Development and Sustainability: Traditional Courtyard House of China and Nepal

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Abstract: Development should take into account the needs of the present generation as well as the environment, economic, social and culture. The onslaught of globalization and technology impacts the development of a developing country, resulting in changes in culture, traditions and social life. The technology, materials and skills used to build the traditional courtyard house in the olden times are primitive, simple and locally available, but include a long history of settlement, culture, tradition and social life. Beijing and Kathmandu are the capital cities of China and Nepal, where rapid industrialization and urbanization change the urban fabric and environment in a short time. The traditional built environment that is a symbol of ancient history, culture and social life is being distracted by the onslaught of globalization.

An ancient structure that exhibits potential for a country’s growth should be managed and developed on a larger scale. The purpose of this paper is to focus on traditional houses that protect the sociocultural, heritage, and traditions from ancient times. A model has been developed for the sustainable development of the traditional courtyard house. It provides basic knowledge for sustainable development that will be beneficial to other contemporary houses of similar nature.

Keywords: Sustainable development, Traditional Courtyard House, Hutong, Newari house, Nepal, China

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1. Introduction
Humans evolved from caves to modern buildings to achieve aesthetic and comfort in daily life, which helps them achieve better living conditions and security in modern times. In today's modern-day, people have the technology and materials to help them create a superstructure. This
structure allows a large number of people to fit into single buildings with all the amenities. These large buildings have everything on their own but fail to provides what traditional homes offer a few years before modernization (Kellert, 2012). The traditional style of the house reflects the vernacular housing that has kept the culture from generation to generation (Ikuga & Murray, 2012). Local material and knowledge are the keys to the vernacular house, which are often practiced without the supervision of a professional architect, due to the constant transformations required by social life and the surrounding barriers, these homes are practically suitable for living as well as for other types of activities. (Ikuga & Murray, 2012). Sustainable development can be defined as the development which fulfills the need of present generation without adjusting the ability of future generations to fulfills theirs (Dasgupta, 2007; Environment, Development, & Brundtland, 1987). The development has a direct and indirect impact on the economic, environmental, social and cultural aspects. Climate change and its effect can be seen worldwide which involves different sectors among them, the building sector demands energy higher than other sectors (Pérez-Lombard, Ortiz, & Pout, 2008). Buildings sectors in China demand huge amounts of energy in residential as well as a commercial building for maintaining a comfortable living environment for the tenants which release a considerable amount of CO2 (Eom, Clarke, Kim, Kyle, & Patel, 2012). Nepal is a developing country that still depends on firewood’s and traditional biomass for fodders and daily use, which makes the CO2 emissions in the environment less as compared to other developed countries (Statistics, 2011). But due to the increasing density of the population in the Kathmandu valley, which is the central hub of Nepal is constraints with small boundaries. This influences people to use different appliances and materials in a residential or commercial building to upgrade their daily life and also increase the rate of CO2 emission in the valley (R. M. Shrestha & Rajbhandari, 2010). So to reduce the impact and making development sustainable necessary alternative energy sources should be installed.

In the current scenario, development is mainly focused on the economy and environment, due to its demand for cost-benefit ratio and climate change. However to establish development every aspect of sustainable development should be considered. It must consider social security and access, which attracts peoples who are willing to live in that place having a historical background with different cultures, religious beliefs, customs, and habits. The combination of economy,
environment, social and culture in the development built a foundation for the future generation to access resources and social environment without being extinct.

2. Materials and methods

This research is mainly done to address the value and importance of the traditional courtyard house for sustainable development. This includes literature studies related to the environment, economic, social and cultural influence for the creation of those houses in ancient times. Climatic data of Beijing and Kathmandu valley are used, which are provided online by a different climatic data provider. Extracted data is analyzed using a climatic analysis tool commonly known as a psychrometric chart. This chart shows the comfortable zone of an area in a year using natural ventilation, whereas other zone required energy for comfort. Travel and Tourism data related to the growth of the GDP of a country is studied and the outcome of the data guide for the sustainable economy. Philosophy and theories related to study are compared, which is still practiced in both countries for maintaining peace and harmony in the house.

![Study Review Diagram]

Traditional courtyard houses attract many researchers for analyzing and publishing different books and papers which provide facts and figures related to the orientation and layout. Survey data to improve traditional courtyard houses are studied, which is done in a group of 30 people of...
both countries using the mobile-based application. The research strategy is shown in (Figure 1). Beijing's traditional courtyard house design and layout gain the attention of national and international researchers, due to its similarity with the imperial courtyard house. There are different article and paper which gives a detailed insight into house design and layout. Climatic analysis of the Beijing courtyard house is performed by Shi and Edward (Y Shi & Ng, 2014) using CFD analysis. They research and experiment on wind effect on the architectural design of the Chinese vernacular courtyard house using the width and length of the building in a ratio (W/L), whereas the height of a building is determined by the north and south height ratio (H1/H2). Their finding shows that the Chinese vernacular courtyard house design adapts accordingly and works differently in a different season. Donia Zhang (Zhang, 2015, 2016, 2017) describe courtyard housing as an ancient architectural artifact, which resembles with the ideal style of housing, where the people living there can experience harmony in their life. Pant, M. and S. Funo (Pant & Funo, 2004) studied the residential courtyard block of Patan city, Kathmandu valley and analyzed the pattern of the courtyard and layout design. Their finding described that the courtyard is arranged largely in size with the religious belief for maintaining harmony. Suwal, R.P (Suwal) focused his study based on the construction technology of the Newari house of Bhaktapur city, Kathmandu valley. He suggested that the fabric of traditional courtyard house is sufficiently old to support the structure which should get replaced and maintained. Many studies are administered for locating the comfort level within the residential block of traditional houses of Kathmandu valley. Bajracharya (Bajracharya, 2014) observed the thermal performance of the traditional residential building of Kathmandu valley, using computer added technology as well as equipment. His finding indicates that the traditional house saves energy up to 10-20% during summer and winter seasons.

