Decoding the Vernacular Practices of The Cold-Dry Climate of The Phyang Village in Leh-Ladakh

Shoumik Desai[1], Apoorva Bhate[2], Akshay Varma[3]

Affiliation: 1-NITTE Institute of Architecture Mangalore; 2-CEPT University, Ahmedabad; 3-Windows to Vernacular

Email: shoumik.desai@yahoo.in; appubhate@gmail.com ; akshay@windowstovernacular.com

Abstract

India has a wide range of diversified climatic, geographical, and sociocultural settings. This gives a distinct character to the settlements in each region. However, owing to rapid urbanization and industrialization, our buildings are becoming more pretentious and is being built on a principle of one size fits all.

Currently, in India, the building sector accounts for 29% of national energy usage. The built-up space is projected to increase by 66% until 2030. This results in national and global greenhouse gas emissions. To combat this, we need to look into our roots, which is unpretentious, and was built by integrating the natural, cultural, and solar geometry principles. Vernacular buildings are the result of resources available and provide an optimal relationship between the natural and built environment. Even though vernacular construction practices have numerous benefits, it is rarely used and adopted in new construction development. This is owing to rising demand for built spaces in a brief period of time, unwillingness to adapt vernacular practices, and contemporary building practices and materials. This is especially important in cold desert regions which have severe temperatures, rough topography, steep gradients, hostile environmental settings, a diverse flora, and are vulnerable to natural risks. In hill settlements, a large number of multistory buildings using modern materials and techniques are being built without regard for the context and environment. This depletes the ecology and ecosystem of the location and also impacts the health and wellbeing of the occupants.

This research aims at mapping the residential typology in the cold and dry desert of Leh-Ladakh. The parameters studied are the thermal properties of the materials, building orientation, massing, and resource mapping. The learnings from this research will help us formulate a design response that will integrate the new technology and vernacular wisdom and yet retaining the essence of the socio-cultural interactions.

Keywords: Phyang-Leh-Ladakh, Cold Climate, Solar geometry, Climatic design, Vernacular Architecture

Introduction

In India, the commercial and residential segments account for 30 percent of entire energy usage (8 percent in commercial and 22 percent in residential), and consumption in these segments is increasing at an annual rate of 8% (Kumar *et al.*, 2010). Given this understanding, under the conventional situation, energy consumption from residential buildings is expected to surge by more than eightfold by 2050. This makes it critical for India to practice energy-efficiency strategies targeted at the residential sector in order to curb the current trend of unsustainable rising energy requirement (Rawal *et al.*, 2014).

India has a wide range of diversified climatic, geographical, and sociocultural settings. This gives a distinct character to the settlements in each region. Climate-based responsive architecture and its familiarity in the form of vernacular architecture and insight are responsible for the building's specific characteristics. In Indian settlements, sustainability is a given and it origins from the method of living. This traditional understanding of constructing human dwellings has been known to be put to the test over time in diverse settlements, as evidenced by planning, orientation, materials, and architectural techniques that have evolved over time in response to socioeconomic, environmental, and other conditions. These vernacular strategies have proved to be useful in reducing energy consumption as well as providing occupant comfort even the adverse climatic conditions. However, owing to rapid urbanization and industrialization, our buildings are becoming more pretentious and are not only losing the socio-cultural identity but also contributing to Global warming by consuming more energy.

Most research in the global south focusses on megacities (Kraas, 2007; Kraas *et al.*, 2014) or on urban hinterlands and disregards smaller or medium-sized towns, despite the fact that these are the rapidly growing towns that require more research (Cohen, 2006; Montgomery, 2008). Between 2001 and 2011, the population growth rates of India's megacities fell, while the growth rates of smaller towns grew consistently (Gooptu, 2016:331-335). When it comes to clusters in mountainous areas, this research gap is even more concerning (Mathieu, 2003).

Hence for this research, an example town in Leh district in Ladakh-Union Territory of India has been chosen. Leh is experiencing rapid urbanization, posing new issues for infrastructure, urban planning, housing, and urban environment (Müller and Dame, 2016). Ladakh is disconnected from the Indian subcontinent by the Great Himalayan Range and is surrounded by the Karakoram Range towards its north. A temporal analysis of satellite photos taken between 1969 and 2017 suggests that the urban sprawl in Leh during the last five decades is quite alarming (Dame *et al.*, 2019). According to the report, the number of people living in cities tripled between 1981 and 2001. Furthermore, the population of Leh increased to 30,870 people in 2011 (Directorate of Census Operations Jammu & Kashmir, 2011, table 1). The effect of high population growth can also be seen in construction activities. Between 1969 and 2017, the built-up area increased from 36 hectares to 196 ha, with construction of 18,660 new buildings (Dame *et al.*, 2019). Furthermore, remodeling may be seen in the town's central areas as well. Many new multi-story structures have sprung up on what was once farming land. The position of Leh as an administrative and infrastructure centre, the expansion of the tourism sector, the diffusion of metropolitan sociocultural lifestyles, and the region's geopolitical importance are the four key drivers of growth and development in Leh.

While previous studies have documented the Ladakhi villages (Nüsser, Schmidt and Dame, 2013; Kaplanian, 2015), our focus is to document the five local houses and further analyze what building characteristics and have been helping the occupants to address the adversities of nature. Further, this vernacular design knowledge will be disseminated using the basics of building sciences knowledge. Three questions are addressed in this study: What are the spatial characteristics of the houses that have been documented? What are the thermal properties of the houses that have been documented? And, what is the vernacular design response to address the adversities of nature as well as topology?

This study aims to document the houses in the Phyang Village of the Leh District. Documentation broadly focuses on planning & architecture aspects. The study of local vernacular architecture, as well as lessons in climate responsive planning and methodologies, can help to produce a green building design strategy.

Methodology

For this research, Phyang village- in Leh district had been identified. According to ECBC 2017, Leh is 3527 meters above sea level and is categorized as cold and dry climate region. The annual average temperature is 5.2 °C. The average maximum temperature in July is approximately 17.4 °C, with a record high of 34.8 °C. While the lowest average temperatures of around -8.6 °C occur in January and the recorded lowest is -27.9°C. The annual rainfall is 103 mm, with the monsoon months seeing the most torrential rainfall (cloudbursts). Due to the effect of western disturbances, there is also heavy precipitation over Leh throughout the winter and pre-monsoon seasons. Because to the Himalayan Range's rain shadow effect, the town experiences arid weather with seasonal water availability (Nüsser, Schmidt, and Dame, 2013). But on average the daily precipitation amounts range between 0.5-1.5mm/day. However, daily precipitation quantities average between 0.5 and 1.5 mm per day. This location also receives the maximum radiation in India, averaging around 7-7.5 kWh m^2 /day.

Further, the houses were selected based on the following criteria.

1. House should have used vernacular building material and local construction techniques for building.
2. Houses selected should be at least 20-30 years old.
3. And, houses should have modifications done over last five-ten years.

Based on the above criteria, a pilot study in the village of Phyang which is 19 km away from the Leh was conducted. Based on the site visit, five houses were shortlisted. Once the houses were identified, the research team got permission from the house owners. The team of 12 members documented the house in a time frame of 15 days, the process was further assisted by a group of Ladakhi students studying in Students' Educational and Cultural Movement of Ladakh (SECMOL), Leh-Ladakh. The protocols were defined beforehand for the documentation process to save time during on-site documentation. The plan, sections, and elevations of the house were documented using the on-site measurements, sketches, cased measure tapes, and digital measuring tapes. Further, this was translated onto digital drawings using AutoCAD for 2D plans and sections and Sketchup for 3D models. Picture documentation was done using phone cameras, and digital SLR. All the data collected was cleaned and collated at the end of each day. All the data was stored in hard-disks and on cloud storage for sharing, backup, and further analysis.

Based on the above-mentioned criteria following six houses have been identified for this study.

1. House 1 - Hanugun House
2. House 2 - Chirpon House
3. House 3 - Tibetan Lady House
4. House 4 - Norbu House
5. House 5 - Skiltang House

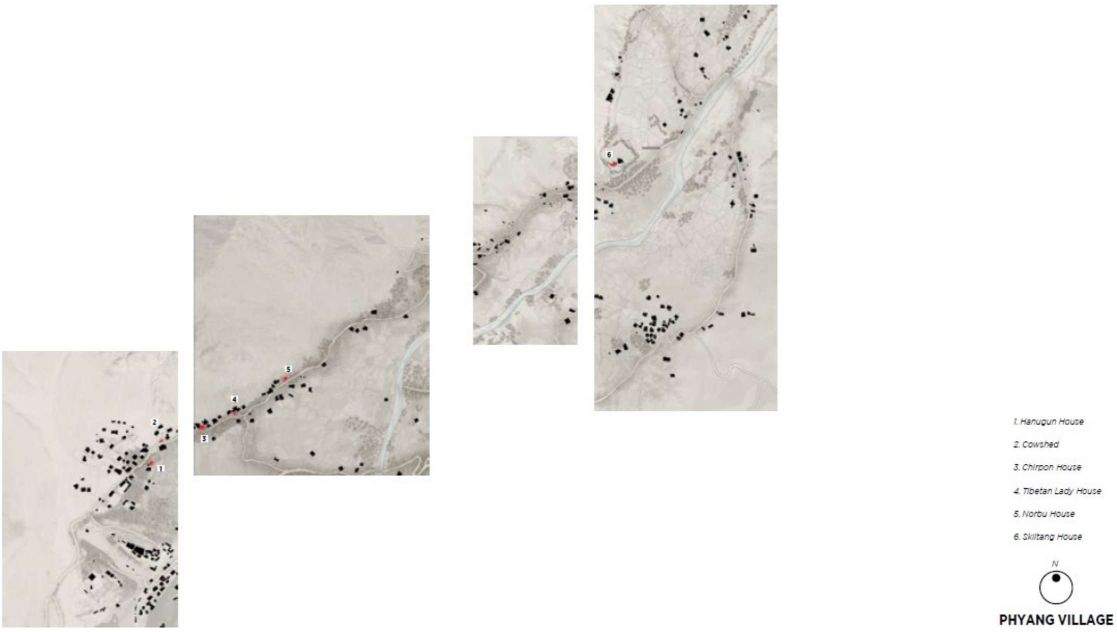

Fig. 1: Siteplan of Phyang Villages with sites located Source: Author

Results

The results section has been divided into three parts. It is as follows.

