmland.

For example, there is a possibility to establish experimentally such systems as the 'terraced paddled field mortgage', which could lend the money for rebuilding houses to farmers with their terraced paddle fields as collateral. With the rehabilitation plan, it is necessary to tackle this as an urgent issue, establishing fund return systems to conduct both the rehabilitation of the townscape and the protection of the terraced paddy fields simultaneously.

Section authors : Hiroki Yamada and Naoaki Furukawa

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Notes:

Note 1. Khokana, which is known for Shree Rudrayani Temple, is a village principally occupied by farmers (*Zaat*) called *Jyapu*. According to Reference 5 with correction by Samita Shrestha, interpreter of this investigation, '*Zaat* is the Newari, which sometimes means as "race" or caste'. Other than *Jyapu* (Farmer *Zaat*), Guruzu (priests), *Shrestha* (Civil servant *Zaat*), *Tuladhar* (merchant *Zaat*), *Nae* (*Zaat* who slaughter animals), *Zogi* (*Zaat* who are members of a music band) also live in Khokana.

Note 2. Ms. Nabha Basnyat Thapa, who is the project officer of the UNESCO Kathmandu office, said at this project's conference held on the 5 February 2015, "even though Khokana is on the tentative list of World Heritage but it is not the Protect Monument zone. Only the Temple is protected according to the Ancient Monument Protection Act by DoA".

Note 3. Cf. Reference 2, p. 64.
Note 4. Cf. Reference 8.
Note 5. Guthi is the joint organization system of religious services with traditional interdependent character, established by the Newar people. According to the definition (f) of the second section, the first chapter of `Guthi Public Corporation Law of 1964` (cf. Reference 9), Guthi is defined as follows, 'it is the group which received the transfer of the fund to produce movable property, real estate or other profit from a charitable person with the proprietary rights in order to construct/manage/ maintain (temples / rest houses / the lodgings / reservoirs / water tanks / bridges / schools / houses / buildings / facilities) for celebrating religious festivals/ceremonies/festival, or other religious or charitable purpose'.
Note 6. All the photographs without specific accreditation were taken by the authors.

2.7. Survey of Intangible Cultural Heritage in Khokana

Introduction

The spatial elements of the traditional neighbourhood of Khokana include not just its buildings, but also spaces such as the streets and plazas and the faith-related elements located there, including small shrines; it also includes life around the wells and other areas. In many cases, these elements are intimately related to intangible cultural heritage such as faith and life.

'Cultural space' is also included within the category of intangible cultural heritage. Intangible cultural heritage generally evokes traditional performing arts and industrial artistic technique, but the concept of cultural space has also been presented not as these individual cultural expressions, but as the totality of the spaces where these artistic acts are actually performed and the life spaces of people who occupy the background of this artistic activity. We may cite Jemaa-el-Fnaa Square in Marrakesh, the Moroccan capital, as an example. There, a wide variety of people, including street entertainers and music groups, stall keepers, food booths, and tourists engage in various activities, and are listed as a whole as an expression of mass culture on the UNESCO Intangible Cultural Heritage List.

Together with our urban planning survey of Khokana, we also conducted a survey of elements related to these cultural spaces. This is because the preservation of these cultural spaces is indispensable to restoring Khokana while preserving its traditional neighbourhood.

2.7.1. Survey of cultural space in Khokana

1. Element Mapping for Cultural Space

For our survey of the elements of cultural space, we identified a certain number of element types and employed the method of mapping their distribution. Identified elements considered to be important in current Nepalese culture are as follows.

- Small Shrine (*Lacchi/Chaitya*)
- Pagoda
- Buddhist temple
- Rest Space (*Pati*)
- Square
- Well
- Pond
- Water Area
- Mustard Oil Mill
- Others

Among these, there are both Hindu and Buddhist small shrines, and it appears that they are distinguished locally by calling the former Lacchi and the latter *Chaitya*. The pagodas are mostly of the

stupa form of Tibetan Buddhism, and most of those situated in Khokana are small.

As may be expected, there are also Hindu and Buddhist temples. In Khokana, the representative temples are the Shree Rudrayani Temple in the centre of the village and the Shikali Maju Temple on the outskirts, both of which are devoted to worship of Hindu goddesses.

Rest spaces are locally called *Pati*, are often built in squares or by the roadside, and in many cases are cottages without walls. They are primarily used for resting, but frequently a divine image is enshrined there. Therefore, differences between *pati* and small shrines are vague.

Squares are divided between those that face the road and are comparatively wide and those in a courtyard that are surrounded by a building and comparatively narrow. In many cases, these squares contain facilities including small shrines, rest spaces, wells, or water areas and are public spaces for performing rituals and daily activities (e.g. laundry, threshing, etc.) At the present time, because waterworks have been installed, drinking water is taken from these waterworks; although well water is no longer used for drinking, it is now used for such purposes as laundry and dishwashing.

There are six main ponds inside Khokana, and it is thought that these are normally used as reservoirs for water used for farm work, but they are also stages where rituals are performed. In particular, the pond called De Pukhu located at the centre of the village is used as a place to slaughter many goats during festivals. According to legend, the divergence of the canal (Rajkulo) constructed by the king during the Malla period flows under Khokana as an underground canal; it is believed that the six ponds are all interconnected through this underground canal.

Water areas are narrow partitions where a spout or concrete water tank is set up around the perimeter; this establishes a space where water is drunk or daily tasks, such as laundry, are performed. It is likely that the spouts are of an older form and that the concrete water tanks have been newly established following the recent development of waterworks. Many of the water areas face the road and are set up so that all of the residents may use them.

The making of mustard oil in the village's mill is one of the main industries of Khokana. Its mustard oil making now receives special mention in the description of Khokana listed on the UNESCO World Heritage Tentative List; it is also considered an important cultural element. At one time, there were four mills, but only two are currently operating (as detailed further above).

Other important elements of cultural space include Shivalinga signifying a symbol of the goddess Shiva, the altars or worship places where sacrifices are made during festivals, symbolic trees, and crematoria along the Bagmati River.

The supplement 'The Khokana Cultural Spatial Elements Inventory' summarises these elements and conducts a distribution survey of Khokana and its surroundings. An exploratory onsite survey was conducted on 22 and 24 September 2015 and this survey was held from 22 to 24 November 2015.

2. The Squares and Public Space

Amongst the elements related to cultural space in Khokana, we consider that the square is a particularly important spatial element. This is because the square is a public space where festivals and daily tasks are performed and also because we understand that the residents see the square as being culturally important.

In the process of mapping, we suggest that the types of squares in Khokana may be roughly divided into two categories. One is the “open type” and the other is the “semi-closed” type.

The open square faces the road, is comparatively wide, and is used on a daily basis by many of the residents. Examples that may be cited include the square called Chwe Lacchi located in the centre of Khokana Village (Site 23), the square called Kwelacchi surrounded by three Guthi buildings (Site 32), and Site 14, Site 22 and Site 28. By contrast, the semi-closed square is a courtyard surrounded by buildings and a comparatively narrow space. Site 7, Site 20, Site 27 and Site 29 may be cited as examples. According to interviews with residents, even the semi-closed squares are basically used as public spaces but they appear to be used and managed by a comparatively limited group of residents.

Both types of square often have facilities, such as small shrines, rest spaces, wells, and watering areas. This indicates that the squares are used as religious spaces and daily life spaces. In particular, the fact that wells and water areas are established in them indicates that water is central to public activities.

Fig. 2-7-1 Examples of a left: “open type” square (Site 32), and right: “semi-closed” square (Site 29)

3. Proposals concerning the preservation of cultural space

Through this onsite survey, we learned that today there remain elements related to cultural space in Khokana Village. Some of these have been seriously damaged by the earthquake, but it has been confirmed that many elements and the religious and daily life activities related to them continue to exist.

One point requiring attention for the future restoration of the neighbourhood is that reconstruction should be undertaken without drastically changing the constitution of this cultural space. Particularly with regard to squares, we anticipate there is a high possibility that the '‘semi-closed type’ will undergo change during reconstruction. This is due to the possibility that, in the process of rebuilding residential buildings, this narrow space will be used as residential land and will, consequently, disappear.

Moreover, we also learned that, in the cultural space of Khokana, elements related to water are important. In particular, the six ponds perform an important role even in rituals conversely, however, water pollution is serious. Moreover, water pollution is indeed serious even for traditional water resources such as wells in squares. We will, therefore, focus on water-related elements in the next section.

2.7.2. Survey of the water landscape in Khokana

1. The importance of the water landscape in Khokana

Through the survey of cultural space in Khokana, we discovered the importance of water-related elements in the village. An important point here is that in the public space of the square, water resources such as wells and water areas are important spatial elements. Another point is that, as shown by the six ponds, water performs an important role in rituals and, simultaneously, the water landscape is also an important spatial element in Khokana's cultural space. In addition, most of Khokana's residents belong to the farmer caste and water is an indispensably important resource for conducting farm work around the village.

Because water elements have this importance in Khokana, we shall use the term 'waterscape' to refer to the various elements related to water.

The problem is that this 'waterscape' is on the verge of a certain type of crisis.

During this survey in November 2015, Associate Professor Kumiko Oguma of the University of Tokyo conducted a water quality survey for the pond and well water, and confirmed that most of the samples had reached levels of pollution unsuitable for drinking. In addition, at the time of the survey, many of the ponds were muddy and even malodorous. Today, because waterworks have been installed, ponds and wells are not used directly for drinking, but they are still used for laundry and farm work, leading to concerns about their ongoing impact. Furthermore, the pond water pollution is also seriously damaging to the aesthetic elements of Khokana as cultural heritage.

Therefore, in this onsite survey, we decided to conduct a survey also for the system of drainage water and to obtain basic information for the preservation of Khokana's waterscape.

2. The sewage system in Khokana

We conducted an onsite survey to apprehend the traditional sewage system in Khokana. To this end, we took the irrigation canals and the sewage system for street gutters as our subjects; the recently installed waterworks are not a subject of this survey.

According to legend, the water canal (Rajkulo) developed by the kings during the Malla period flows in the east of the village from south to north and its divergence is pulled into Khokana. It is also believed that in Khokana Village, the Rajkulo is an underwater canal that connects each of the six ponds together.

In the onsite survey, we were unable to confirm the existence of such an underground canal. However, we were able to confirm the presence of the irrigation canal thought to be a divergence of the King's canal (Rajkulo). Moreover, we also confirmed the direction of the water flow from the gutters of each of the village roads. This is because the sewage produced from the activities (such as laundry) in the square mainly drains into the street gutters. The attached Fig. 2-7-2 summarises these survey results.

Through this survey, we confirmed the divergence of the water canal thought to be the King's water canal (Rajkulo) being pulled into the village from the east and the circular flow of the canal outside the village. We believe this a system to supply water for farm work to the terraced paddy fields that spread around the village. Regarding the movement of water within the village, it was confirmed that the water is

drained through the street gutters, generally following the topography from east to west. It should be noted that this drained sewage water flows directly into the abovementioned canal that surrounds the village, and is not part of a system that separates water for farm work from sewage water. However, the sewage water from the street gutter does not flow directly into the ponds. Nevertheless, in actuality, the possibility that sewage water is entering the ponds by seeping into the ground in times of heavy rainfall cannot be denied.

Looking at the sewage system of Khokana in this way, it may be understood that Khokana is a hub for providing water to the surrounding terraced paddy fields. As Khokana is formed at the edge of the topography on top of a mountain ridge, it is thought that an irrigation system was achieved by circulating water to the tip of the ridge through a manmade canal and, from there, supplying water in a radial pattern to the surrounding sloped land. In essence, we believe that Khokana's waterscape was a system in which the supply of water to the village and the function of an irrigation system were organically linked together.

Fig. 2-7-2 Inside of Khokana village and its surrounding irigation and drainage system

3. Proposals for the Preservation of Khokana's Waterscape

In this way, we believe that Khokana's waterscape was traditionally a logical system. However, we have found that, today, this system faces a serious problem of water pollution and is on the verge of a crisis.

We believe that one of the causes is the development of waterworks. Undeniably, the waterworks have allowed residents to access safe drinking water. However, we believe that this has separated the original drinking use from the water obtained from the water canal and wells and has thus invited the unexpected consequence that the pollution of the water resources used has, until now, been neglected.

We propose two measures for solving this situation. The first is to improve the water drawn

into the village by the canal. Because this water is supplied through an open channel irrigation canal, it is possibly already polluted when it reaches Khokana. Therefore, we suggest it is necessary to take such measures as establishing a water purification plant to purify the water at the stage just before it reaches Khokana.

The other measure is developing the sewers. At present, the sewage water drained from the wells and water areas flows directly into the road gutters and, from there, flows into the water used for farm work. We propose it is necessary to develop sewers to prevent this sewage water from flowing into the farm work water and ponds.

In this way, by working to improve the water quality, the pond water will be cleaner than it is now and the aesthetic value of Khokana as cultural heritage will also improve. We believe that this will also lead to an improvement in residents' quality of life by allowing them to use well water more safely.

2.7.3. Conclusion

Through this survey, we learned that not only the traditional neighbourhood but also the elements of cultural space perform an important role in constituting Khokana Village's value as a cultural heritage site. In particular, we learned that the waterscape is an especially important element of Khokana. However, it has also become clear that there are issues facing the preservation of these elements. Regarding the recovery of Khokana too, we propose that developing while preserving these elements of cultural space will guarantee its value as cultural heritage.

Undoubtedly, besides cultural space, rituals and other elements of intangible cultural heritage play an important role. However, as there remains much to learn concerning the apprehension and understanding of these elements, we would like to make their consideration an issue for future research.

Section author : Tomo Ishimura

3. Buildings (Houses) and Survey of Disaster Damage Condition

3. Buildings (Houses) and Survey of Disaster Damage Condition

3.1. Exhaustive Survey of building damage condition

3.1.1. Survey aim

On 25 April 2015, a 7.8 magnitude earthquake with its seismic centre in the Gorkha region in Central Nepal struck, taking the lives of nine people in Khokana Village. The village itself, which is listed on the World Heritage Site Tentative List, was also seriously damaged. This report details the findings of a exhaustive survey conducted of buildings facing the street in the Southern Settlement Area, which is the main part of the village, from the perspective of preserving the townscape of the village neighbourhood; its aim is to gain useful insight for the recovery plan for this area.