1. Documentation of five houses. Plans, sections, and elevations for five houses.
2. Building characteristics. The building envelope, thermal properties, and house demographics.

3. List of vernacular design strategies to adverse climatic conditions.

1. Documentation of five houses.

This part talks about the five houses that have been documented.

- **House 1 - Hanugun House**

Located on the western side of the Phyang valley, this 60-year-old structure belongs to the Hanugun family. It was built after the demolition of their old house which was about 200 years old. Fine quality poplar was used in the structural members like posts, brackets, girders, and beams of the old structure and hence were reused while building the new structure. The mud to make pagbu, the traditional Ladakhi mud blocks, for the walls was taken from their neighboring farms. The plantations of willow and local popular trees fulfilled their requirements of wood for flooring and roofing.

In 2012, the family moved to a newer house on the same plot, and the old structure is currently inhabited. The structure has an outdoor cowshed which is used for keeping the cattle presently. The structure consists of ground + 2 stories.

It houses the tangras at ground floor level to shelter a variety of cattle like sheep, zho, and cows. Pangpugs was specially dedicated to storing cow dung and firewood for winters. The chankang (storage for vegetables and local wine) and the pankang are also present at the same level though they have overhead access. The toilet pits of 2.2 m^2 end at the ground floor level.

The first floor consists of the main living area which includes the chansa of 2.2 m^2, living room, 1 donkang of 2.2 m^2), 3 zimskang each of about 2.15 $m^{2,}$ and access to the pankang of 2.13 m^2 and chankang (wine storage room). The second floor consists of a chotkang of 2.66 m^2 with an overhead skylight, for religious significance. The temple room is painted in bright yellow and orange colors with traditional Buddhist patterns running across the wall. The toilet has a double-height pit that goes down to the ground floor. The yabs is done up with mud flooring and provides for the skylights and vents in the chansa and living area on the first floor. The following images show the plans/sections and elevations.

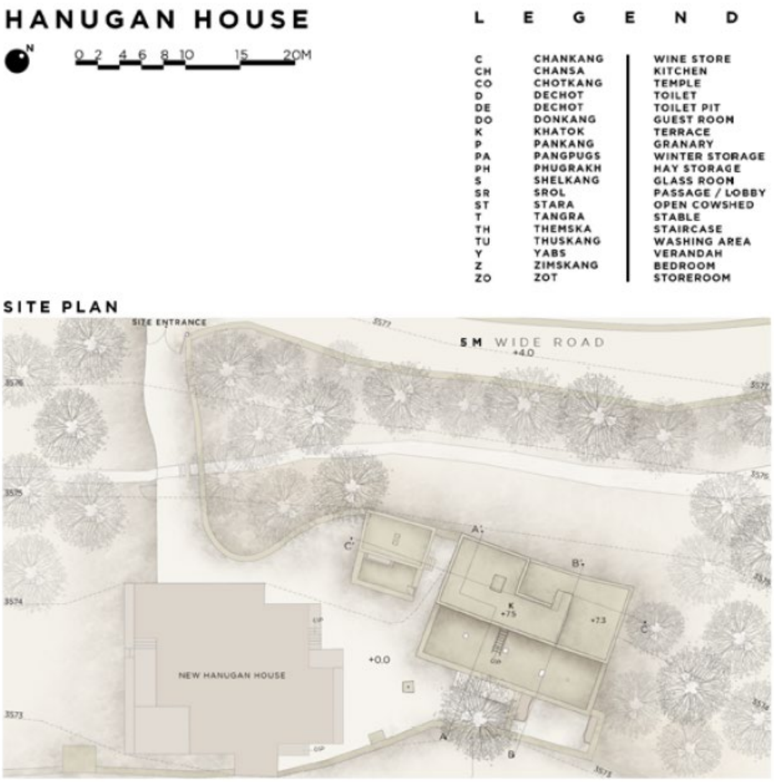

Fig. 2: Hanugan house - Site Plan Source: Author

Fig. 3: Hanugan house plans @various levels Source: Author

Fig. 4: Hanugan house - Sections Source: Author

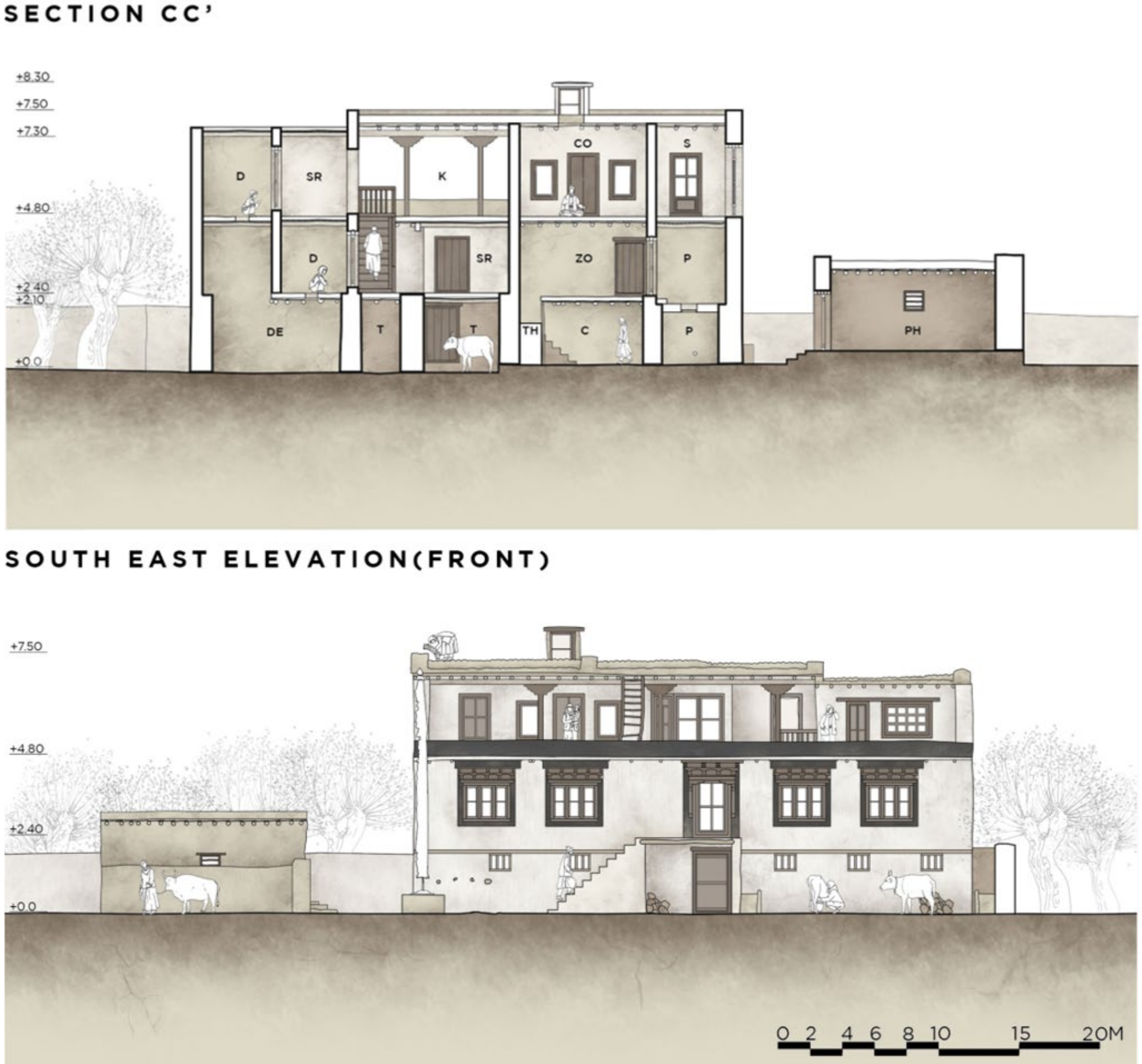

Fig. 5: Hanugan house - Section & Elevation Source: Author

- **House 2 - Chirpon House**

Built on a slight contour facing the road, this structure belongs to two different eras. The ground floor is about 160-200 years old and was initially used as living rooms for the Chirpon family.

Around 4-5 families used to stay in this house. The upper floors were constructed and used as living rooms while the ground floor was completely utilized as the cowshed. The ground floor of this house is partially earth-bermed. The upper floors are about 65-70 years old. The family owns farms on the opposite side of the road where Barley, Rice, Apricots, Apples, Walnuts, Poplar, Willow, and Potatoes are grown. The family shifted to a new house but as per old customary beliefs, they refuse to demolish the old structure without the consultation of a Lama.

The house consists of 4 tangras,3 staras, 2 dechot, 2 dry toilets, 1 thuskang of about 3.28 m^2, 1 chansa of 50.8 m^2, 2 bang, 1 prayer room, 6 bedrooms of around 10 m^2, a khathok, and several zots of 2.5 m^2. Skylight has been used above the staircase block for daylight gains. The terrace on the second floor is accessed by the staircase block. The prayer room is accessed from and opens into this terrace. The structure has been built in a typical Ladakhi style of construction with the use of doa (stones) and kalak (mud blocks) covered by a layer of shaskalak (mud plaster). The karkun (windows) and sgo (doors) are made from wood. Poplar of varying diameters has been used to support the floors. Straw is used on the roof for insulation purposes.

A direct gain glass room is present on the second floor but is currently inaccessible as it has been locked by the Lama. A special feature seen in this house is the presence of double-height storage at the rear end of the structure, used to store hay. The following images show the plans/sections and elevations.

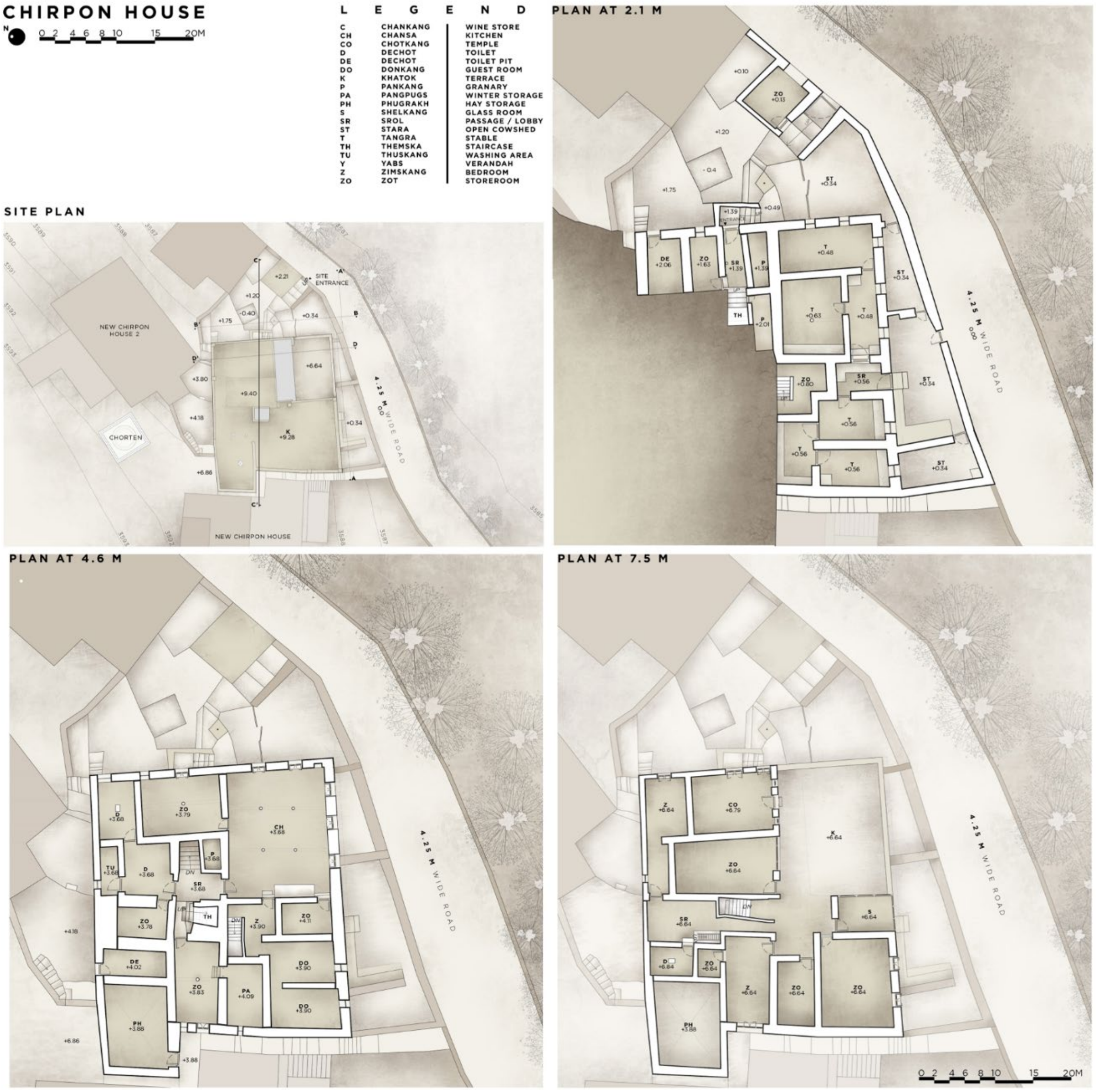

Fig. 6: Chirpon House - Plans @various levels Source: Author

Fig. 7: Chirpon house – Elevation Source: Author

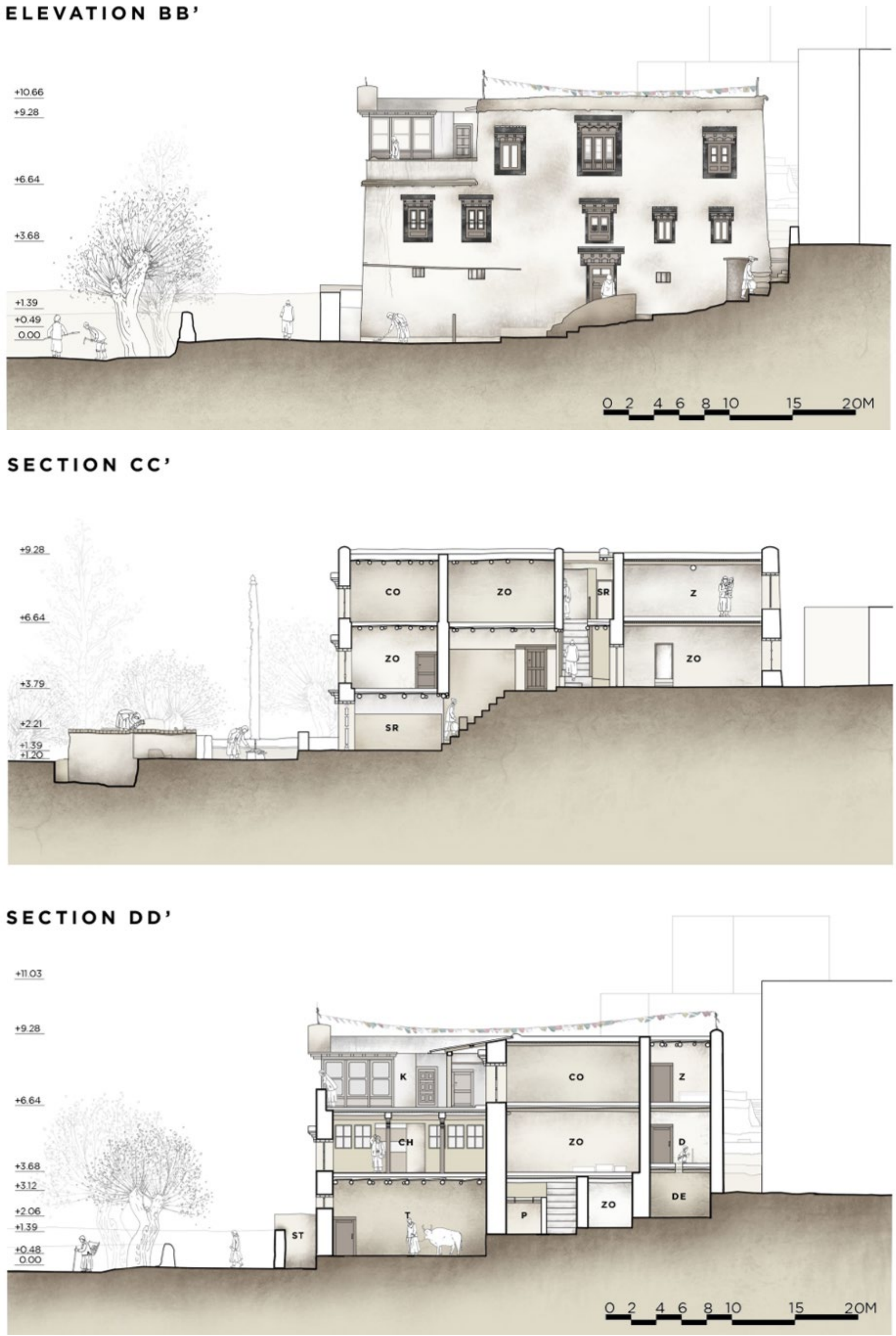

Fig. 8: Chirpon House - Elevations & Sections Source: Author

- **House 3 - Tibetan Lady House**

The house originally owned by a Tibetan lady is 30-40 years old and is situated among a cluster of dwellings facing the main road. It was left abandoned after the owner died, and it is now in a deteriorated state. The house is a ground + 1 story load-bearing structure with half of the ground floor earth-bermed.

Poplar, willow, wooden posts, mud bricks for the first story, and stone for the bottom floor are among the structural parts. A tiny creek runs alongside the main road in front of the structure's south elevation. This brook provides water for all of the occupants' domestic needs. The tangras (about 60 m^2) on the ground level were used to house cattle such as cows and zhos. A pangpug for hay and cow dung is also included. On the ground floor, there is also a toilet pit. The outside themska leads to the first floor, which has a 12.5 m^2 donkang, a 20 m^2 zimskang, a chansa, a dining room, and a 6 m^2 dechot.

With an area of around 11 m^2, the chansa is compact and comfortable, with an internal temple space as well as a Bukhari vent (a portable fireplace). For seating, a raised platform was created along the dining room's perimeter, which also housed a Bukhari. The home can be approached through an open court, which is temporarily covered by a makeshift roof.

According to the analysis, the deteriorated condition of the house could be attributed to the natural weathering or the unaffordability of maintenance by the resident. The open court seems to be a consequence of the unaffordability of the permanent roof structure. Regardless of the house condition, it is evident that the house is a vivid expression of a shared architectural vision in Tibet and Ladakh.