3.1.2. Survey perspective

Referring to past research[1] and interviews conducted with specialists[2], buildings were classified as traditional construction (mix structure of brickwork and wooden frame) or non-traditional construction (Reinforced Concrete (RC) Build: C Type), with traditional construction being further divided into those having no extension work (A Type) and those with extension work (B Type)[3]. Regarding damage

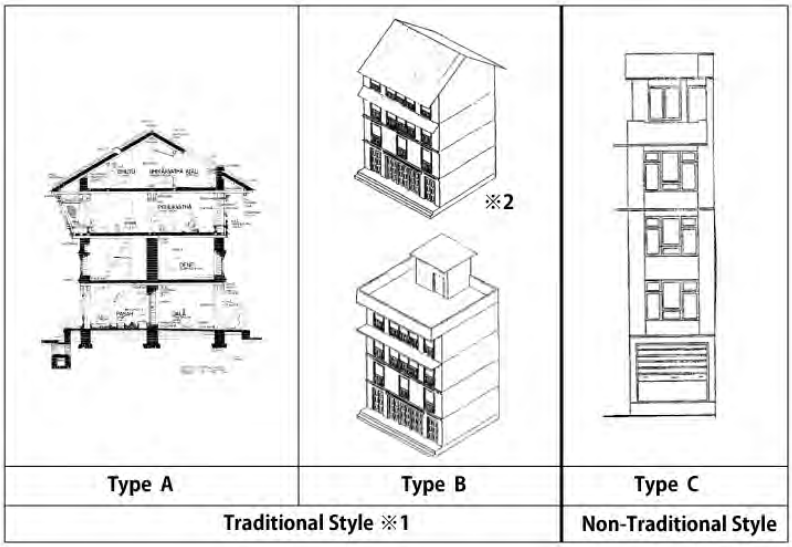


Fig. 3-1-1 Building typologies (Quoted note 3, modified by author)
*1 if it is difficult to judge by collapse, the building would be defined as Type AB
*2 Even if the building had been expanded, it will be regarded as Type A if it is in good condition.

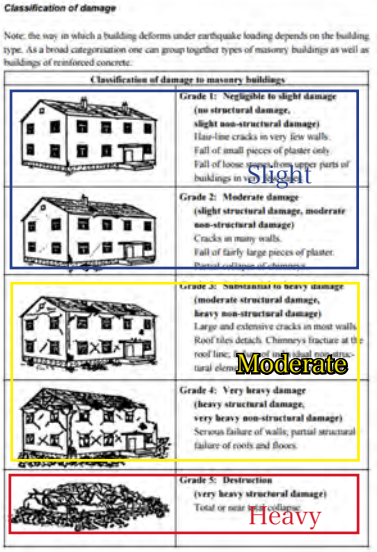


Fig. 3-1-2 Three stages of damage level (from note 4)

level, we established the three stages of heavy, moderate, and slight[4]. This survey focused on using eyesight to appraise the disaster damage to facades from the perspective of townscape preservation.

3.1.3. Survey method

We resided at the site from 22 November to 6 December 6 2015, and conducted the survey with a total of seven members, comprising: two faculty members of the University of Tokyo, Urban Design Lab, two students enrolled in the masters' degree programme, Professor Bijaya Shrestha of Khwopa Engineering College (a graduate of Tokyo University), and two of his students. Based on two person's teams comprising one person from Tokyo University and one from Khwopa Engineering College, each building was assigned a number, had its façade photographed, and had its measurements taken focusing on:

- number of floors;
- number of added floors;
- the existence of partitioning;
- the purpose of the ground floor;
- wall thickness;
- frontage; and
- ceiling height,

while also judging the stage of damage level based on the building classification described above (Tab. 3-1-1).

Tab. 3-1-1 Survey sheet

OUTLINE	**Style**	☐ A ☐ B ☐ C
	Damage	☐ Total ☐ Half（story: ） ☐ Facade remains ☐ Little/None
	Story	☐ 1st ☐ 2nd ☐ 3rd ☐ 4th ☐ 5th ☐ 6th
	Added Story	☐ 4th ☐ 5th ☐ 6th ☐ None
	Vertical Division	☐ Divided（Number: ） ☐ Not divided ☐ Unknown
	Corner	☐ In a corner ☐ Not in a corner
	Housing Type	☐ Type Ⅰ ☐ Type Ⅱ ☐ Type Ⅲ ☐ Type Ⅳ ☐ Type Ⅴ ☐ Unknown
	1st floor usage	☐ Housing ☐ Retail ☐ Storage ☐ Animals Shed ☐ Pati ☐ Walk through path
	1st floor size	CH: mm Storefront: mm Wall thickness: mm
	2nd floor size	CH: ☐ Lower than other stories ☐ Same ☐ Unknown
	Structure	☐ Bricks ☐ Timber frame + Bricks ☐ RC Addition: ☐ Bricks ☐ Timber frame + Bricks ☐ RC
	Brick Type	☐ Baked Bricks ☐ Sun-dried Bricks
	Masonry Joint	☐ Mud ☐ Mortar ☐ Unknown

3.1.4. Survey result and considerations

Through the exhaustive survey, records were taken for a total of 596 buildings in both the Northern and Southern Settlement Areas (Appendix 4). We will perform an analysis on 577 buildings[5] in the Southern Settlement Area.

1. Building ratio by construction method

We learned regarding the building ratio by construction method that approximately 60% of the total are buildings made from traditional construction methods (Fig. 3-1-3, 4).

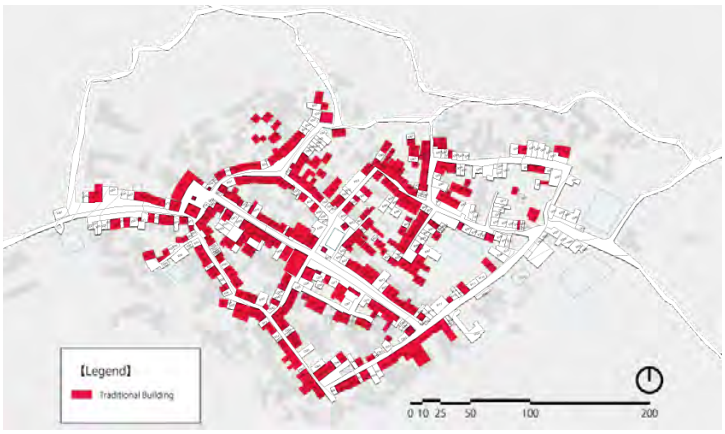


Fig. 3-1-3 Distribution map of traditional method of construction buildings in the southern settlement area

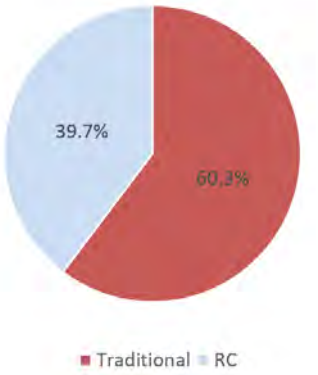


Fig. 3-1-4 The ratio of traditional construction buildings and RC buildings in the southern settlment area

2. Disaster damage condition

Because this survey strictly concentrates on disaster circumstances pertaining to the external appearance of buildings, it is taken as a premise that its results will not match those of a structural survey. However, based on our observations approximately 15% of the traditionally constructed buildings were totally destroyed, half were partially destroyed, and approximately 40% were slightly damaged or undamaged (Fig. 3-1-5,6). Regarding the disaster circumstances for the 232 non-traditionally constructed buildings, approximately 96% were slightly damaged or undamaged (Fig. 3-1-9), but we also learned through the interviews that there were cracks inside the buildings and curving in the floors. The detail of this damage is a subject to be addressed in the future.

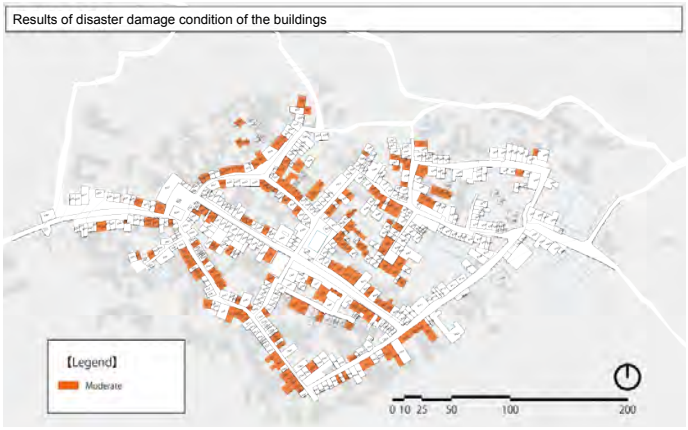


Fig. 3-1-5 Disaster damage consition of traditionally constructed buildings in the southern settlement area

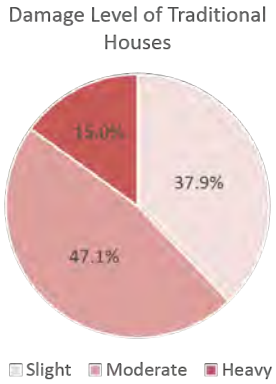


Fig. 3-1-6 Damage level of traditional houses

3. Issues related to the damage to traditionally constructed buildings

Besides the issue of the reconstruction method to be used for the 52 totally destroyed buildings, it is also necessary to establish whether existing repair reinforcement construction is possible for the 163 traditionally constructed buildings (Fig. 3-1-7) that have been partially destroyed, and the necessity of a fixed and specific presentation of methods. The residents of these partially destroyed buildings have dismantled the upper floor part of their collapsed houses and have covered the ceiling with zinc-coated steel (Fig. 3-1-8); they continue living bi-local lives, using the toilet facilities and storage spaces of their houses during the day, and sleeping in temporary residences at night.

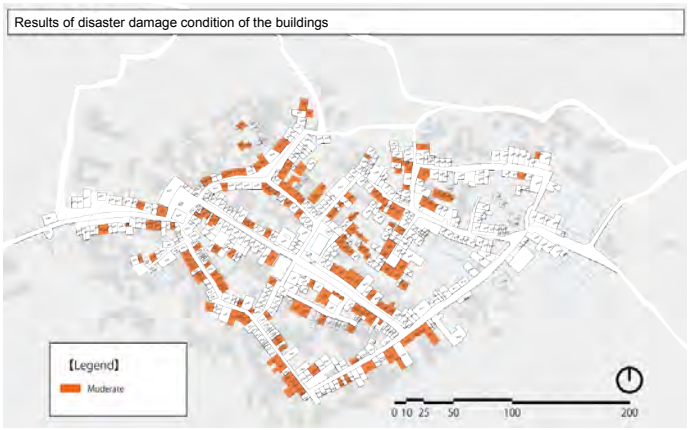


Fig. 3-1-7 Dirtribution map of half collapsed traditionaly constructed buildings in the southern settlement area

Fig. 3-1-8 Half collapsed traditionally constructed buildings

4. Issues and considerations for non-traditionally constructed buildings

Among non-traditionally constructed buildings, we observed many mainly five-storey buildings, made principally of reinforced concrete as their main structural part, with brick masonry on the exterior walls. The equally distributed non-traditionally constructed buildings (Fig. 3-1-9) pose a serious obstruction that damages the townscape. This research focused on the materials and finishing used on the surface of these buildings and their floor height for both sides of the neighbourhood constituting the façade of the Main street; we conducted the following analysis with the aim of apprehending the current situation.

Fig. 3-1-9 Distribution map of non-traditionally constructed buildings in southern settlement area (Slight and moderate damage)

(1) Materials and finishing

On both sides of the neighbourhood along the Main street, we classified the materials and finishing that constitute the façade and conducted analysis after calculating the distribution area. In Façade A, despite 11 out of the 15 buildings (approximately 70%) were traditionally constructed buildings, the results for the distribution area of the wall material and finishing constituting the façade showed that it was in equal proportions constituted of brick and mortar/painted wall (Fig. 3-1-10,11,12). Half the surface area of the façade was replaced with modern materials. Moreover, on the traditionally constructed buildings, a trend was observed towards finishing the ground floor and the entire surface with mortar as a technique for repairing exterior walls; there was also an observed trend of finishing non-traditionally constructed buildings with vivid colours. Detailed analysis of roofs, bracing, tiles, and wood carved windows that serve as important elements of traditionally constructed buildings is an issue for future consideration.

Fig. 3-1-10 Materials and finishing that constitute the façade of the main street

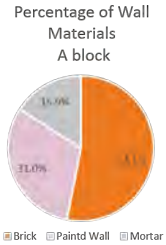


Fig. 3-1-11 Percentage of wall materials on A side

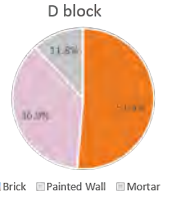


Fig. 3-1-12 Percentage of wall materials on B side

(2) Ground floor ceiling height

We learned from analysis of the ground floor ceiling height ascertained through the total survey that, whereas the average ceiling height for traditionally constructed buildings is approximately 1,900mm, the average ceiling height for non-traditionally constructed building is 2,500mm (Fig. 3-1-13). Changes in ceiling height naturally impact on the neighbourhood townscape. In this research, we next created and analysed a cross-sectional Figure of the Main street.

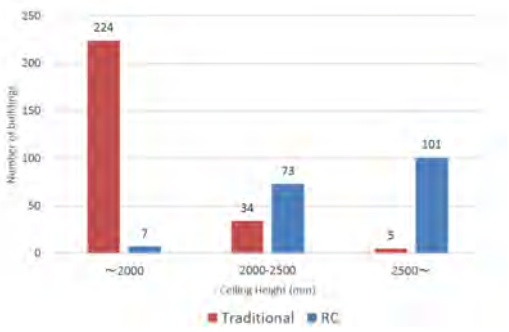


Fig. 3-1-13 Ground floor ceiling height of traditional and non-traditional buildings

(3) Townscape cross-section

On the main street, we created and analysed separate cross-sectional Figures for traditionally constructed buildings (Section A) and non-traditionally constructed buildings (Section B) (Fig. 3-1-14). The difference in the floor heights and number of floors for traditionally and non-traditionally constructed buildings is clearly changing the townscape of the neighbourhood. There are also many buildings that raise the floor height of the ground floor, and concrete stairs to eliminate the resulting gap have appeared, thus changing the landscape of the ground level. There is a tendency to use the ground floor as a garage for motorbikes and there were also observed cases of making a slope down to the street (Fig. 3-1-15). The degree to which the order of Newar living spaces detailed in past research[6] is carried on in non-traditionally constructed buildings is an issue we would like to address in the future.

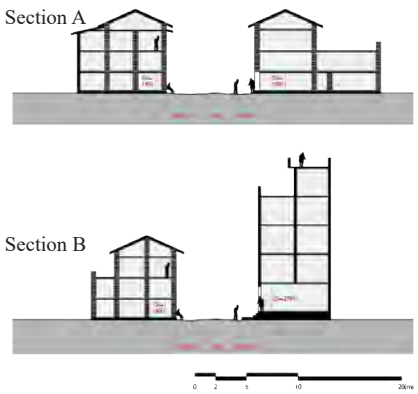


Fig. 3-1-14 Section diagram of the main street

Fig. 3-1-15 Ground level of main street (Taken in November, 2015)

(4) Considerations

There were many non-traditionally constructed buildings to which earthquake damage was minor. Therefore, from the perspective of the disaster recovery, there was comparatively little discussion on non-traditionally constructed buildings; as detailed above, though, there are many issues concerning townscape preservation. In the future, we suppose there is a significant possibility that reconstructed buildings will follow non-traditional construction methods; however, it is necessary to clarify the issues and formulate design guidelines in a direction that will not damage to the traditional townscape.

Section author : Tomoko Mori

Notes:

Note 1. Rohit Jigyasu et al., 'Katomanzu keikoku no dentōteki shūraku bungamati no henyō to seijakusei no zōdai ni kan suru kenkyū' (Study of Change and Increase in Fragility in Bungamati, a Traditional Village in the Kathmandu Valley) Rekishi toshi bōsai ronbunshū (Studies in Disaster Mitigation for Urban Cultural Heritage, Vol. 3, pp. 195-202, June 2009

Note 2. We received advice on Oct 23rd 2015 from Professor Masaya Masui of Kyoto University who participated in the September 2015 survey in Bhaktapur (Projected selected for grant funding for scientific research of Associate Professor Yamamoto Naohiko of Nara Women's University)

Note 3. UNESCO: Heritage homeowner's preservation manual, 2006

Note 4. EMS98 (G. Grunthai (Editor)): European Macroseismic Scale 1998, 1998

Note 5. Includes three cottages. The breakdown of the 593 building excluding the cottages is 577 buildings in the Southern Settlement Area and 16 buildings in the Northern Settlement Area.

Note 6. Ratna Keshari Prajapati et al., "Newaaru-zoku no sumai ni okeru hitobito no kōdō to kūkan ninshiki kara miidasareru kūkan gainen, nepaaru/katomandu bonchi no kokana to bungamati no baai," (Spatial Concepts Identified in the Actions)

3.2. Results of the Survey on the Disaster Damage Condition of Traditional Houses and RC Buildings, and Structural Analysis

3.2.1. Analysis of the extent of damage by exhaustive survey

We analysed the extent of damage of traditional houses and RC buildings in Khokana through an exhaustive survey. We will analyse the data statistically to comprehend the relation between the characteristics of the buildings and the extent of damage. When the damage was severe and it was difficult to establish the characteristics of the building, we surveyed by posing questions to the residents within the possible range.

The extent of damage by type of building structure is shown in Fig. 3-2-1. There are 107 Type A buildings, 172 are Type AB, 80 are Type B, and 234 are Type C. Type AB means that the damage is heavy, with the result that it is difficult to distinguish whether the building type is A or B, as shown in Pict. 3-2-1: in these cases, it is impossible to judge the relation between the degree of damage and the type of building structure. Fig. 3-2-2 shows the damage condition by type of building structure (Types A and B are combined, and compared with C). The degree of damage of Type C (RC buildings) is smaller, and around 95% of these buildings have no damage. We will analyse the traditional houses, Types A, AB, and B, below.

In the traditional houses in Khokana, the buildings extended by brick on the top floor are seen as shown in Pict. 3-2-2. Fig. 3-2-3 shows the disaster damage condition by the presence or absence of extension to the buildings: 165 buildings are non-extended, 77 are extended, and 117 are ‘unknown’. Since most buildings with a heavy degree of damage fall within this last category, it is impossible to judge the relation between degree of damage and the presence or absence of extension to the buildings.

Fig. 3-2-4 shows the extent of damage by the position of the buildings: 35 buildings are at the corner of the building complex, and there are 324 others. Buildings at the corner have heavier degrees of damage. It is assumed that the damage to non-corner buildings was decreased by the coupled vibration effect between the adjacent buildings.

Fig. 3-2-5 shows the extent of damage by the number of building storeys: 18 buildings are one-storey, 19 are two-storey, 95 are three-storey, 131 are four-storey, 1 is five-story, and the remaining 95 are ‘unknown’. Except for the unknown buildings, the degree of damage of one-storey buildings is the smallest, and the degree of damage of 4 or 5 storey buildings is the largest. When the building mass becomes larger by extension of the upper floor, resulting in the compression force acting on the brick walls in the lower storey becoming larger, the shear strength of the joint of the brick wall of the lower storey becomes larger. Conversely, the seismic force acting upon the upper floor is larger due to the amplification effect, and the compression force is smaller. In essence, therefore, the brick walls of the upper floor, with smaller shear strength of the joint, tend to be damaged. It is assumed that the more storeys a building has, the greater the degree of damage that it is likely to suffer.

Fig. 3-2-6 shows the extent of damage by the thickness of the walls of the ground floor. The number of the thickness of the wall means the number of bricks, and the size of one brick is 230mm: eight buildings are 1B, 19 are 1.5B, 216 are 2B, 35 are 2.5B, two are 3B, and 79 are ‘unknown’. Most buildings

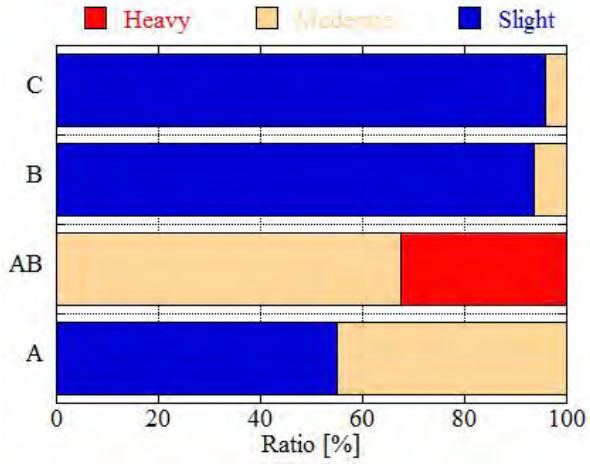


Fig. 3-2-1 Relation between the type of building structure and degree of damage

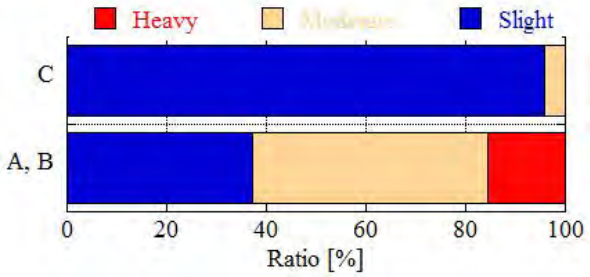


Fig. 3-2-2 Relation between the type of building structure and degree of damage (Type A and B is combined)

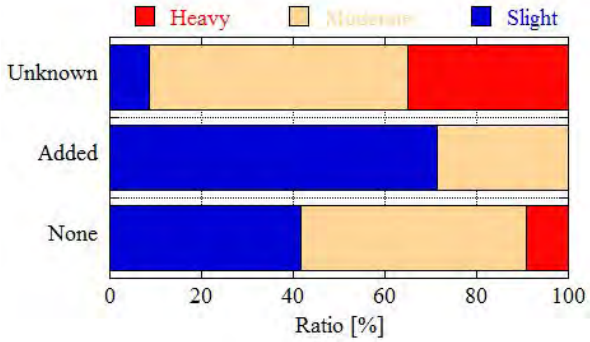


Fig. 3-2-3 Relation between the presence or absence of extension and degree of damage

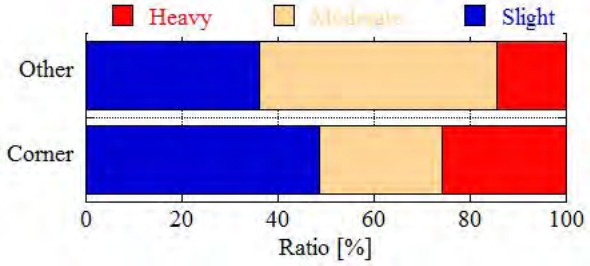


Fig. 3-2-4 Relation between the position of the buildings and degree of damage

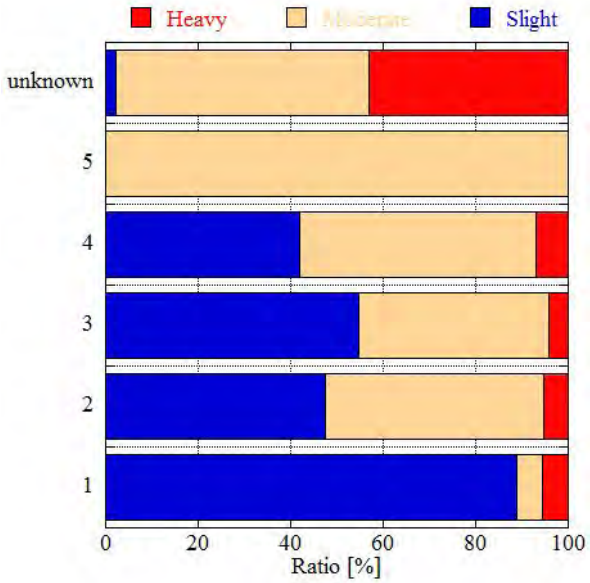


Fig. 3-2-5 Relation between the number of building story and degree of damage

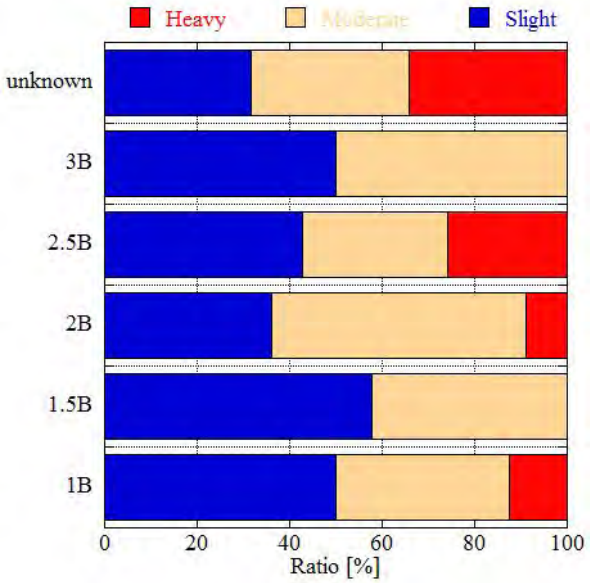


Fig. 3-2-6 Relation between the thickness of the walls at the first floor and degree of damage

have walls with a thickness of two bricks at the ground floor, so there seems to be no relation between the thickness of the walls of the ground floor and the degree of damage. Since the compression force acting on the top floor is smaller than that on the ground floor, and the shear strength of the joint of the brick walls is smaller than on the ground floor, it is, therefore, assumed that the thickness of the wall of the top floor has larger effect on the degree of damage.

Fig. 3-2-7 shows the relation between the ceiling height and the frontage of the ground floor. The frontage differs from 2 meters to 13 meters by each building, but the ceiling height of the ground floor tends to be around 1.6 meters to 2.1 meters in Types A and B, and 2.2 meters to 2.7 meters in Type C. Fig. 3-2-8 shows that there are no relations between the ceiling height, the frontage of the ground floor, and the degree of damage.

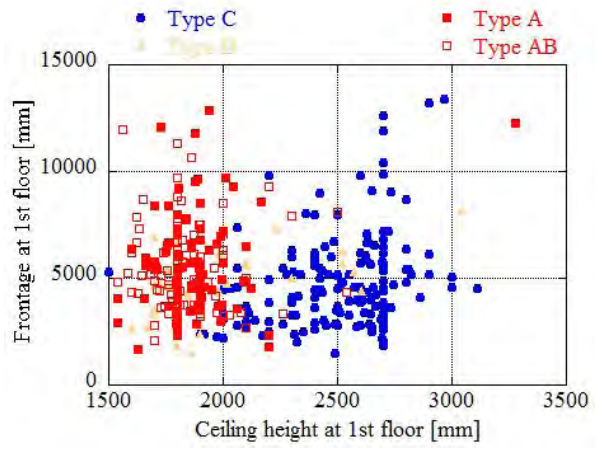


Fig. 3-2-7 Relation between the ceiling height and the frontage at first floor

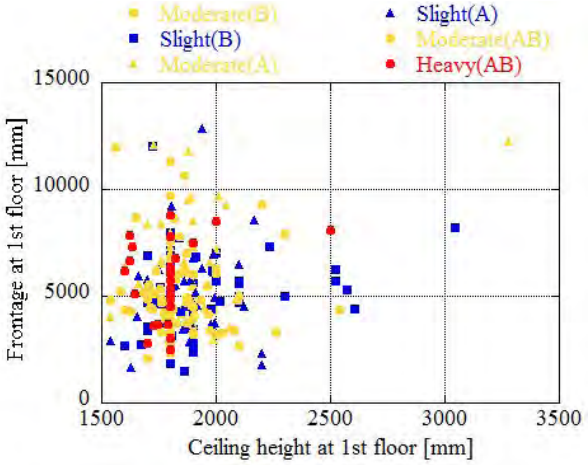


Fig. 3-2-8 Relation between the ceiling height, the frontage at first floor, and degree of damage

Pict. 3-2-1 Heavy damage of the building Type AB

Pict. 3-2-2 Extension at the fourth floor

3.2.2. An analysis of the extent of damage through the façade drawings before the damage

We seek to comprehend the relation between the opening ratio of the building and the aspect ratio (height / width) through the façade drawings of the buildings before the damage. As shown in Fig. 3-2-15, we measured the opening area of the ground floor by sight, and roughly estimated that of the upper floor and the collapsed area by the scale of the drawings. The façade drawings before the damage of Tah Jhya Street, Tah Lachhi Street, and Nyala Dan Street are shown in Figs. 3-2-9, 3-2-10, and 3-2-11. We analysed 49 buildings which are shown in these drawings except Type C.

Fig. 3-2-12 shows the extent of damage by type of structure: 23 buildings are Type A, 21 are Type AB, and five are Type B. Fig. 3-2-13 shows the relation between the ratio of opening at the ground floor and that of the top floor. The buildings of Type B tend to have an extended top floor, and have a smaller ratio of the opening of the top floor than that of the ground floor. As shown in Pict. 3-2-4, the ratio of opening of the ground floor is almost equal to that of the top floor in most Type A buildings.

Fig. 3-2-14 shows the relation between the opening ratio and the aspect ratio of the ground floor, and Fig. 3-2-15 shows that of the floor. The opening ratio of first floor is distributed from 20% to 60%, and that of top floor is from 10% to 40%. The aspect ratio is distributed from one to two in most buildings. The relation between the opening ratio or the aspect ratio and the degree of damage is not seen, so it is assumed that there should be other intervening factors.