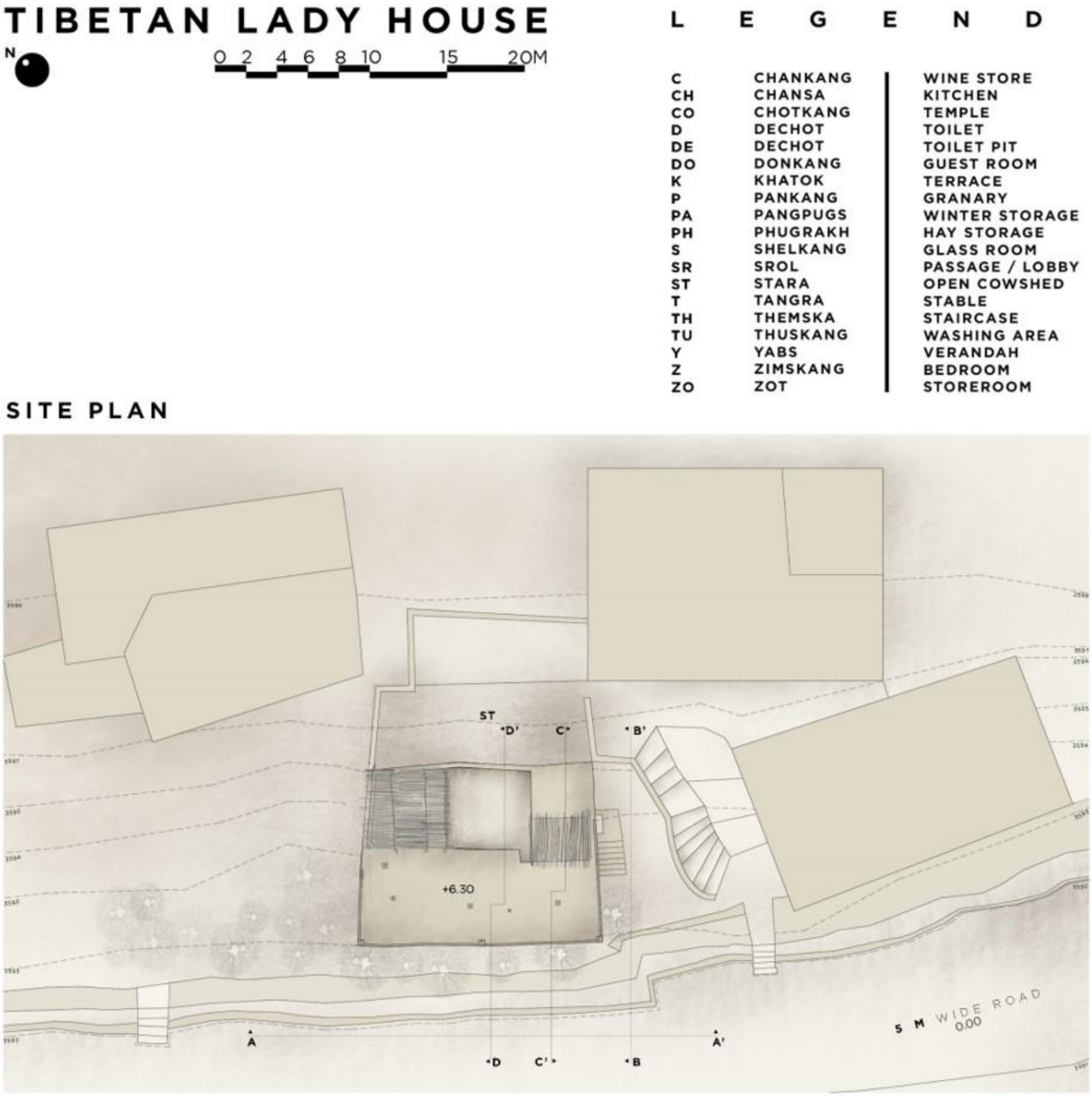

Fig. 9: Tibetian House - Site Plan Source: Author

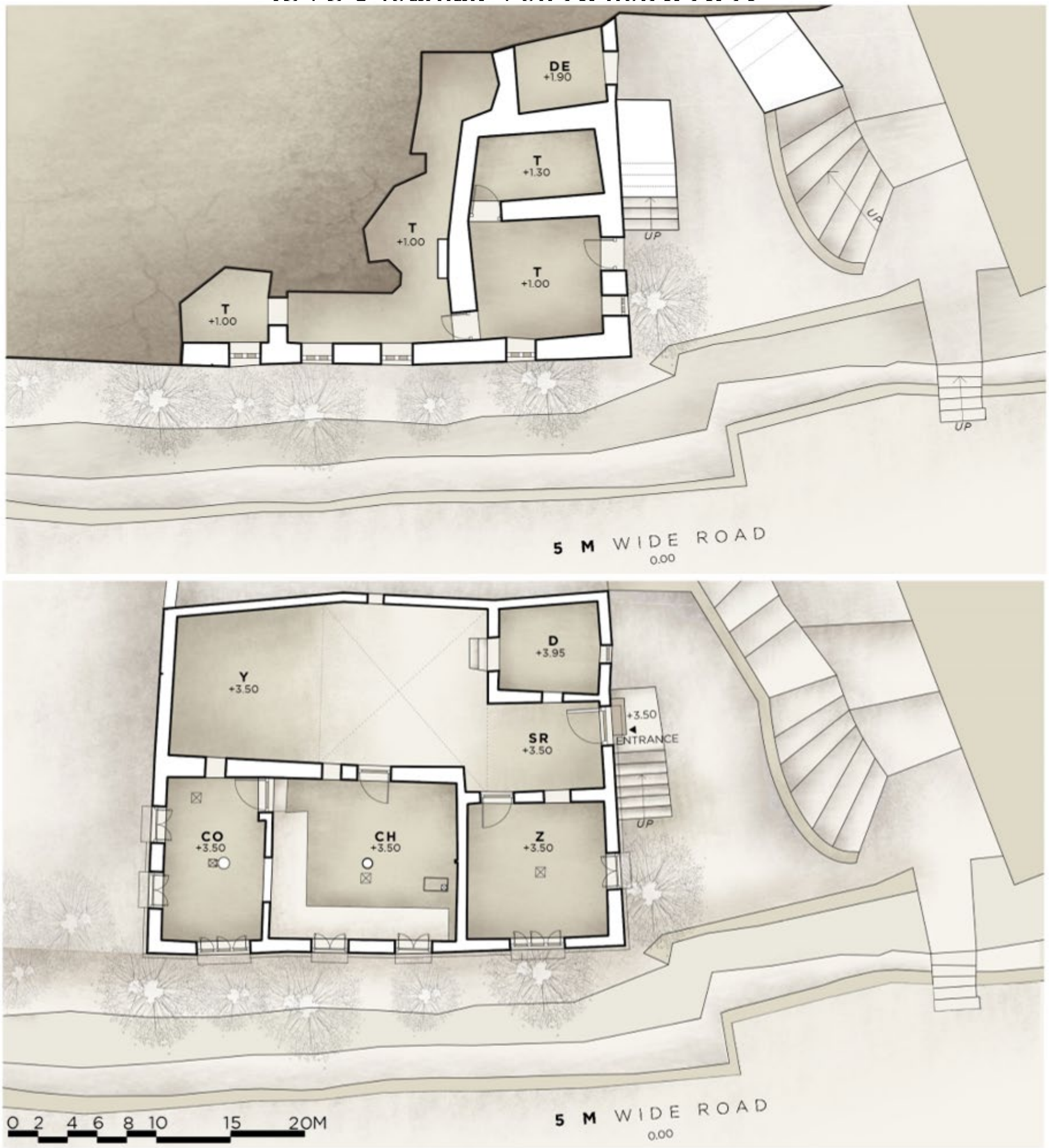

Fig. 10: Tibetian House - Plans @various levels Source: Author

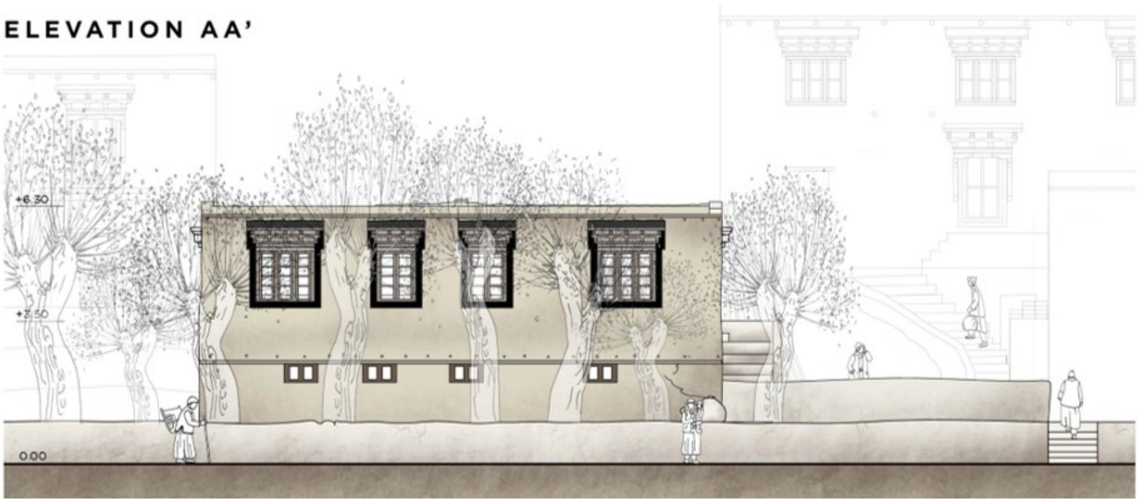

Fig. 11: Tibetian House – Elevation Source: Author

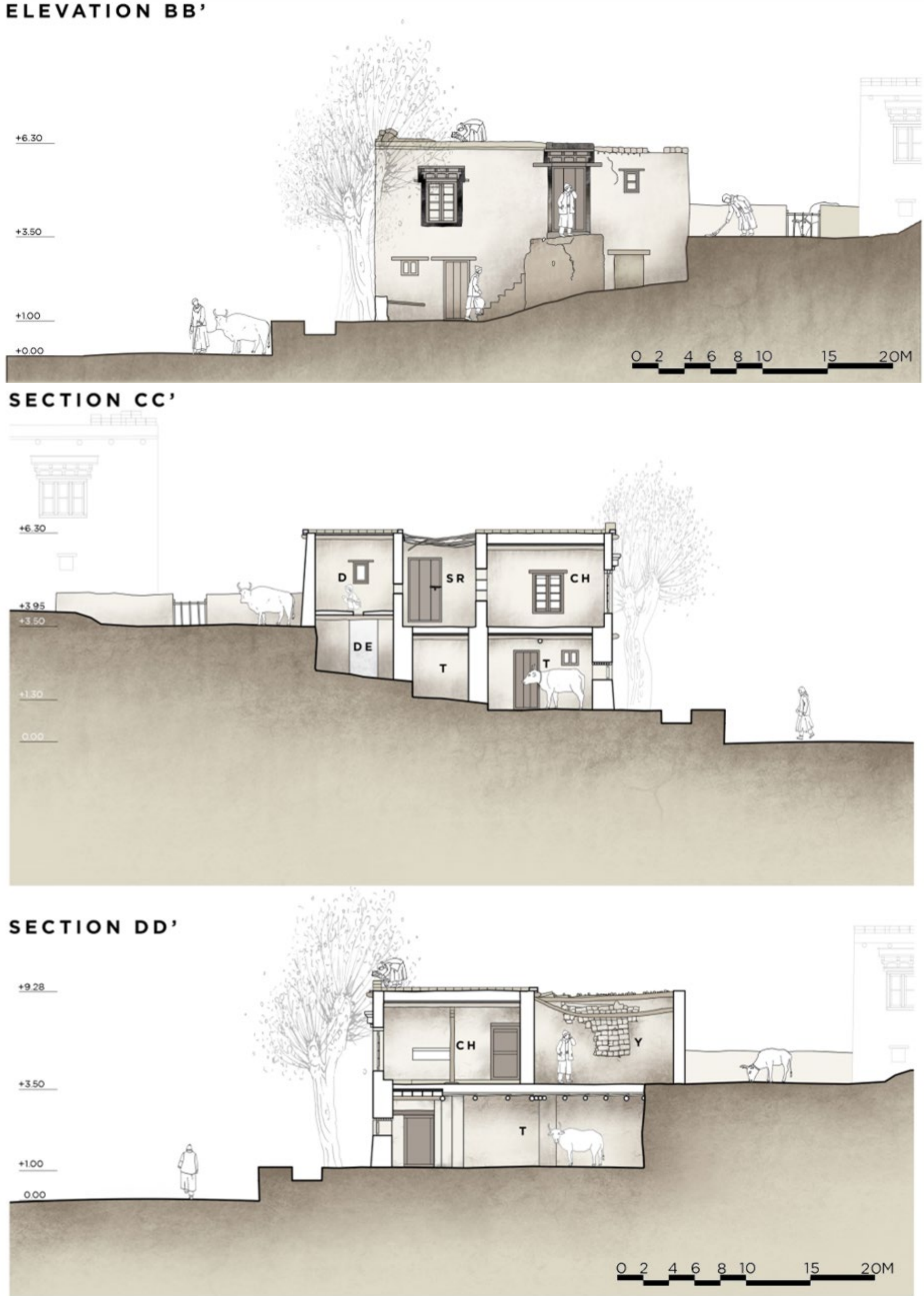

Fig. 12: Tibetian House - Elevations & Sections Source: Author

- **House 4 - Norbu House**

Owned by Norbu Tsewang's family, the entire house has been constructed in two parts. It is located on a steep terrain facing the main road. It is a load-bearing house with a flat roof. The oldest part of the house was built about 200 years ago and is located at a higher contour. 130 years later, Mr. Norbu's father further extended the house, which today touches the road. During the construction of the new structure, certain changes were made in the fenestrations of the old structure to merge with the new house, by creating new accesses. 5 generations of Mr. Norbu's family has lived in this house. The family has their farms on the land adjacent to the road and opposite their old house. They grow apricots, walnuts, and apples of both Ladakhi and Kashmiri type. Exotic flowers and vegetables are grown in their greenhouse installed near the farm.

The old house is now used as a cowshed and for storage purposes. The 200-year-old structure has a kitchen on the ground floor, a room for hay storage, and another room for storage. The oldest part of the house is entirely made of stone and rubble and then plastered from outside while the extension is plastered with white mud plaster. The hay storage room is earth-bermed. The first floor has a terrace, a room, and access to the temple via a staircase which was demolished at the time of new construction. The temple is now accessed from the terrace of the new structure. The cowshed is present on the ground floor as well as at different levels around the house. The ground floor is made of stones and the upper levels of mud blocks. Poplar is used as the structural member of the roof. Willow sticks run along the span between two poplars above which lies a layer of yaksees. The mud blocks are placed on the yaksees and the floor is finished with a mud layer. Most of the rooms include vents for the Bukhari (a portable fireplace). The kitchen houses a traditional Ladakhi chulha and was the primary living space of the family and all routine activities of the household took place here.

On the second floor, there is a direct gain window facing the south. This room was for recreation during winters. It remained warm through the day however became cold at night. The Guestroom on the first floor has attached storage. A cut out is made in the floor slab and is used for storing grains.