Section author : Mitsuhiro Miyamoto

Fig. 3-2-9 TAH LACHHI STREET

Fig. 3-2-10 NYALA DAN STREET

Fig. 3-2-11 TAH JHYA STREET 2

Fig. 3-2-12 TAH JHYA STREET

Pict. 3-2-3 Picture taking during the survey

Pict. 3-2-4 Opening of the traditional houses

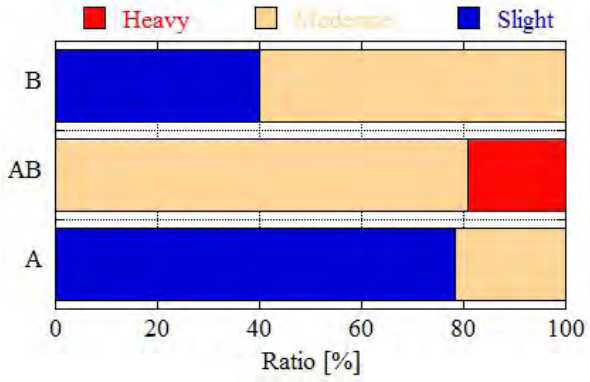


Fig. 3-2-13 Degree of damage of the target buildings

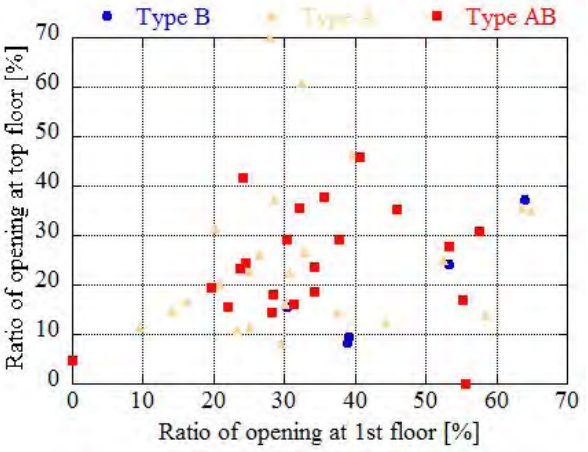


Fig. 3-2-14 Relation between the ratio of opening at first floor and that at top floor

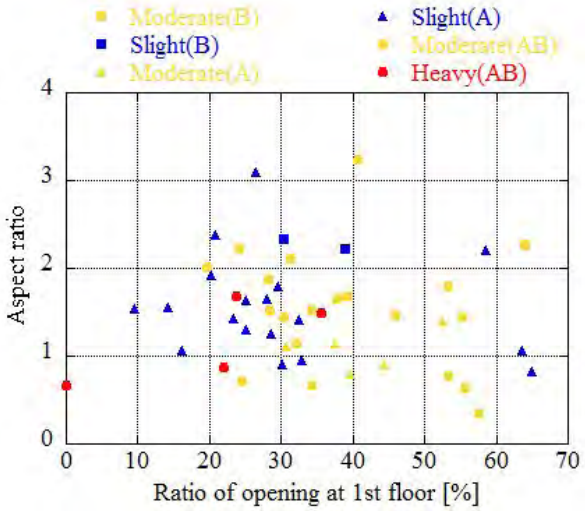


Fig. 3-2-15 Relation between ratio of opening and aspect ratio at first floor

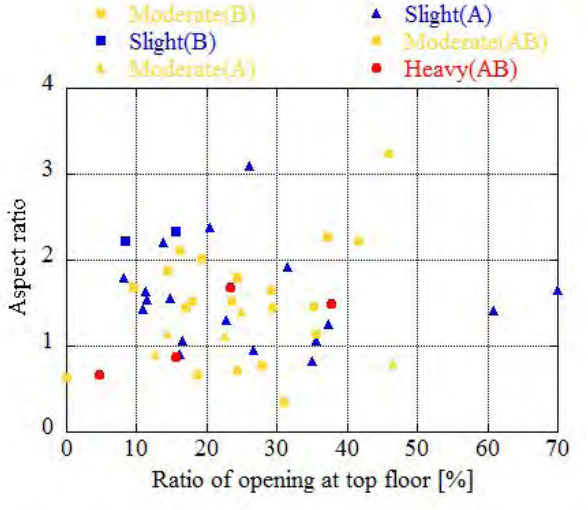


Fig. 3-2-16 Relation between ratio of opening and aspect ratio at top floor

3.3. Survey on the Situation of Devastated Houses

3.3.1. General information of microtremor measurements

Microtremor measurements were conducted on the traditional houses in Khokana (shown in Fig.. 3-3-1) on November 29 and 30 2015. To confirm the coupled vibration effect of interconnected houses, the measurements were performed at the same height for each house, monitoring two horizontal components. The measurements were performed four times. There was no external damage from by the earthquake, but several inside partition walls were collapsed.

(a) Outside view 1

(b) Outside view 2

(c) Inside view 1

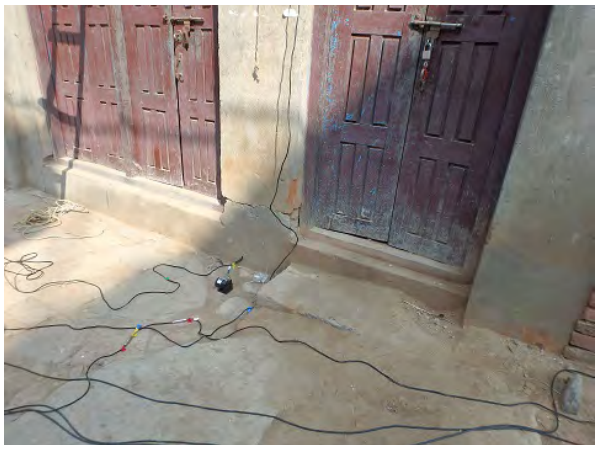
(d) Inside view 2

Fig. 3-3-1 Traditional houses of Khokana

The ‘all measurement points’ are shown in Fig. 3-3-2. The measurements were performed four times on all the houses to monitor vibration of in-plane direction and out-of-plane direction. The multiple measurements were performed at the one measurement point on free ground and at several points inside the houses. The ground point was in front of the houses (Fig. 3-3-3(a)), and the points inside the houses were at the top of the windowsill (Fig. 3-3-3(b)) as it was difficult to place the velocity-meter on top of the wall.

The measurements were conducted using a portable vibration monitoring system named SPC-51 and servo velocity-meters named VSE-15D, produced by Tokyo-Sokushin.

Fig. 3-3-2 The measurement points which velocity-meters are placed



(a) ground

(b) inside of the house

Fig. 3-3-3 Example of the measurement points

3.3.2. Measurement results

The result of the first measurement taken four times is shown below as an example. Five velocity-meters (Ch1 - Ch5) were placed at the points shown in Fig. 3-3-4 to monitor the vibration of the in-plane direction. The Fourier amplitude ratio was obtained by dividing the Fourier spectrum of building vibration monitored inside the houses by the Fourier spectrum of ground vibration (Fig. 3-3-5). The frequencies which have peak in Fourier amplitude ratio are dominant frequencies.

Fig. 3-3-4 The measurement points which velocity-meters are placed

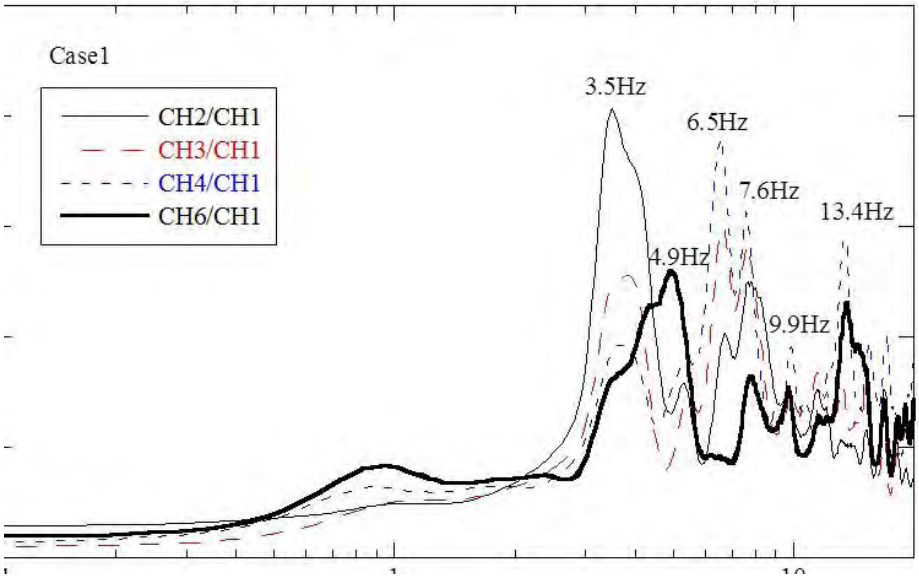


Fig. 3-3-5 Fourier amplitude ratio

The measurement points are shown in Fig. 3-3-6: Ch1 was placed on the ground at the side of the houses, and Ch2 was placed on the windowsill on the 3rd floor.

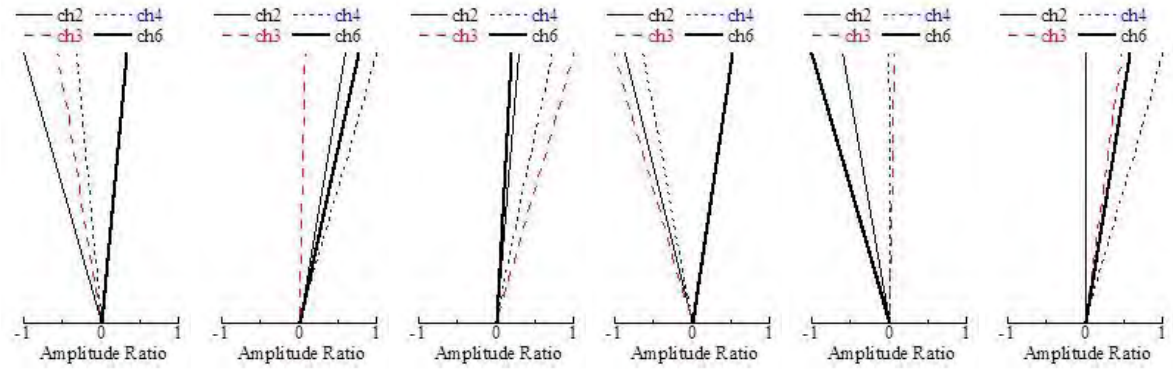
To compare Fourier amplitude ratios between the four measurements, Ch6 in case 1-2 and Ch3 in case 3-4 were fixed at the same position for the calibration. The vibration mode of each dominant frequency is shown in Fig. 3-3-7 - Fig. 3-3-10. The figures show that interconnected houses vibrate together in the in-plane direction at each dominated frequency, due to the coupled vibration effect.

The detail of the data and the results of other measurements are shown in APPENDIX A.1 - A.4.

Section author : Mitsuhiro Miyamoto

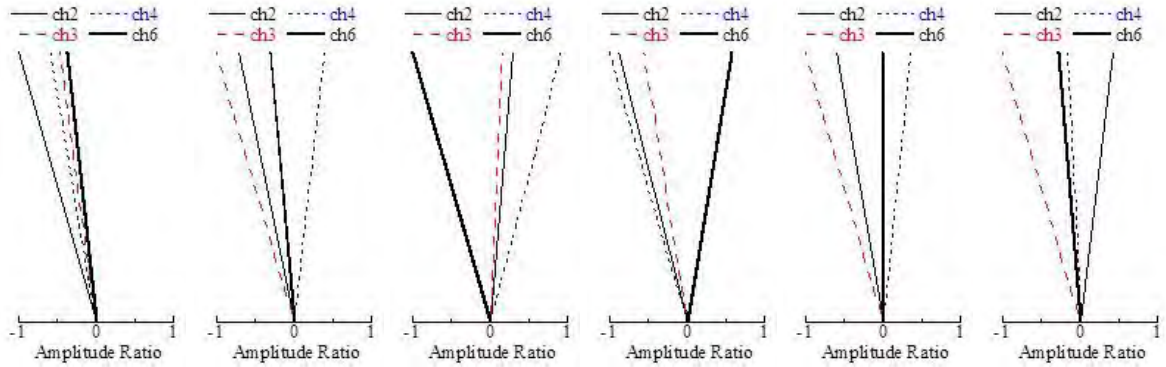
(a) Ch1(ground)　　(b) Ch2 (window sill)

Fig. 3-3-6 Velocity-meters



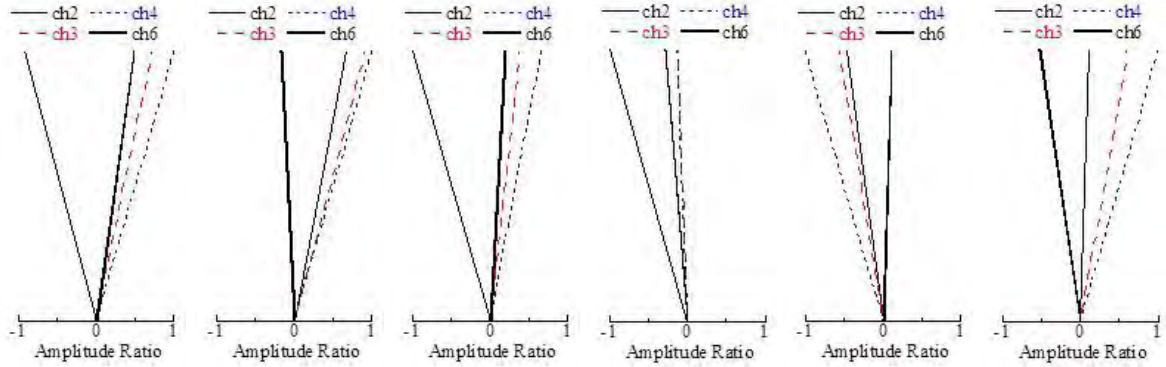
(a) 3.5Hz　(b) 4.9Hz　(c) 6.5Hz　(d) 7.6Hz　(e) 9.9Hz　(f) 13.4Hz

Fig. 3-3-7 Vibration mode (case 1)



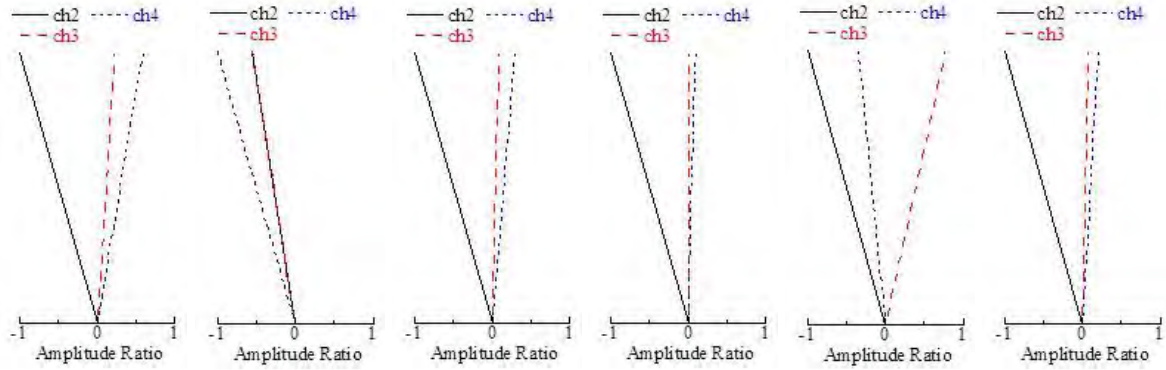
(a) 3.9Hz (b) 5.9Hz (c) 7.7Hz (d) 8.8Hz (e) 10.9Hz (f) 11.6Hz

Fig. 3-3-8 Vibration mode (case 2)



(a) 4.0Hz (b) 5.1Hz (c) 6.7Hz (d) 8.2Hz (e) 11.2Hz (f) 13.5Hz

Fig. 3-3-9 Vibration mode (case 3)



(a) 4.1Hz (b) 4.8Hz (c) 6.6Hz (d) 7.8Hz (e) 8.2Hz (f) 11.6Hz

Fig. 3-3-10 Vibration mode (case 4)

3.4. Conjecture on the Factors Affecting the Damage Level of Buildings, Based on Investigation on the Transformation of the Townscape

3.4.1. Context of this survey

From our investigations of the townscape detailed in Chapter 2, Section 6, we postulate that traditional houses or their townscape became fragile structurally by extending and renovating their original states. We thus examine how the transformation of houses and their townscape may have influenced the damage caused by Gorkha earthquake, that is, the relation between the formal-spatial transformation and the disaster damage, based on the field survey of damage and collapses both inside and outside the houses. (For the details of the building numbers used in this investigation, see Chapter 2, Section 6.)

The issues of this investigation are not based on structural analysis; nor would they become direct contents of Design Guidelines either. However, we indicate the causes of damage or collapses of houses that are surmised by our survey.

This section shows the following six factors that were observed inside the investigated site. It also includes some damaged houses outside the investigated site to provide clear cases of each factor.

1) Insufficient connection between original part and extended part;
2) Loss of horizontal rigidity caused by installation of interior staircases after segmentation;
3) Fragile structure of the annexes built at the rear;
4) Damage to low-rise houses caused by water storage tanks falling from high-rise houses;
5) Use of fragile construction materials; and
6) Inappropriate construction methods.

It is recommended that the guidelines on rebuilding and restoration of damaged houses be developed considering the factors noted above after conducting further investigations.

3.4.2. Method

1. Dates, researchers, and site of investigation are as detailed in Chapter 2, Section 6
2. Investigation approach: Visual survey of damaged houses and interviews with residents inside the investigated site.

3.4.3. Reflection 1: Causes of the damage and collapse

1. Insufficient connection between original part and extended part

Concerning the houses in the investigated site (along Nyala Dan Street), there are many cases of three-storey houses with transformed attics and one floor added on top of the third floor (S12 and N14). Those houses, therefore, weigh more than they did prior to the extension, and their structure is consequently weakened by the extension with insufficient connection between original part and extended part. This would be a significant factor contributing to the breaking of the connected part in the event of an earthquake. We cannot say that the extension directly causes the damage or collapse of houses if they are small-scale works, such as kitchen extensions involving installation of side walls. In the case of Kirtipur, where we see lots of cracks under the extended area of houses (Fig. 3-4-3), it is considered that the increase in weight, despite the extension of only one floor, influenced the scale of the damage. We also found cracks running over the inside wall of the floor directly below the extended floor (S13) because of the difference in strength between the beams of reinforced concrete and the existing brick walls at the interface.

After the distribution of property from parents to children (i.e. conversion to more than one household), houses are divided by household and each then extends their own space. There are some traditional houses with parts which were intensively damaged because those houses were partially extended, thus causing their loads to become unbalanced (Fig. 3-4-8 and Fig. 3-4-11).

We sometimes found remarkable examples of houses which have increased in weight in Khokana (though not inside the investigated site). In essence, they left fragile brick walls on the lower floor and extended on the upper floors using reinforced concrete. In such cases, the upper floors cannot easily be demolished due to the danger of collapse, and this dangerous situation for neighbours still remains. The removal of wreckage after the collapse of houses extended by reinforced concrete, which are different from those extended by brick, has become a serious problem.

Extension is the vertical connection onto a building, but the connection in the horizontal direction is also a factor in the damage and collapse. As seen in Buildings N00 and N01, there are some cases of houses collapsing because of structural fragilities of the interface between existing parts and rebuilt parts since the original houses were divided and half of them were rebuilt. For example, a collapsed house in front (N00) and the one at the rear (N01) were originally a single house. It is considered that the rebuilding of only Building N01 caused the outward collapse of N00 at the end of the 2015 disaster.

Fig. 3-4-1 House extended on the 3rd floor (S16). Roof and struts are relocated to one floor higher up. The trace of the past supporting beams is left on the façade.

Fig. 3-4-2 Cracks over the wall under the beam of the extended floor.

Fig. 3-4-3 Cracks are seen on the left side, under the extended floor more than right side where traditional roof style remains (Kirtipur), taken by author on 18th Sep. 2015

Fig. 3-4-4 Example extension of reinforced concrete on the houses (An example from outside of the investigated site)

Fig. 3-4-5 Example of extension of reinforced concrete on upper floor

Fig. 3-4-6 Cracks over the corner of the wall (S13)

Fig. 3-4-7 Example of extension of brick and reinforced concrete on the brick house (An example from outside of the investigated site)

Fig. 3-4-8 Example of disproportional extension. The two houses are not structurally unified. (An example from the outside of the investigated site)

Fig. 3-4-9 Example of damaged houses (N00) neighboring the one with blue balcony (N01)

2. Loss of horizontal rigidity caused by installation of interior staircases after segmentation

Partitions of wooden boards or bamboo were installed in the centre of rooms (for the division of borders of properties) and staircases for each household were constructed after the distribution of property. There are some houses whose horizontal rigidities at the corners were reduced by those works.

Fig. 3-4-10 Example of segmentation each divided parts due to the inheritance (Kirtipur) ,taken by author on 18th Sep. 2015

Fig. 3-4-11 Example of extension after segmentation extension by each heir after property distribution (Kirtipur), taken by author on 18th Sep. 2015

Fig. 3-4-13 Outside staircases built at the backside because of lack of space inside (N12)

Fig. 3-4-12 Section of newly installed staircases (S12_b)

Fig. 3-4-14 Ruins of the collapsed house at the rearside of N04

3. Fragile structure of the annexes built at the rear

There are some collapsed houses at the rear of the street. We call the generation who contributed to the rehabilitation of Khokana after the 1934 earthquake of 1934 the 'first generation'. Then, the low-rise houses of about 2 storeys were built at the rear of the street (in courtyards) when the children of the second generation (that is, the third generation) grew-up. These houses are jerry-built in comparison with the houses along the street. We thus highlight that the fragile structures of the former houses led to their collapses**.**

4. Damage to low-rise houses caused water storage tanks falling from high-rise houses

According to the interviewees, the fall of water storage tanks from the high-rise houses on to the traditional low-rise houses led to their damage. The considerable height differences of adjacent houses could be one of the causes of the heavy damage. For example, in one case, the water storage tank on the roof floor of a high-rise house of reinforced concrete (S17) fell onto the roof of the neighbouring traditional low-rise house (S18), causing the upper floor of the traditional house to mostly collapse (Fig 3-4-17, 18). It is considered this is just one example of many collapses caused by falling water storage tanks.

Fig. 3-4-15 Water storage tank placed on the roof top floor (N13)

Fig. 3-4-16 Water storage tank placed on the ground after the disaster (S12-b)

Fig. 3-4-17 High-rise house where water storage tank was placed (S17) and damaged low-rise house by the fall of the tank (S18)

Fig. 3-4-18 Damage spot by the fall of water storage tank (S18)

Fig. 3-4-19 The inside of brickwall is made and not unified with the outside made of burning brick.

Fig. 3-4-20 Damage of a brick wall after the disaster, with peeling off of surface brick

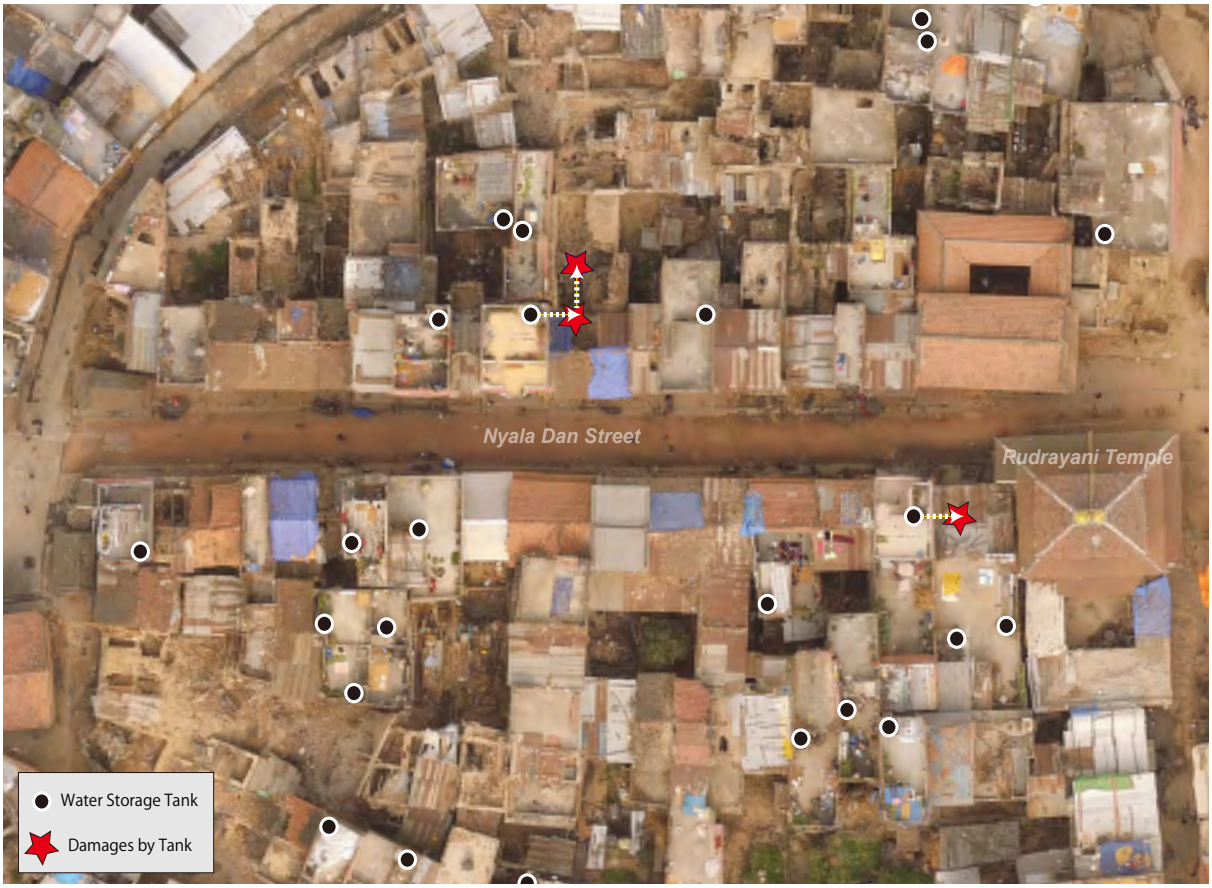


Fig. 3-4-21 Positions of water storage tanks according to the visual survey of photographs and that of actual damages according to the interview (Water storage tanks plotting on the photograph taken after disaster)

5. Use of fragile construction materials

As a matter of course, the bricks of the general houses are made more simply and cheaply than those used in royal palace and temple architecture. Even if the outer surface of the brick is constituted of burnt brick, its inside is sun-dried brick. Furthermore, mud mortar (soil made of clay taken from the site) is used inside. We sometimes saw cases of collapses where only the surface have bricks come away because the internal bricks and external bricks were neither unified, nor properly stuck together.

6. **Inappropriate construction methods**

We also saw some cases of collapses because of inappropriate construction methods. We do not deal any further with these cases in this section.

3.4.4. Reflection 2: Correlation of spatial-formal transformation and damage situation

Based on the investigation of the townscape in Chapter 2, Section 6 and the reflection on cases of collapses and damage in the paragraphs directly above, we now examine and arrange, in chronological order, the correlation of the spatial-formal transformation of houses along the street and townscape and the disaster damage situation.

1. Before the 1934 earthquake

Every house but four completely collapsed in Khokana in the 1934 earthquake. The foundations of the ground floor of some houses built before 1934 are made of stones taken from the riverside and they remain in situ without cracks even after the 2015 earthquake. It is natural that the earthquake-resistant performance of houses built before 1934 is ineffective given that many of them collapsed in the 1934 earthquake. However, those houses would have some countermeasures and wisdom against the threat of earthquakes. Currently, the hard stones equivalent to those previously used as foundations are no longer used in the foundations of houses, and we cannot see that the replacement construction techniques have been successful. Among the four houses which did not collapse in the 1934 earthquake, S11 and S12 (which were SRU05 at that time, before it was divided in two) have remained on the street. The earliest documents we were able to find date back to 1969 and there is no way to investigate the forms and spaces of the houses before 1934. However, we consider it likely that they were, on the whole, mostly the same as the current houses.

2. Rehabilitation after the 1934 earthquake

The rehabilitation was conducted through the whole of Khokana after the 1934 disaster. The vernacular and beautiful townscape that is inscribed on the UNESCO World Heritage Tentative List was created at that time and its structural framework has remained until now. As residents restored and used their houses where the stone foundations remained even after the disaster, it seems that they rebuilt their houses in same position and form for rehabilitation, in succession to those that stood before the disaster

Fig. 3-4-22 Foundation of masonry constructed by before by stone the earthquake of 1934 (S14)

Fig. 3-4-23 Wall of masonry observed from the inside of the house (S10-b2)

(we now define the generation which contributed to this rehabilitation the ‘first generation’ on this section). The traditional houses inside the site which keep the original form, being neither divided nor extended, only collapsed due to the fall of water storage tanks from high-rise houses. The structural strengths of the original houses that were built after the 1934 earthquake would be stronger in comparison to the houses before segmentation/extension.

3. The growing up of the second generation’s children: the third generation (the first extension period)

There are some cases in which, when the second generation had families and their children (the third generation) were in adolescence, the jerry-built houses were constructed at the rear of the street for second generation families. Thus, the family was separated. However, several houses built at that time collapsed in the 2015 disaster (e.g. the rear of N04), probably because of structural fragility as they constructed with little care given to the structure for their annex buildings.

4. Distribution of property after the deaths of the first generation

The properties of the first generation were distributed to the males of the second or the third generation after the deaths of first generation members. It seemed that, initially, the facades were maintained as before and only the interior spaces were divided vertically. However, some works, such as the installation of interior staircases, caused structural fragilities of the houses, despite those segmentations not change their facades.

5. The growing up of the second generation's household (the second extension period)

The distribution of properties to the second generation (or the third generation) led to the situation where they could either extend or renovate their houses or sites, according to each household’s income and status. First, the third floors were extended to enlarge their kitchens when the children grew up and their existing spaces became insufficiently large to accommodate them. We discovered that the extension works only started after 1976 because there are no traces of extensions in the photographs until that year. It should be noted that the houses were extended when the opportunity to restore arose after the partial damage, such as the falls of tiled roofs, caused by the Bihar-Nepal earthquake of 1988. These extensions led to the increasing weights of houses themselves and thus to the expansion of collapses and damage when the 2015 earthquake struck.