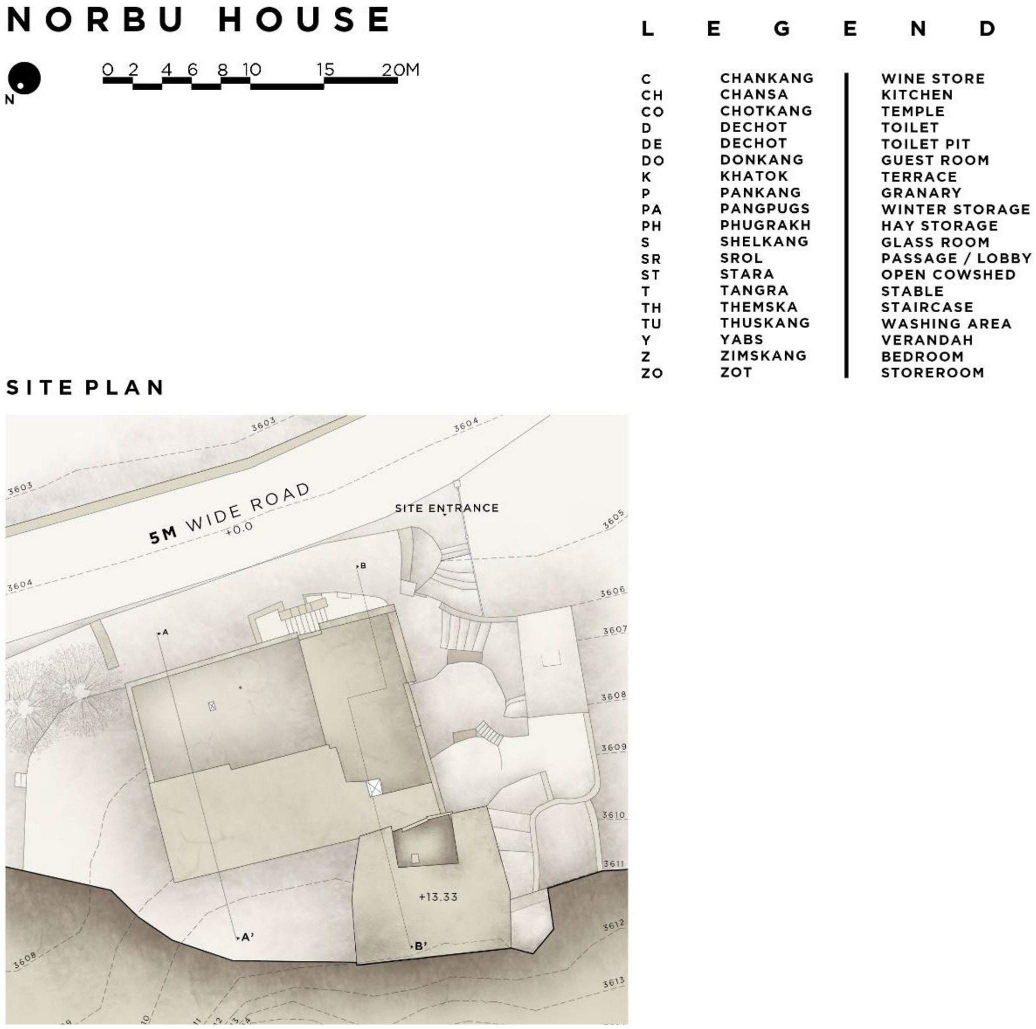

Fig. 13: Norbu House - Site Plan Source: Author

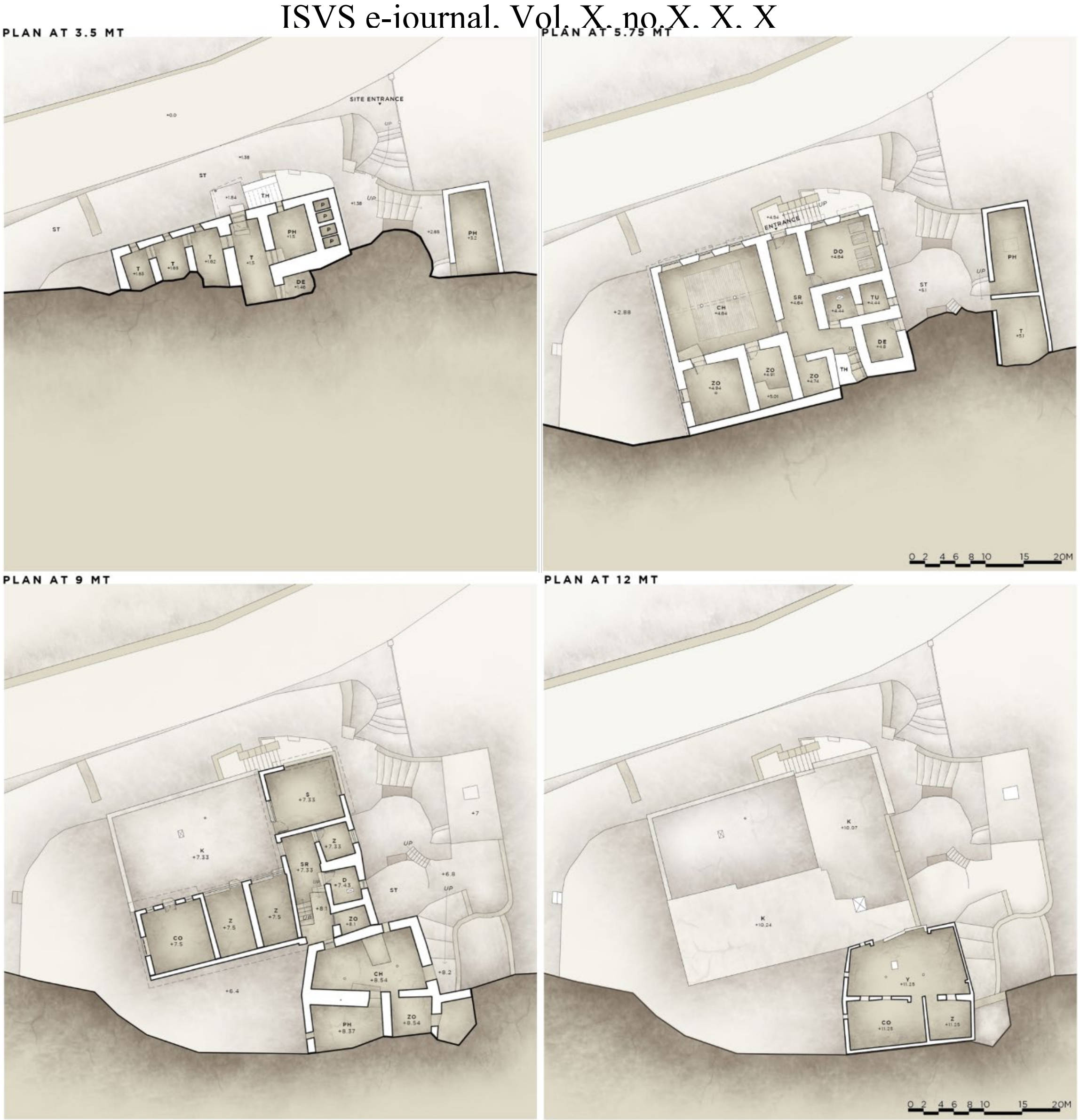

Fig. 14: Norbu House - Plans @ various levels Source: Author

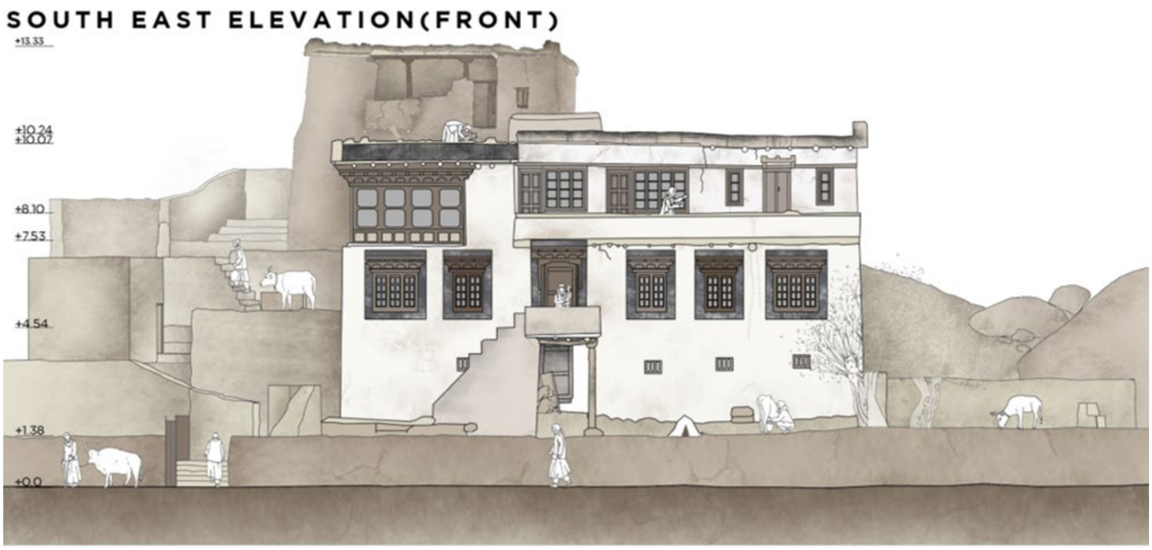

Fig. 15: Norbu House – Elevation Source: Author

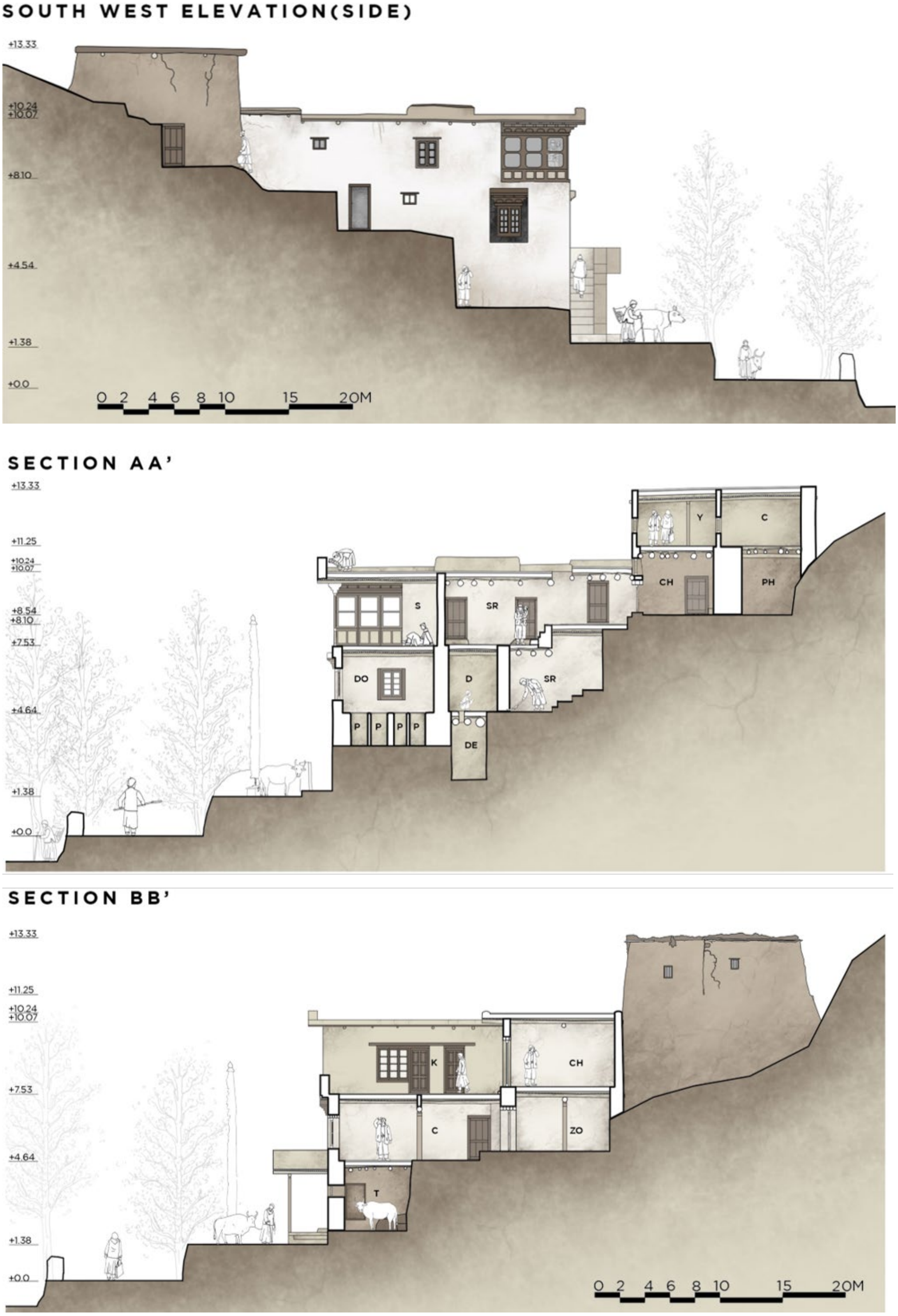

Fig 16: Norbu House - Sections & Elevations Source: Author

- **House 5 - Skiltang House**

Overlooking the entire Phyang valley stands the beautiful 150 years old Skiltang House. It is an outstanding example of the traditional architecture found in Leh. The name possibly suggests 'central house' as 'skil' means 'in the middle' and 'tang' stands for rooms. The house was constructed using locally available materials such as rocks quarried from the neighboring mountains, pagbu (mud blocks) from their fields, and wood from the trees such as Poplar or Willow. Stones were used for constructing the lower floors, mud blocks for the higher floors, and wood for flooring and roofing.

Parts of this old house are still in use for storage purposes, though the owners have shifted to a newer house, adjacent to this old structure. The house consists of several tangras at the ground level made of stone walls used to shelter a variety of domesticated animals such as cows, zhos, and sheep through the night and in stara during the day. The ground floor also contains the pangpug. Toilet pits are also found on this level. The ground level also includes the pankang which has access from the first floor. The elevation depicts a white chorten with three attached prayer wheels. This has religious significance and also adds a sense of beauty to the house.

The first floor consists of four rooms, one of which is currently being used as zot, one as pankang, the chansa, and a dechot. The chansa was well lit with vents in the ceiling, for Bukhari and the mud stove. The old traditional mud stove, as well as the shelves, have been preserved. Access to the ground floor from the granary using a wooden ladder was once provided but has now been removed. A part of the second floor has been demolished leaving only two rooms, the chotsang and the donkang. The donkang has long windows with a low sill level facing the southeast direction. The prayer room is painted red on the inside.