6. Further separation of each household of the third generation (the third extension period)

After 2004, the villagers tended to demolish existing houses and then rebuild high-rise houses in cases where there would not otherwise be enough space despite the extension on the third floor or at the rear. This tendency has transformed the townscape of Khokana with immediate effect. Furthermore, the number of residents who do not work as farmers has increased and the difference of income among households is a contributing factor in the frequent trading of the land. Building N07 (or the rear of N04 which was sold), for example, was extended through buying and adding to the land.

Their high-rise houses of rigid structure, constructed of reinforced concrete, may in fact have

prevented the collapse of the traditional houses by stopping the tremor of traditional housing adjacent to high-rise houses. Conversely, however, the traditional houses were damaged because of the water storage tanks falling from the roofs of the high-rise houses. Furthermore, the traditional brick houses of fragile structure might have been damaged because of the differences of periods of characteristic oscillation or structural strength. There are also other cases in which the rebuilding of the halves of traditional houses caused the structural disproportion of the remaining other halves, leading ultimately to their collapses.

3.4.5. Conclusion

The issues discussed in this section are only conjectures based on the visual investigation of the buildings and the interviews of the residents: i.e. the above is a hypothesis. However, the transformations of the houses effected by every generation might have led to structural fragility. Moreover, the original structure of traditional houses was not always as fragile as those of the present day. Of course, the structural strength of houses varies according to their architectural forms, their lots, construction methods, and maintenance issues. Therefore, the hypotheses outlined above cannot easily lead to definitive conclusions.

If we express an opinion from the perspective of formal-spatial transformations and the damage investigation inside the houses, it is first necessary not to evaluate earthquake-resistant performance based on the present condition of the structure: instead, we must premise that the current form is the culmination of various transformations. In formulating guidelines about the restoration or rebuilding of the future houses in traditional form, one of the future issues is to conduct an appropriate investigation of the existing traditional houses and to evaluate them in comparison to their past forms.

Chapter authors : Hiroki Yamada and Naoaki Furukawa

References:

1) Teizo FUJIWARA, Tadanobu SATO, Tetsuo KUBO, Hitomi MURAKAMI: Survey Report of 1988 earthquake on Nepal-India Border Region, Annual report of Disaster Prevention Research Institute Kyoto University. All Rights Reserved, Volume 32, A, 1989 (in Japanese)

Notes:

Note 1) The epicentre of the earthquake Nepal-Bihar was 10km far from Bhaktapur. However, according to the Annual report of Reference 1, at Bhaktapur, the ancient city of the Katmandu Basin, seven people were dead, 43 people were injured, and 1,750 houses were damaged.

Note 2) All the photographs without specific accreditation were taken by the authors.

3.5. Survey on the Residents' Intentions about Rebuilding Houses after the 2015 Earthquake

3.5.1. An overview of the survey

After the April 2015 Nepal earthquake (the Gorkha earthquake), interview surveys of local opinions about rebuilding houses was conducted. The survey's aims were to detect problems and tendencies about rebuilding, and to estimate its influences on changes of the townscape.

Interview surveys were conducted from 10 to 19 August 2015, and from 25 December 2015 to 1 January 2016. Four areas were determined for the surveys (Chorcha and Suryamadhi in Bhaktapur, Chyasal in Patan, and Khokana), and a total of 34 people agreed to be interviewed. The second interviews were principally conducted with the same people or their families (Two of them were unable to attend the second interview).

The methods of the survey were investigating the appearances of buildings and conducting interviews.

From the buildings' appearances, 1) construction and 2) suffered damage were investigated. Additionally, interviews were conducted as needed to complement this information.

In the interviews, interviewers asked the interviewees to provide the following details:

1) name;
2) age and gender;
3) family structure;
4) uses of each floor before the earthquake;
5) state of residence after the earthquake;
6) type of land ownership;
7) ways of rebuilding (sites, funds, and method);
8) programme of rebuilding;
9) problems with rebuilding;
10) problems before the earthquake; and
11) any other matters.

Furthermore, the interviewees themselves and the state of damage of their houses were recorded using photographs.

3.5.2. Study about intention for rebuilding in Khokana

In this section, the intentions of residents for rebuilding and the changes to their intentions will be studied, focusing especially on Khokana.

In Khokana, the interviews were conducted with eight residents on 12 and 15 August 2015 (the first investigation), and on 27 December 2015 (follow-up investigation).

Tab. 3-5-1 summarises the results. In Tab.3-5-1, the columns are for each of the eight interviewees

Tab. 3-5-1 Aggregation of survey results

				Khokana							
				K-1	K-2	K-3	K-4	K-5	K-6	K-7	K-8
被害	全壊	Damage	completely collapsed		○	○		○	○	○	○
	半壊		partially collapsed	○			○				
居住状況	現地補修	Housing Situation	**repairing on the site**	○			○			→ ○	
	現地仮設		temporary house on the site								
	他所仮設		temporary house on the other site	○	→ ○	○			→ ○		→ ○
	他所賃貸		rent on the other site					→ ○			
	他所自宅		**own house on the other site**				○				
土地所有	専有	Land-ownership	single-ownership	○	○	○	○			○	○
	共有		**joint-ownership**					→ ○	→ ○		
再建場所	現地	Site for rebuilding	on the site	→ ○	→ ○	○	→ ○	→ ○	→ ○	→ ○	→ ○
	他所		on the other site								
再建資金	補修資金	Funds for rebuilding	maintainance assistance	→ ○				○			○
	政府ローン		**eartquake victim special loan**			○	→ ○			→ ○	
	土地売却		selling own lands		○	○				→ ○	○
	自己資金		own funds								
再建構法	補修	Method of rebuilding	repairing	→ ○				○			○
	伝統工法		traditional (brick & wood)			○			→ ○		
	RC造		**RC**		→ ○		→ ○	○		→ ○	○
	仮設建築		temporary house								
再建目途		Program of rebuilding		→ ?	→ ?	?	0.5 ?	→ ?	→ ?	1 ?	→ ?
再建課題	土地所有	Problems of rebuilding	**land ownership**						→ ○		
	資金		**funds**	→ ○	→ ○	○	→ ○	→ ○	→ ○	→ ○	→ ○
	土地売買		selling own lands							→ ○	
	建築許可		building permit				→ ○				
	建築資材		buiding material cost								
	境界確定		fixing the boundary								
被災前の課題	満足	Problems before earthquake	satisfied							○	○
	掃除		not easy to sweep		○		○				
	採光		not enough of natural lighting								
	階高		not enough height of stories			○		○			
その他	再建機運	Other matters	**motivation for rebuilding**		↗ ↘		↗ ↘	↗		↘	
	共有関係		relationship between coowners	-	-	-	-	↗		-	-
	政府支援		government support		↘			↘			
	海外支援		overseas support		↘						
	外観意匠		**exterior design**		ネ	ネ	ネ	ネ	ネ	ネ	ネ
	意匠協調		**cooperation for design**	○	○		↘	○	○	○	○

(K-1~K-8) and rows are for the contents of the interviews. If an answer to one question has two cells, this means that the interviewee's answer changed (arrows in the same row mean the answer did not change). Unfortunately, the interviewer did not meet one interviewee ('K-3') for a second interview.

The houses of six interviewees had collapsed completely, and five of them lived in temporary houses as at August 2015. One of the other interviewees lived in another site, and the other lived in the house on site while repairing it. At the time of the second interview, three people had returned to their houses on site having become accustomed to living there and because of their job.

Regarding land ownership, six have single (sole) ownership of their homes, while only two were joint owners. In other areas, especially in Bhaktapur, land ownership is more complex and one of the big problems that is interfering with reconstruction and rehabilitation.

In comparison with the other sites surveyed, land ownership did not appear to be a particular problem for rebuilding in Khokana. Such a state is different from that in the downtown area.

All of the interviewees hoped to rebuild on the site. Some of them tried to rebuild by seeking funds from the government's earthquake-related special loan and by selling their land, while others maintained their houses by allocating maintenance assistance while living there. Nevertheless, one interviewee did not consider funding because the problem of land ownership did not admit this solution (K-6).

Regarding the method of rebuilding, at the first interview, two of the interviewees hoped to rebuild using traditional mixed-structures with bricks and wood, while another two planned to maintain their current traditional houses. The number who hoped to rebuild by RC structure increased by two from the first to the second interview, becoming 5 in total.

Nevertheless, we discovered that not everybody could aim for rebuilding for the future. The interviewee who had planned to rebuild in half a year or one year at the first interview had been forced to abandon this prospect by the second interview. The reasons for this included delay securing building permission from the government, having no plan for sourcing funds (e.g. by selling land), and having been unable to obtain specific details about the loans provided by the government (because of mortgage problems, it was even unclear whether the money could be borrowed). Motivation for rebuilding tends to diminish with the elapse of time. Moreover, both expectations of and disappointment with foreign NGO groups co-existed.

Moreover, two were satisfied with the traditional living space, while others had dissatisfaction with hardness to sweep or lowness of height of stories (two each). The latter intentions will probably affect the rebuilding.

3.5.3. Summary

In Khokana, 'The Khokana Reconstruction and Rehabilitation Committee' was established, and local young people have played a central role as members of the committee to organise inhabitants for reconstruction by removing rubble, financing for concrete reconstruction, and holding meetings. Moreover, Khokana had another committee which acted independently. At the second interview, it was said that these two committees were trying to integrate and act together.

Young architects and civil engineers are members of the Khokana Reconstruction and Rehabilitation Committee, and they have created reconstruction plans of the ceremony hall and produced future images of the townscape. They acquired funds by exhibiting their plans and images at local meetings. Many inhabitants had high hopes on the activities of the committee, which do not depend on the government. Therefore, most inhabitants tend to follow the committee's opinions and policies.

At the interviews, many people hoped to cooperate in the design of the townscape, and to rebuild their houses with the Newar style exterior design (written 'ネ' in the row of exterior design in the Tab. 3-5-1). These are also the results of reconciliation of differences among local opinions by the committee. At the same time, they demonstrate expectations about the fund-raising capabilities of the committee.

A local meeting was held a few days before the second investigation. The committee was raising funds for demolishing buildings, and its recommendation to rebuild with RC structure was announced

there. This seems to be reflected in the results of the second investigation. Conversely, were some inhabitants had the realistic opinion that it was difficult to raise funds to unify the exterior designs of all the houses, and they emphasised their personal rights by calmly judging the committee's strong opinions and activities.

There are great problems concerning how to raise funds, how to solve the land ownership issues, and in selecting the method for rebuilding houses, in a situation that requires immediate reconstructions and improvements to townscapes following a natural disaster. During the investigations, we witnessed efforts towards reconstruction and changing intentions for rebuilding, while positive looks or appreciations on their own way of life that had formed their life space in Khokana were not heard clearly during the interviews.

In the reconstruction of Khokana, an appropriate process is required to pay due attention to and share the importance of the way of living that the Newar established in Khokana; only in this context should debate over the design of each house and of the townscape ensue.

Section author : Yasushi Takeuchi

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4. Proposal of the Khokana Preservation and Improvement Plan

4. Proposal of the Khokana Preservation and Improvement Plan

4.1. Basic Plan for Preservation and Improvement

4.1.1. Basic policy for preservation and development

Faced with the rehabilitation and reconstructing of buildings damaged by the earthquake, one should be mindful of improving the life environment of the residents and modernisation. This plan utilises the characteristic features of the village, preserves the group of traditional buildings, the cultural landscape, and the surrounding environment; while at the same time designing an area for development.

4.1.2. Framework of the preservation and improvement plan

Dividing the former Khokana VDC into the three areas of 'Cultural Landscape', 'Historical Settlements', and 'Harmony Area', a Preservation plan will be established for 'Cultural Landscape' and 'Historical Settlements', and a Development plan will be established for the 'Harmony Area' (Fig. 4-1, 4-2).

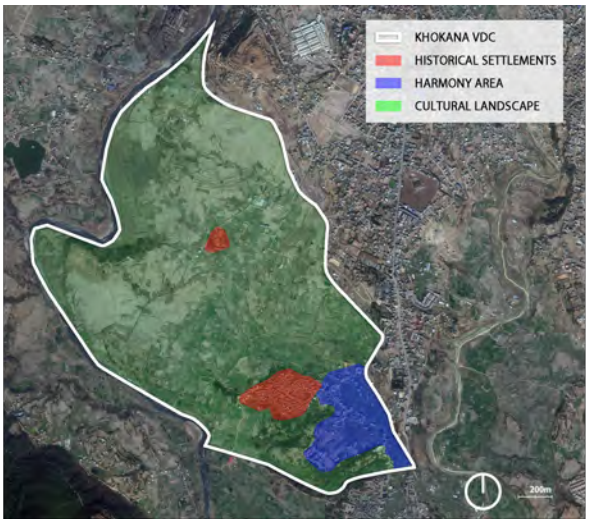

Fig. 4-1 Area of the preservation and improvement plan (Bing map modified by author)

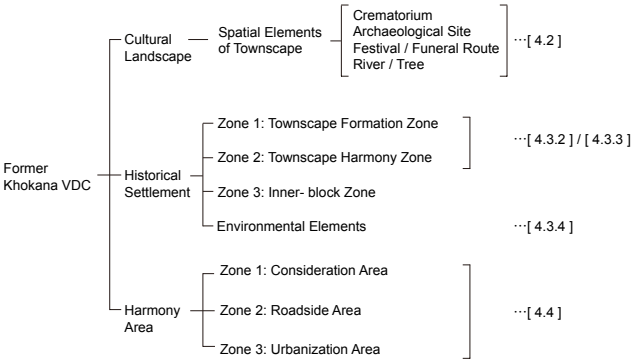

Fig. 4-2 Framework of the preservation and improvement plan

4.2. Cultural Landscape

4.2.1. Basic policy for preservation

To maintain the historical and cultural value of the 'Cultural Landscape', the spatial elements of the landscape, which are the direct source of this value, should be preserved. Moreover, not only the value of the spatial elements of the landscape, but also that of the surrounding environment should be maintained. Land use should be maintained at its current level and new buildings should not be built in that area.

4.2.2. Spatial elements of landscape

Elements identified as conveying the characteristics of the region's cultural value in the area of 'Cultural Landscape' should be designated as spatial elements of the landscape (Tab. 4-1, Fig. 4-3).

Fig. 4-3 Distribution of spatial elements of landscape (Bing map modified by author)

Tab. 4-1 Spatial elements of landscape

	Site No.	Category
Cultural Landscape Constituent Elements of Landscape	38	Waterway
	39	Pond
	40	Pati
	41	Open space and others
	42	Pati and others
	43	Pati and others
	44	Shrine and others
	45	Pati and others
	46	Water space and others
	47	Temple
	48	Shrine
	49	Crematory
	50	Cremation route
	51	Festival route

4.3. Historical Settlements

4.3.1. Basic policy of preservation plan

The objective of the plan is preserving the traditional townscape created by the Newari houses and the cultural and religious elements of the settlement through improvement, façade beautification and respectful reconstruction. The plan tries to achieve both the modernization of the lifestyle with the preservation of the townscape.

'Historical Settlements' are divided into two zones: Zone 1 in particular actively forms a traditional townscape, while Zone 2 aims to create a townscape that harmonises with Zone 1.

Fig. 4-4 The area of Historical Settlements (Bing map modified by author)

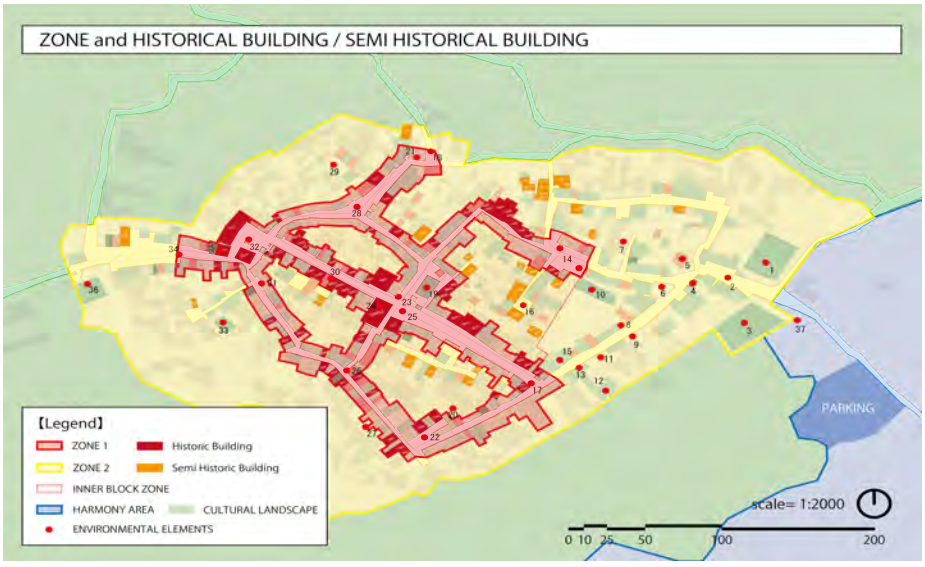

Fig. 4-5 The boundaries of Zone 1 / Zone 2 and distribution of Historical buildings / Semi-historical buildings

4.3.2. Explanation of ZONE 1/ ZONE 2, traditional buildings/semi-traditional buildings

1. ZONE 1: Townscape formation zone

The 'Townscape Formation Zone' is the area where, at the present time, a continuous historical townscape has been maintained; consequently, it should be a selectively rearranged townscape. Buildings within ZONE 1 that have particular historical importance and a small degree of damage will be designated 'Traditional buildings' (Tab. 4-2).

2. ZONE 2: Townscape harmony zone

The 'Harmonised Townscape Zone' is the area where, while the continuity of the historical neighbourhood is weak, a harmonised townscape of the neighbourhood is desired for the future. Buildings within ZONE 2 that are of particular historical importance and that have a small degree of damage will be designated 'Semi-traditional buildings' (Tab. 4-3).

3. Zone 3: Inner -block zone

The 'Inner - Block zone' is the area located ZONE 1 to the backside of buildings of Patios, inner streets, and wells are the spaces that support the daily lives of the village's inhabitants. They are, therefore, important for understanding the development of the settlement. In this research period, we could not conduct a detailed survey inside the blocks. This remains as a future issue to understand the space and the methods to preserve it..

Tab. 4-2 List of traditionally constructed buildings

No.	Building No.	Usage	No.	Building No.	Usage	No.	Building No.	Usage
1	-	Temple	24	C030	House	47	F020	House
2	A002	Guthi Building	25	C035	House	48	F028	House
3	A003	House	26	C043	House	49	F034	House
4	A006	House	27	C045	House	50	F037	House
5	A009	House	28	C052	House	51	F043	House
6	A014	House	29	D003	House	52	F044	House
7	A015	House	30	D004	House	53	F045	House
8	A016	House	31	D005	House	54	F046	House
9	A030	House	32	D006	House	55	F047	House
10	B003	House	33	D008	House	56	F048	House
11	B005	House	34	D009	House	57	F049	House
12	B006	House	35	D012	House	58	I002	House
13	B013	Museum	36	D015	House	59	I003	House
14	B014	House	37	D019	House	60	I005	House
15	B015	House	38	D035	House	61	I016	House
16	B022	House	39	D040	House	62	I018	House
17	B023	House	40	D047	House	63	I020	House
18	B024	House	41	D048	House	64	I027	House
19	B092	House	42	E004	House	65	I030	House
20	B093	House	43	E017	House	66	J012	House
21	C001	House	44	E027	Guthi Building	67	J015	House
22	C002	House	45	E029	Guthi Building	68	J022	House
23	C021	Municipality Office	46	F010	House	69	K014	Oil Mill

Tab. 4-3 List of semi-traditionally constructed buildings

No.	Building No.	Usage	No.	Building No.	Usage	No.	Building No.	Usage
1	B027	House	15	C063	House	29	G008	House
2	B029	House	16	D035	House	30	G035	House
3	B054	House	17	D040	House	31	G043	House
4	B056	House	18	D058	House	32	G069	House
5	B060	House	19	D059	House	33	G070	House
6	B061	House	20	E023	House	34	I020	House
7	B063	House	21	F020	House	35	I027	House
8	B070	House	22	F030	House	36	I030	House
9	B071	House	23	F059	House	37	J002	House
10	B097	House	24	F060	House	38	J012	House
11	C054	House	25	F061	House	39	J015	House
12	C055	House	26	F062	House	40	J022	House
13	C056	House	27	F065	House	41	K004	House
14	C061	House	28	F066	House			

4.3.3. The contents of the preservation plan by zone

The preservation plan for the 'Historical Settlements' is summarised in Tab. 4-4 below in accordance with the two zones and the types of current buildings (Traditional house and RC building).

Tab. 4-4 The contents of the preservation plan

	ZONE 1	ZONE 2
Traditional Building	The basic approach to traditional buildings will be to maintain their current condition, and with regard to buildings damaged by earthquake, repairs using traditional construction methods will be conducted in order to restore them. Traditional construction methods will also be used for rebuilding.	Semi-traditional buildings will be preserved to the extent possible. It is desirable that other earthquake damaged traditional buildings be repaired using traditional construction methods.
RC Buildings	Use color as the basic approach for landscaping concerning existing RC Buildings and lead them in the direction of traditional buildings when rebuilding.	Draw up design guidelines.

1. Zone 1

① Traditional buildings (belonging to slight and moderate in type A and slight in type B as described in Chapter 3, Section 1)

Traditional building repairs will be mainly limited to maintaining the exterior appearance and will treat maintaining the current condition as its basic approach. Furthermore, restorative repair will be considered for buildings that have undergone renovations or repairs unsuited to traditional forms.

② Standards for non-traditional buildings

Rebuilding (new building), extensions, repairs, or colour changes will follow the standards below and actively strive to form a townscape.

• Traditional houses damaged by earthquake (Type B moderate)

As much as is possible, existing parts will be preserved and utilised, and restoration will be performed on earthquake-damaged houses using traditional construction methods.

• Existing RC buildings (Type C)

A colour guideline will be created and used as a basis for remodeling. For other elements, an overall landscaping plan will be considered.

• Newly built houses (Type A, B heavy)

Construction Method	Use traditional construction methods
Roof	Use a sloped tiled roof as a rule and angle braces
Number of Floors	Three and half floors, in consideration of the continuity of the neighbourhood
Ceiling Height	Adjust with other buildings to form neighbourhood townscape
Extension	Not to be conducted
Exterior Wall	Use brick and follow the colour guideline
Windows	Use wooden window frames, and a guideline is also necessary with respect to window frame colour and window glass to avoid damaging the townscape
Door	Use wood, and follow traditional forms for color and shape.
Platform	Make allowances for the continuity and harmony of the neighborhood

2. ZONE 2

① Semi-traditional buildings

Semi-traditional buildings will be treated according to the same standards as traditional buildings.

② Standards for other buildings

Rebuilding (new building), extensions, repairs, or colour changes will maintain similarity or harmony with the exterior view of traditional buildings and will follow the standards below.

Construction method	Using traditional construction methods is desirable, under conditions that fulfil the standards below, RC is also permissible
Roof	Install sloped tiled roofs along the street and angle braces
Number of floors	The maximum number of floors shall be four, in consideration of the neighbourhood townscape
Ceiling Height	Harmony with Semi-traditional buildings will be prioritised, in consideration of the neighbourhood townscape
Extensions	Extensions are permissible if the entire building, including the extension, has four floors or fewer, but consideration of the townscape is necessary for the shape and colour of the extension
Exterior Wall	Use brick and take into consideration the harmony with the neighborhood townscape when choosing a color.

Window	As much as possible, wooden window frames should be used. It is also necessary to ensure the window frame colour and window glass do not damage the atmosphere of the neighbourhood. When using metal on the window frame, arrangements must be made so that the position and colour of the windows do not stand out.
Door	Use wood and take into consideration the neighbourhood townscape when choosing colours and shapes. When using metal on the doorframe, arrangements must be made so that the position and colour of the doors do not stand out.
Balcony	Items that seriously impede neighbourhood continuity, such as outside attachments to the outer walls facing the streets, are impermissible. Balconies may be installed on the rooftops and behind buildings provided they do not affect the scenery of the streets.
Platform	Considerations will be made for maintaining continuity and harmony with the neighborhood

4.3.4. Environmental elements

Concerning environmental elements, the basic approach will be to maintain the current conditions; however, with respect to buildings that have been damaged by the earthquake, traditional construction methods will be employed to perform repairs. Furthermore, for work performed around environmental elements (that impacts upon environmental elements), a system for obtaining the permission of the local administration and residents' organisations is necessary.

Tab. 4-5 List of environmental elements

Site No.	Category	Site No.	Category	Site No.	Category
1	Pond	14	Waterspace, open space, alter, and shrine	26	Water space
2	The site of Dhoka	15	Mustard oil mill	27	Well and open space
3	Pond	16	Shrine	28	Open space, well, stupa, pati, and others
4	Water space	17	Well, shrine, and pati	29	Open space, well, stupa, and water space
5	Mustard oil mill	18	Shrine, pati, water space,	30	Temple
6	Well and water space		and the site of Dhoka	31	Water space
7	Well	19	Pond, water space, shrine, and pati	32	Open space, well, shrine, pati, Duthi,
8	Shivalinga	20	Well		water space, and others
9	Water space	21	Mustard oil mill	33	Pond
10	Pond	22	Open space	34	The site of Dhoka
11	Trees	23	Open space, pati, and others	35	Mustard oil mill
12	Temple	24	Temple	36	Pond and pati
13	Water space	25	Stupa and others	37	Shrine

4.4. Harmony Area

4.4.1. Basic policy for improvement and development

In addition to planning a unified sense of harmony between the 'Historical Settlements' and 'Cultural Landscape' to be preserved as a historical village, the 'Harmony Area' will be established as an area where planned development can be conducted that makes consideration for future development.

In present day Khokana, there is concern that the population increase that is expected to continue in the future will worsen the living environment; the reconstruction of living environments for those residing in temporary housing due to earthquake damage is also an urgent issue. To tackle these issues while simultaneously maintaining the historical village, a 'Harmony Area' will be established as a development plot that maintains harmony, avoiding negatively impacting the historical townscape in the immediate vicinity of the village and accommodating housing demand in a planned manner.

4.4.2. The framework of improvement and development

The 'Harmony Area' is divided into three zones that are each oriented differently toward improvement and development (Fig. 4-6). Below, we provide an overview of each zone.

1. ZONE 1: Consideration area

This will promote improvement and development in consideration of future tourist development and as an entrance to the 'Historical Settlements' from Khokana Road that makes considerations for the townscape of the 'Historical Settlements'. Building colour, design, and height will be regulated to avoid impeding the townscape woven together by the traditional buildings of the 'Historical Settlements' and the landscape of the terraced paddy fields to the north designated as 'Cultural Landscape'.

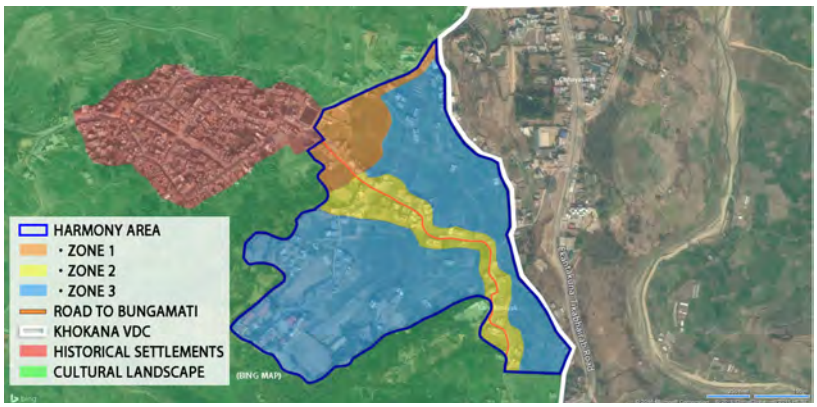

Fig. 4-6 The boundary of Harmony area and its three zones (Modified Bing map by author)

2. ZONE 2: Roadside area

This will define the road to Bungamati, with which Khokana shares a deep historical and cultural relationship, as an important axis that promotes development while taking the townscape into consideration. Building colour, design, and height will be regulated to maintain harmony with the historical townscape of Khokana and Bungamati.

3. ZONE 3: Urbanization area

This will preserve the townscapes of the 'Historical Settlements' and 'Cultural Landscape' while actively attracting development to accommodate increasing housing demand. It is land separated from the main road for which a infrastructure has not yet been installed, therefore it is necessary to develop it including roads, water and sewer services.

4.5. Tourism Development Plan

4.5.1. Basic idea of the tourism development plan

The 'Historical Settlements' seem to have been earmarked to become one of the main tourist attractions of Khokana in the future, through the improvement of its traditional townscape by the preservation plan outlined above. Along with this preservation plan, the effective development of sightseeing spots of the whole village would maximally enhance the potential for tourism.