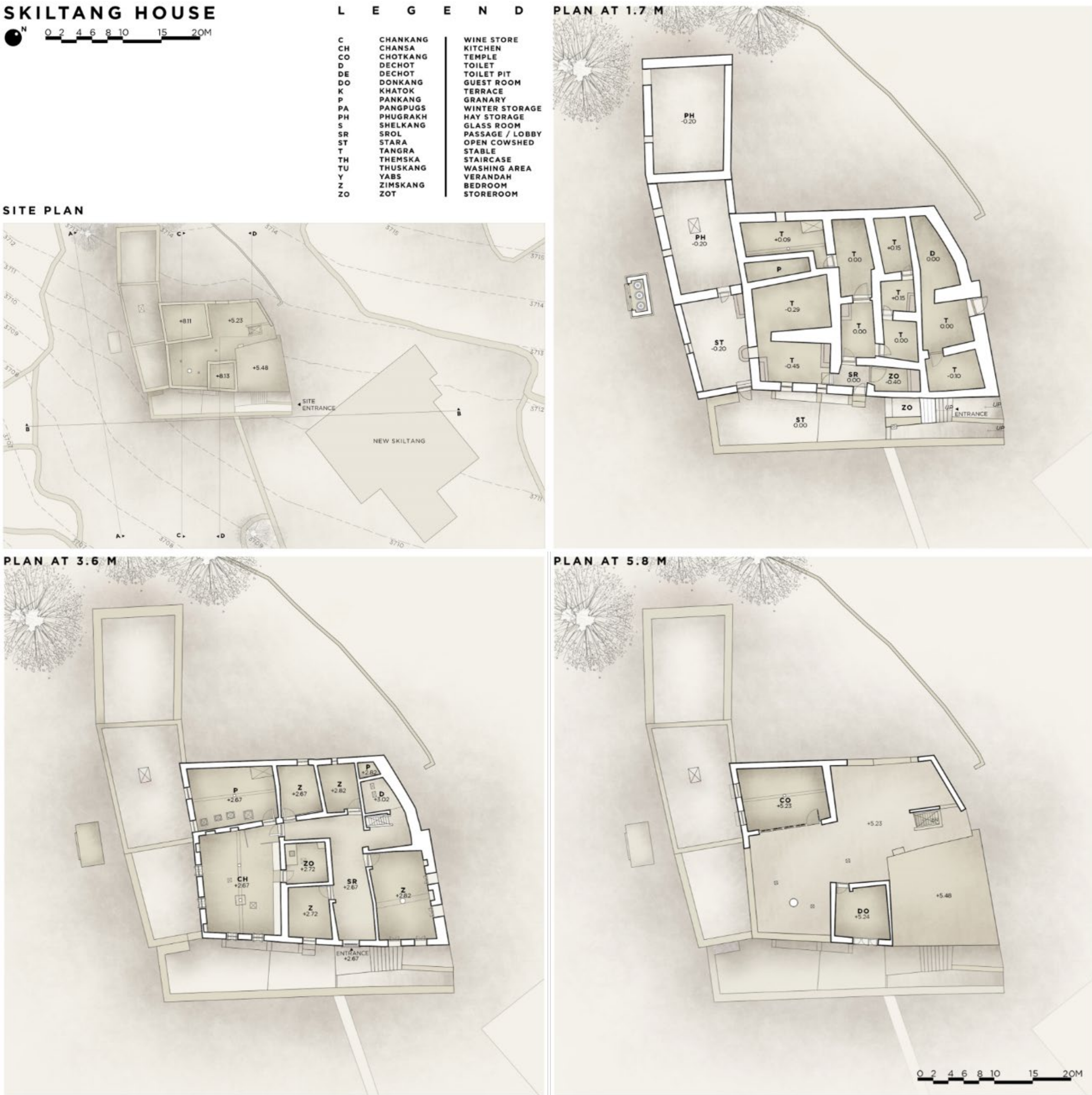

Fig. 17: Skiltang House - Plans @various levels Source: Author

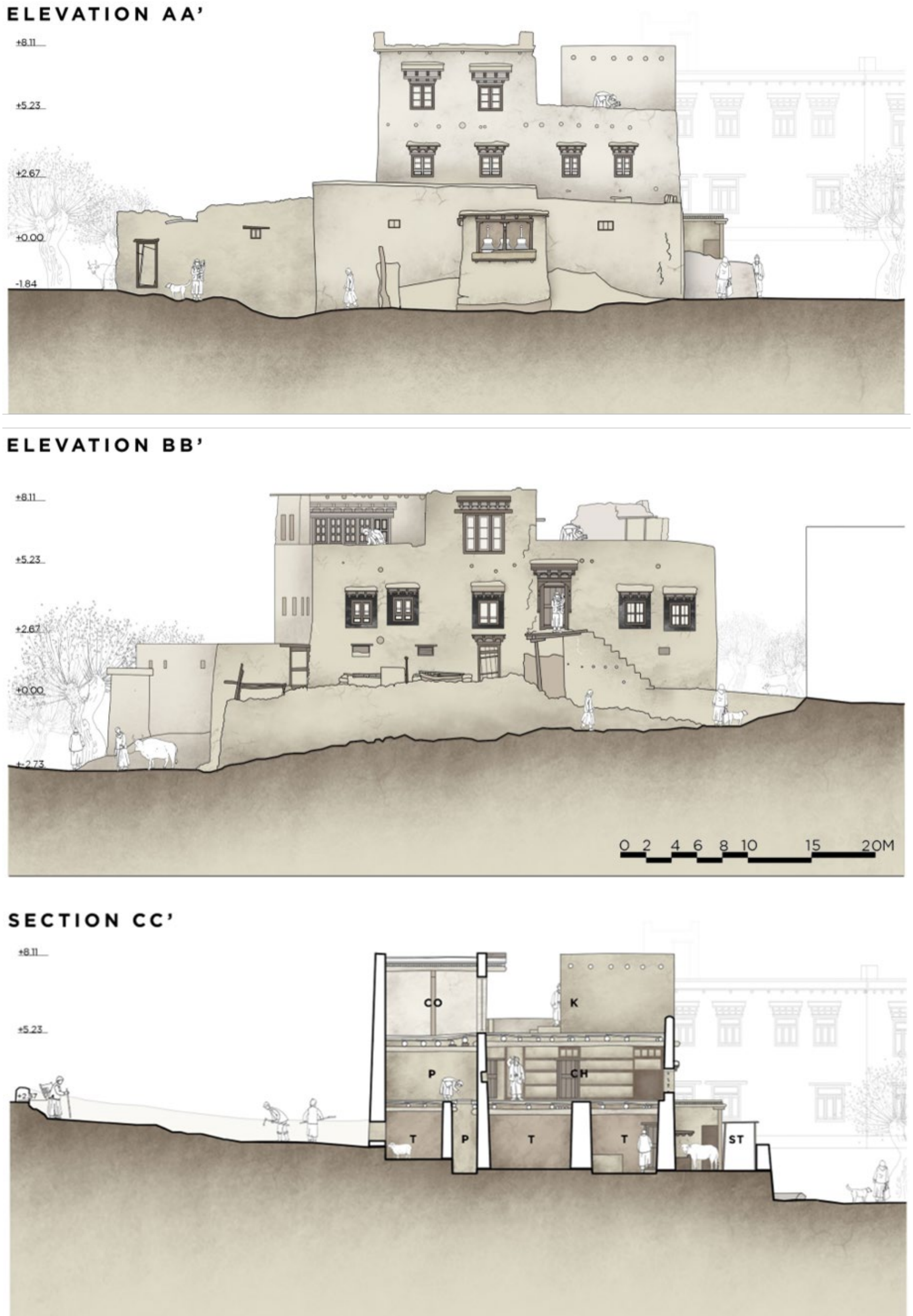

Fig. 18: Skiltang House - Elevations & Section Source: Author

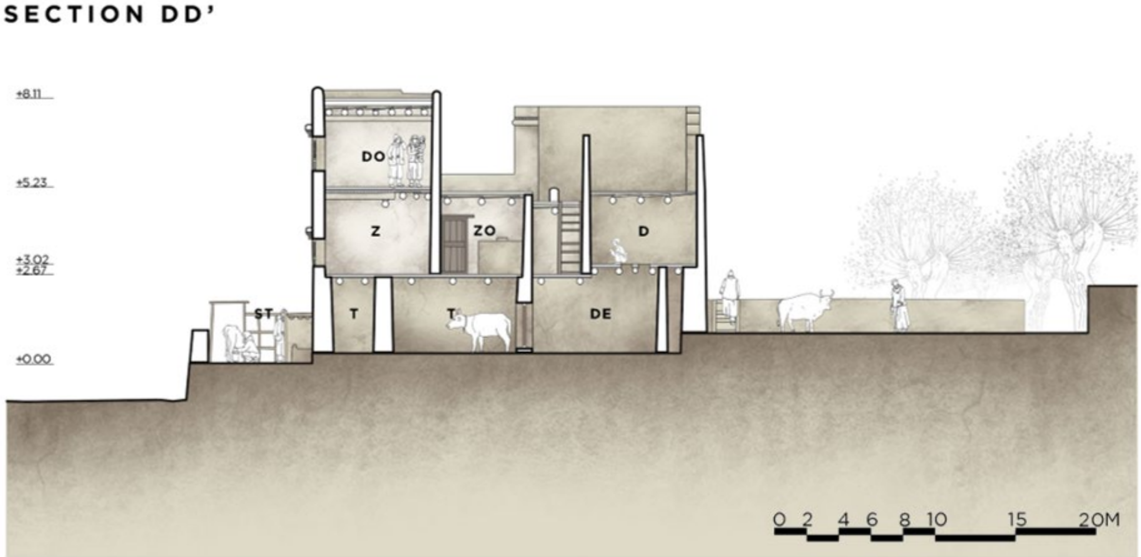

Fig. 19: Skiltang House - Section Source: Author

2. **Building characteristics. The building envelope, thermal properties, and house demographics.**

The primary results of this documentation suggest that the houses have a very strong dependency on the locally available material which is available in the range of 0-800 meters. The houses are observed to be three stories high around 7.5 meters and an average floor height of 2.5 meters. The rooms are clustered closely to reduce the heat loss from the building. The average aspect ratio of the buildings is observed to be 1.3 with a long side facing north south. This helps to maximize the solar radiation gains and helps maintain comfortable indoor climatic conditions.

The ground floor is generally an animal shelter and is placed beneath the main hall as the bodily heat generated i.e., internal gain by the cattle warm up the main hall from below. Moreover, it creates air insulation to reduce the heat losses through the ground. The first floor generally consists of the kitchen, bedrooms, toilets, and washing areas. The cooking activities in the kitchen serve as a source of internal heat gain and help maintain a comfortable temperature. Further, owing to the limited water availability, dry toilets have been used. The third floor is generally used as a summer room with flat roofs as they have little rain and is also easy to remove the snow. Average room depth is found to be around 5.5 meters owing to the limitations of the building materials and it also helps to maintain thermal. This is because large volume spaces need more time and electrical energy to warm up and also it loses heat very quickly. The mean window-to-floor ratio (WFR) and window-to-wall ratio (WWR) is 6.2% and 6.6% respectively. This shows that these houses have very low windows to reduce the heat gain and protect the inside space from the high cold winds. However, this also leads to limited daylight access in the rooms. The average overhang depth is 0.28 meters and is made of local wood. The lintels of the wooden doors and windows are ornately corbelled elements. This also works as a thermal barrier, preventing heat loss through conduction from the wall.

Load-bearing structures have been used in this construction with an average wall thickness of 0.9 meters. Drywall masonry techniques have been used for wall construction and are generally constructed with stone, sun-dried mud bricks, and plastered with fine clay markala. This results in an average wall U-value of 1.58 W/m^2. K for the dwellings. The ground floor wall is generally made of stones and mud plaster. Whereas, the first-floor walls are made from mud plaster, mud bricks, and mud mortar. The roofs are generally 0.38 meters in thickness and constructed from poplar beams, willow branches, grass piles, mud, and earth. This serves as a thermal insulation layer. The average roof U-value is 0.50 W/m^2. K. Owing to these thermal properties of the roof and floor, the indoors tend to be comfortable even when snow sits on the roof for days.

Apart from the reduced transportation, another benefit of using the locally available material is that they provide high thermal insulating properties which help in achieving indoor thermal comfort. The details have been summarized in table 1. By using the vernacular materials climatic comfort in the wide diurnal range of Phyang village can be achieved. In extreme winters, traditional building constructed with stones, lumber and earth blocks were able to provide a temperature difference of nearly 40ºC. Inside temperatures measured at 20ºC while the outside temperature dropped to freezing -20ºC. It is because of these benefits; local material is ideally used for centuries to construct not just houses but also the magnificent monasteries and palaces in the region.

Table 1: Analysis of houses with Vernacular parameters

Characteristics		Units	House 1	House 2	House 3	House 4	House 5
1. Building envelope and thermal properties							
1.01	Orientation	the longer side is facing	North-South	North - South	North East-South West	North West-South East	North West-South East
1.02	Aspect ratio	long: short	1.44	1.19	1.21	1.35	1.21
1.03	Window to wall ratio (WWR)	%	5%	7%	6%	7%	8%
1.04	Window to floor ratio (WFR)	%	3%	5%	9%	8%	6%
1.05	average room depth	meters	5.5	4.94	4.53	4.85	6.18
1.06	walls - U-value	$W/m^2.K$	1.7	1.6	1.8	1.4	1.4
1.07	roofs- U-value	$W/m^2.K$	0.5	0.5	0.5	0.5	0.4
1.08	windows- U-value	$W/m^2.K$	3.4	3.7	3.2	3.7	4.3
1.09	wall material assembly	outside to inside - material name	Ground floor: mud mortar(20 mm) +stone(770mm) +mud mortar(25 mm) Upper levels: mud plaster(20 mm) +mudbricks(300mm) +mud mortar(20 mm) + mud plaster(20 mm)	Ground floor: mud mortar(20mm) +stone(800 mm) +mud mortar(25mm) Upper levels: mud plaster(20mm) +mud bricks (300mm) +mud mortar(20mm) +mud	Ground floor: mud mortar(20mm) +stone(700mm) +mud mortar(25mm) Upper levels: mud plaster(20mm) +mudbricks(300mm) +mud mortar(20mm) +mud plaster(20mm)	Ground floor: mud mortar(20mm) +stone(1070mm) +mud mortar(25mm) Upper levels: mud plaster(20mm) +mudbricks(300mm) +mud mortar(20mm) +mud plaster(20mm)	Ground floor: mud mortar(20mm) +stone(1070mm) +mud mortar(25mm) Upper levels: mud plaster(20mm) +mudbricks(300mm) +mud mortar(20mm) +mud plaster(20mm)

Characteristics		Units	House 1	House 2	House 3	House 4	House 5
				plaster(20mm)			
1.10	max. wall thickness	meters	0.77	0.80	0.70	1.07	1.07
1.11	roof material assembly	outside to inside - material name	mud layer(125 mm) + yaksees grass piles (40mm) +willow(40mm) +poplar (175 mm)	mud layer(100mm) + yaksees grass piles (40mm) +willow(40 mm) +poplar (175 mm)	mud layer(100mm) +yaksees grass piles (40mm) +willow (40mm) +poplar (175 mm)	mud layer(125mm) +yaksees grass piles (40mm) +willow (40mm) +poplar (175 mm)	mud layer(170mm) +yaksees grass piles (90mm) +willow (40mm) +poplar (175 mm)
1.12	max. roof thickness	meters	0.38	0.35	0.35	0.38	0.47
1.13	windows thickness	meters	0.10	0.08	0.12	0.08	0.05
1.14	type of window	sliding/casement etc	Casement	Casement	Casement	Casement	Casement
1.15	overhang length	meters	0.2	0.3	0.29	0.32	0.32
2. Building design characteristics							
2.01	Total area	m^2	591.0	820.3	138.0	451.6	591.0
2.02	total no. of rooms	number	12	30	7	18	22
2.03	no. of floors	number	G+2	G+2	G+1	G+2	G+2
2.04	type of structure	Load bearing/frame	Load bearing	Load bearing	Load bearing	Load bearing	Load bearing
2.05	total building height	meters	8.3	9.28	6.3	13.33	8.11
2.06	type of roof	flat/sloping	flat	flat	flat	flat	flat
2.07	age of the building	years	60	165-200	30-40	130-200	150

Source: Author

Conclusions

Traditionally, in Phyang or any other settlement in Ladakh, dwellings are constructed from locally accessible materials within their surroundings, with the exception of a few imported materials such as wood or glass. Construction workers and skilled craftsmen from the community assisted in the construction of the structures. This was a method of passing down knowledge to the next Ladakhi generation. However, in the current situation, the majority of materials and labour is imported from far regions and the construction techniques involving reinforced cement concrete (RCC) is becoming more prominent. The problem is that the new building methods does not account for the knowledge, understanding and contextual wisdom which was the very foundation of the traditional houses which were built by their grandparents.

The stones and pebbles for the footing and ground floor can be found abundantly everywhere over the valley slopes, as well as on their own property. Due to the arid and desert geography of the region, wood was formerly a valuable and uncommon product. Formerly, vegetation was only found along the banks of rivers and streams. However, over time, desert greening has become a popular alternative, and now each villager has their own group of poplar and willow trees. This materials serves as the roof's structural elements. The potable water needs of the residents are provided by The Phyang creek flowing across the village. The Phyang stream is at its best flow after the glacial melting. After the glacier thaw, the Phyang stream is flowing at its best. The stream water is channelled and sent to the inhabitants' fields and housing compounds for their drinking and farming needs. Traditional mud blocks were built from local soil, and Markalak clay is put to the roof for waterproofing. Mud blocks are now purchased from outside sources due to the loss of traditional expertise about how to make them with local soil as a result of shifting socioeconomic patterns. To manufacture earth blocks for construction, local soil is occasionally blended with soil from Shey or Basgo. If not made on-site, mud blocks are obtained from Chuchot, Thiksey. Changtan is transported from the Tibetan border, where it is mixed with water and sprayed to walls like paint. Cement is delivered from Leh.

Further, with the arrival of solar energy in the region there is a marked shift in the construction of buildings. Solar geometry principles are being ignored in the upcoming buildings. The vernacular materials are being replaced by the use of concrete. However, concrete is a noncompatible material as it freezes and does not provide any insulating properties in the cold climatic conditions of the region. In addition, migrants from Bihar and Nepal, who have arrived to Leh in search of work, perform the majority of the farming and building work. This is a negative trend since local traditions are declining, and local craftsmanship and craft skills are becoming extinct.

Every location on the planet comes with its own set of challenges with regards to the climate, and topography conditions. However, the vernacular and traditional understanding offers solutions for the same. Over some time, we call this practice a pearl of vernacular wisdom. The study conducted in Phyang village exemplifies traditional understanding of addressing the extreme climatic conditions through highly articulated vernacular architecture; which has helped the locals to survive for centuries. These native techniques are time-tested and sustainable. Hence, greater weightage needs to be laid not only on the documentation but also to decoding this knowledge. This knowledge could further be used to help formulate informed policies and build houses that have the vernacular wisdom as well the power of modern construction techniques.

References:

- Cohen, B. (2006) 'Urbanization in developing countries: Current trends, future projections, and key challenges for sustainability', *Technology in Society*, 28(1–2), pp. 63–80. doi: 10.1016/j.techsoc.2005.10.005.
- Dame, J. *et al.* (2019) 'Urbanisation and socio-ecological challenges in high mountain towns: Insights from Leh (Ladakh), India', *Landscape and Urban Planning*. Elsevier, 189(May), pp. 189–199. doi: 10.1016/j.landurbplan.2019.04.017.
- Directorate of Census Operations Jammu & Kashmir (2011) *District Census Handbook Leh (Ladakh)*.
- Jacobsen, K. (2016) *Routledge Handbook of Contemporary India*, *Routledge*.

- Kaplanian, P. (2015) 'The Ladakhi House To cite this version : HAL Id : hal-01246859'.
- Kraas, F. (2007) 'Megacities and Global Change in East , Southeast and South Asia Megacities and Global Change in East , Southeast and South Asia Frauke Kraas', (August).
- Kraas, F. *et al.* (2014) *Global Change , National Development Goals , Urbanisation and International Migration in China : African Migrants in Guangzhou and Foshan*. doi: 10.1007/978-90-481-3417-5.
- Kumar, S. *et al.* (2010) 'Energy Conservation and Commercialization (ECO-III) Performance Based Rating and Energy Performance Benchmarking for Commercial Buildings in India'.
- Mathieu, J. (2003) 'the Mountains in Urban Development', *Chronos Verlag*, pp. 15–33. Available at: http://www2.arc.usi.ch/index/aisa/ris_ist_labi_aisa_rivista.htm/2003_2_labi_rivista.pdf.
- Montgomery, M. R. (2008) 'The urban transformation of the developing world', *Science*, 319(5864), pp. 761–764. doi: 10.1126/science.1153012.
- Müller, J. and Dame, J. (2016) 'Small Town, Great Expectations: Urbanization and Beautification in Leh', *South Asia Multidisciplinary Academic Journal*, (14). doi: 10.4000/samaj.4208.
- Nüsser, M., Schmidt, S. and Dame, J. (2013) 'Vernacular Architecture and Climatic Control in the extreme conditions of Ladakh', 2013(October 2013). doi: 10.13140/RG.2.1.3240.5201.
- Rawal, R. *et al.* (2014) 'RESIDENTIAL BUILDINGS IN INDIA: ENERGY USE PROJECTIONS AND SAVINGS POTENTIALS', *Www.Aeee.in*, 066(September), p. 209. Available at: https://beeindia.gov.in/sites/default/files/Design Guideline_Book_0.pdf%0Awww.energyefficiencycentre.org%0Awww.aeee.in%0Ahttps://www.eceee.org/library/conference_proceedings/eceee_Summer_Studies/2015/6-policies-and-programmes-towards-a-zero-energy-buildin.