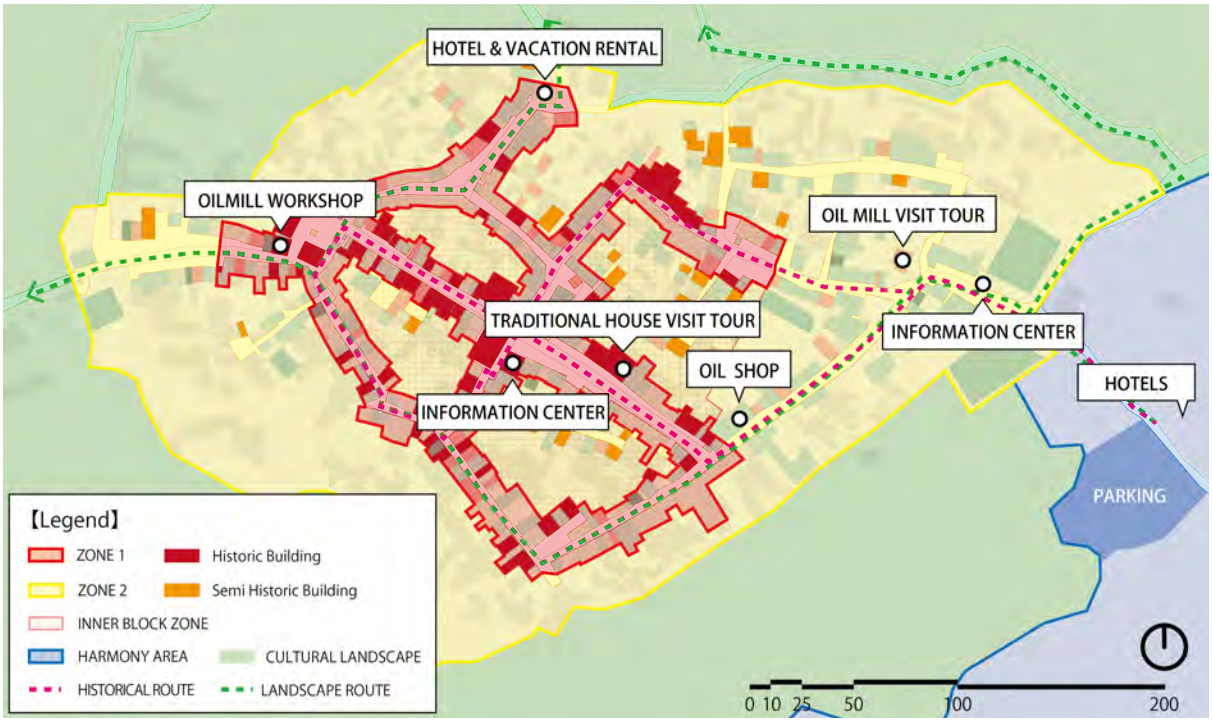

Fig. 4-7 Tourism office and tourist route

4.5.2. Tourism development plan

1. Layout of the car parks outside of historical settlements

Inside 'Historical Settlements', especially in Zone 1, motor vehicle traffic should be excluded as much as possible to create pedestrians spaces through which visitors can stroll along the sightseeing routes enjoying the village scape. A circulation plan should be developed in which the car parks for sightseeing buses and tourists' private cars are located in the 'Harmony area' so that visitors can walk into the historical centre after parking their cars. This plan should carefully considered to ensure that it does not negatively influence the historic townscape inside the 'Historical Settlements': for example, the concentration of hotels for tourists should be located near the parking area.

2. Establishment of the sightseeing route for pedestrians

The sightseeing route should be established to enable visitors to both enjoy and learn about the historical townscape and the cultural background of Khokana while walking. The route should effectively show the attractiveness of Khokana, mainly inside ZONE 1. First, they start from the car park inside the 'Harmony area' and visit the conservation centre outlined below, before visiting the mustard oil factory. A tourist map illustrating the sightseeing route should be distributed at the information centre or other convenient spots, so that visitors can walk around easily following this route and then take this map home as a souvenir.

3. Installation of the guide signboards and the signs

The guide signboards corresponding to the sightseeing route or signs for the design of the preservation area should be installed in the appropriate format, structure, colour, etc., harmonising with the traditional townscape.

4. Strategic townscape improvement

Electric poles and overhead wires should be installed without spoiling the townscape. The pavement of the streets should be appropriate for the preservation district. Also, the drainage and its improvement system should be established.

Fig. 4-8 Current view of the area around the bus park

Fig. 4-9 View from the historical route

Fig. 4-10 Poles disturving the townscape

Fig. 4-11 Mustard oil mill

Fig. 4-12 The traditional building open to the public

5. Creation of the sightseeing spots making use of public facilities

Public facilities dotted inside the 'Historical Settlements' should be used as sightseeing spots. For example, the ex VDC office of Khokana situated in the centre of the 'Historical Settlements' should be transformed into the Conservation centre for the townscape where visitors can also learn about the historical settlement landscape. The youth centre situated at the east entrance should also transformed into the information centre, providing tourist information and guidance. Visitor tours and workshops should be organised in the mustard oil factories, with shops dotted inside the village to maximally enhance their potential for tourism. Traditional houses should be transformed into accommodation or visiting spots to establish them as reception footholds for tourists or to provide traditional culture.

Chapter author：Kathmandu project team, Urbandesign Laboratory, The University of Tokyo

5. Summary of the Investigation and Future Issues

5. Summary of the Investigation and Future Issues

5.1. Summary of the Survey of Historic Settlement

During the Agency for Cultural Affairs' 'Project for Investigation of Damage Situation of Cultural Heritage in Nepal', launched in September 2015, both the damaged cultural heritage in Nepal – caused by the Gorkha Earthquake – and the technical supporting measures for the future rehabilitation over the fields including urbandesign, intangible cultural heritage, structural engineering etc. were investigated and studied. Within this framework, Khokana was selected among the damaged Historical Settlements inscribed on the World Heritage Tentative List and its 'Investigation on Historical Settlements' was conducted.

The field survey was conducted between November and December 2015, comprising the following methods:

- spatial analysis of the settlements from cultural perspectives;
- investigation of the spatial transformation of the townscape;
- an exhaustive survey of the damaged buildings and structural impacts, including microtremor measurements;
- multidirectional investigations including:
    - Intangible Cultural Heritage impacts;
    - water quality impacts; and
    - inhabitants' intentions.

Subsequently, the future preservation and development plans were proposed. The summary of the investigation results for each field and the issues recognised by the participating specialists through the investigations have already been detailed in each chapter of this report. This section will provide the overview of these results and issues.

First, as the result of the exhaustive survey (Chapter 3, Sections 1 and 2), the heavy damage to the Historical Settlements, the essence of Newar culture, was confirmed. The fact that the houses built with traditional construction methods were much more heavily damaged than those of reinforced concrete built recently seems to have been caused by their extension and renovation or deficiencies in their maintenance (Chapter 3, Section 4). It is rash to conclude that the earthquake-resistant performance of the traditional houses is low. It is necessary to examine carefully and scientifically what situations or circumstances may have influenced the scale of the damage, considering the chronological transformation of extension and renovation of the houses. In addition, the results of the microtremor measurements (Chapter 3, Section 3) demonstrate that the structural effect of interconnected traditional houses differs from that of temples built in a single tower style. The structural performance of traditional houses should be examined not only for single houses but also for interconnected houses.

It is difficult to rebuild the settlements composed of historical houses, rather than single monuments. There is a range of problems that cannot be resolved simply from the perspective of cultural heritage preservation, such as guaranteeing the safety of residents and other villagers, rehabilitation, and sustainment of the development of each settlement as a whole, in addition to improvements of the inhabitants' lives.

Khokana was evaluated as a candidate for World Heritage Site status in 1996. The current townscape had already transformed by then, and the collection of traditional buildings was heavily damaged. The Chapter 2, Section 6, investigation concerning the townscape focused on the original townscape rebuilt after the 1934 earthquake which caused catastrophic damage in Khokana; It will be an indicator for rehabilitation and the causes of their spatial transformation. Although the Khokana Reconstruction and Rehabilitation Committee aims to rehabilitate the Historical Settlements, the reality is that the inhabitants' needs for more comfortable living spaces, as detailed in Chapter 3, Section 5, Survey on the Residents' Intentions about Rebuilding Homes after the 2015 Earthquake, have led to the transformation of townscape of Khokana. The ideal and the reality – the ideal rehabilitation vision for the Historical Settlements and rebuilding each inhabitant's house ¬do not always accord. Furthermore, there are shortages of funds for rebuilding houses or subsidies that promote the ideal townscape. It is necessary to share the final vision for the rehabilitation of Khokana, coordinating the various opinions of the administration and the inhabitants, before developing the feasible measures to rehabilitate each inhabitant' house and the townscape.

The investigation of Khokana has not only placed emphasis on fiscal damage situation, but it is important to focus also on the viewpoint of Intangible Cultural Heritage to consider the significance of the rehabilitation as total preservation of the cultural value: in essence, cultural heritage protection and its rehabilitation for inhabitants. As detailed Chapter 2, Section 7's 'Survey of Intangible Cultural Heritage in Khokana', the Newar people have inherited the spiritual importance belonging to the village or buildings as the space for living and belief. It is necessary, therefore, to be conscious of preserving and inheriting their intangible values, in addition to the materials and forms, during the restoration, rebuilding, and rehabilitation of the houses and the townscape. The cultural water space is especially important among those intangible values. As detailed in Chapter 2, Section 4's 'Water Irrigation Circumstances and Water Quality Analysis', the immediate improvement of the water environment is expected for the appropriate conservation of cultural spaces.

Based on the investigation detailed above, Chapter 4 provides a 'Hypothetical Basic Plan for Preservation and development on the Khokana Settlements' by the Urban Design Laboratory of the Department of Urban Engineering, The University of Tokyo. This could become an effective tentative plan for discussion with the Khokana Reconstruction and Rehabilitation Committee and for inhabitants to consider the alternative visions for future rehabilitation together.

Section author : Hiroki Yamada

5.2. Problems Clarified through the Investigation of Disaster Damage Condition and a Future Perspective

5.2.1. Two problems were identified concerning the damaged houses built with the traditional construction method and those built with non-traditional methods:

1. Problems concerning the damaged houses built with traditional construction methods.

① Rebuilding techniques for the completely destroyed traditional houses.

Regarding private houses, the incentive for rebuilding with the traditional construction method, namely financial support, has not yet been established. The conservation of the settlements in the future therefore depends on the inhabitants' intention to fund the associated costs. Certain rules, including agreements among the inhabitants, mainly concerning the Khokana Reconstruction and Rehabilitation Committee or the structure of any financial support, should be established.

② Restoration and reinforcement method for partially destroyed traditional houses

Regarding the partially destroyed houses, the specific measures, such as examining the possibility of the restoration and reinforcement work making use of residual parts, have not yet been determined. Establishment of the restoration and reinforcement methods is an urgent issue from the viewpoint of townscape preservation. Technical support and the further practical examinations recommended based on the results of the microtremor measurements by the structure team are both needed in the future.

2. Problem concerning the houses built with non-traditional construction methods

The damage suffered by houses built with non-traditional construction methods was relatively slight. However, the number of houses built with non-traditional construction methods is approximately 40% of the total number of houses we investigated, and those houses have obstructed the historical townscape. It is possible that the number of houses built using non-traditional construction methods may increase through the future rehabilitation process. Along with agreements on the number of floors or the height of each floor being appropriate to the historical townscape, guidelines on the detailed facade design, such as appropriate materials and colours, should be developed.

5.2.2. Systemic problems

To establish a system for townscape control, it is necessary to unify the methods of cultural property protection with those of urban planning. However, as both of these are not yet fully developed in Nepal, there are many problems to be solved.

1. Problems concerning the administration of cultural heritage, such as evaluation or definition

In the rehabilitation guidelines currently being developed by the Department of Archaeology, 'Historical Settlements' will be defined for the first time. It is necessary, however, to protect the houses

built with traditional construction methods, to restore the existing traditional houses, and to establish the financial incentive to rebuild using the traditional method.

2. Problems concerning the administration of urban design

The housing land development area along the arterial road, 'Ekantakuna-Tikabhairab Road', has reached right before the Khokana Settlements. According to the interview survey of the authorities of Karya Binayak, the municipality into which five Village Development Committees (VDCs) were integrated last year, the land use plan to be realised in 20 years and the traffic plan to be realised in 5 years start to be prepared. It is necessary to establish the legal grounds to conserve Khokana Village as cultural property and to reflect this on the land use plan to be developed as an integrated measure. Recent concerns include the chaotic expansion of the region, such as the development of the area surrounding the village, along with perpetuating expanded farm roads leading to temporary houses. Regarding the building restriction for houses built using non-traditional construction methods, it is necessary to cooperate with the administrative body responsible for building control.

3. Preservation plan

Considering the results of these investigations, our preservation plan is proposed in Chapter 4. This proposition of the framework to preserve the settlements is one of the key tangible contributions of this report, but the habitants' actual responses should be considered. When the inhabitants' opinions are gathered during the symposium of this investigation which is to be held in the future, the plan should be improved and further materialised. Furthermore, the ideal is give unify cultural properties protection administration and the city planning administration based on our improvement plan. This is our main focus from next year onwards.

5.2.3. Future issues of the historical settlements as the inscribed site on the Tentative World Cultural Heritage List

The strategy of extending the World Heritage site of the Kathmandu Valley needs to be formulated. The four sites registered in the tentative list were the residential areas of the people who were active around the royal palaces inside the Kathmandu Valley, such as the base village of the former trade roads and the village with Medieval monuments; they are intended to be added in to the World Heritage Site list as properties which have historical relations with the Kathmandu Valley.

As already detailed above, Rajkulo, built as the water supply system of the Kathmandu Valley, for example, supplies water to watering places and ponds of the three royal palaces of Kathmandu, and it has also functioned as the irrigation canal circulating water throughout the Kathmandu Valley. There are no records of who built Rajkulo, and with few existing sources following rapid urbanisation, its whole story has not yet been revealed. However, it is easy to imagine that this system contributed to the settlements around the royal palaces. It is necessary to investigate the lives of inhabitants throughout the whole valley at that time in order to explain the universal value of this water system.

Moreover, the setting of the boundary of the property and its buffer zone needs to be examined. Integrated agreements with the city planning administration are needed, as detailed earlier, and we intend to tackle this as a future issue.

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5.2.4. Project proposals

The following four projects are proposed.

1. Pilot project of the structural reinforcement for the damaged houses built in traditional construction methods

Launch the pilot project on structural reinforcement; if realising the reinforcement of private houses is difficult, aim, for example, to establish the restoration reinforcement technique for the partially destroyed mustard oil factories built using the traditional construction method (common ownership buildings) inside the residential area,.

2. Mustard oil factories base arrangement project

This project is for tourist development, for example by transforming and arranging closed factories into exhibition spaces to be visited by tourists.

3. Water spaces improvement project

The culturally important water spaces should be improved with the support of Japan International Cooperation Agency (JICA) as the portent project of earthquake disaster rehabilitation. The water supply system in the valley seems to have high technical and cultural values, in addition to its strong relation with intangible culture. It is desirable, therefore, that this old wisdom should be re-evaluated and renovated.

4. Re-evaluation and Rehabilitation project of Rajkulo

Deep understanding and rehabilitation of Rajkulo should be re-evaluated, not only because as one of the measures to resolve the chronic water shortage in the urban area of Kathmandu, but also because it is one of the important systems underpinning the prosperity, life, and culture of the Kathmandu Valley. Starting from surveys and other methods of collecting information, we would work on the rehabilitation and development project

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