2.1 Study area
This research study is focused on the courtyard house of the Kathmandu valley and Beijing, so the study revolves around Nepal and China. These countries are friendly neighbors of each other and also share some culture and tradition.

2.1.1 Study area 1: Beijing, China
The total area of the People's Republic of China (PRC) is 9,696,160 61 km² (CIA, 2013, Nov 23) which is also a third-largest country in the world. According to a survey conducted in 2017,
China has the largest population of the world at 1.428 billion (Wikipedia, 2020, Feb 6). (Figure 2) shows a map of Beijing, China. The location of China in the world lies in between latitude 18° and 54° North, and longitudes between 73° and 135° East. Land coverage and land use of China can be seen in Table 1 and Table 2. The landscaping of China spread from the Gobi and Taklamakan deserts on the northern side, whereas mountain range separates China from its neighbor country in the south and central Asia. Nepal and China border lies in the south of China, where Mount Everest divides the territory.

The eastern border of China is densely populated, the two longest rivers of China, yellow and Yangtze River flow along the Tibetan plateau to the seaboard. China paved the Silk Road in the ancient period, which connect the Kazakh border with the Eurasian steppe. China is geographically divided into 23 provinces, five autonomous regions, and four municipalities, of which 56 different ethnic groups having different cultures and traditions.

Table 1. Geographic distribution of China

<table>
<thead>
<tr>
<th>Distribution</th>
<th>Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land</td>
<td>9,569,901 sq. km</td>
</tr>
<tr>
<td>Water</td>
<td>27,060 sq. km</td>
</tr>
<tr>
<td>Total</td>
<td>9,596,961 sq. km</td>
</tr>
</tbody>
</table>

(Source: (CIA, 2013, Nov 23))

Table 2. Land Use of China

<table>
<thead>
<tr>
<th>Distribution</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arable land</td>
<td>14.86%</td>
</tr>
</tbody>
</table>

Figure 2 Geographical map of Beijing, China
2.1.2 Study area 2: Kathmandu Valley, Nepal

Nepal is formally recognized as the Federal Democratic Republic of Nepal (CIA, 2012, 5 Dec). Nepal is in the middle of the two largest countries, China to the north and India to the other three sides, which makes Nepal as a landlocked country. The shape of Nepal is a unique trapezoidal (Figure 3), which is 800 kilometers long and 200 kilometers wide, with a total area of 147,181 km² (Wikipedia, 2020, Jan 21). Nepal is a small country with diverse geography, which divides its territory into three area belt commonly known as Terai-Pahad-Himal. The Terai area is known for its low altitude and fertile soils ranging from 300m to 1000m. This area band can be seen from east to west along the border of Nepal and India. The population and economy in this area band are high due to the presence of agricultural land and industrial area. Pahad is mid-hill which is known for its subalpine forest area, hills and valley. Pahad area band located in the middle in the height range from 1000m to 4000m. The weather in this area band is easy to live in, Kathmandu valley is also located in the same area. Himal is the mountain range that comprises the top eight out of ten peaks of the world including Mount Everest. Himal area band, located on the northern border between Nepal and China, has an elevation range from 4000m to 8848m. This belt has severe weather conditions with snow all year round and the soil is sterile compared to other bands, which lowers the economy and living standards of people living in the

(SOURCE: (CIA, 2013, Nov 23))

<table>
<thead>
<tr>
<th>Permanent Crops</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.27%</td>
<td>83.87%</td>
</tr>
</tbody>
</table>

**Figure 3 Geographical Map of Kathmandu Valley**
area. Nepal is one of the developing countries with an estimated GDP of $28.8 billion and has increased annual growth by 6.3%. The total population of Nepal is 30,327,877 (CIA, 2012, 5 Dec) with a growth rate of 0.98%. Land distribution and land use can be obtained from table 4 and table 5.

<table>
<thead>
<tr>
<th>Table 4. Geographic distribution of Nepal</th>
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<tbody>
<tr>
<td>Distribution</td>
</tr>
<tr>
<td>---------------</td>
</tr>
<tr>
<td>Land</td>
</tr>
<tr>
<td>Water</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>

(Source: (CIA, 2012, 5 Dec))

<table>
<thead>
<tr>
<th>Table 5. Land Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distribution</td>
</tr>
<tr>
<td>Agricultural land</td>
</tr>
<tr>
<td>Arable land</td>
</tr>
<tr>
<td>Forest</td>
</tr>
<tr>
<td>other</td>
</tr>
</tbody>
</table>

(Source: (CIA, 2012, 5 Dec))

2.2 Data collection and analysis (Sustainable development of traditional courtyard of China and Nepal)

2.2.1 The climate of Beijing, China

There are different climatic zones in China according to different regions which are influenced by the complex topography of the country (Fu, Jiang, Guan, He, & Xu, 2008). China is influenced by the dry winter and wet monsoons, which results in the temperature variation during the winter.
and summer season (classification, 2017; Zifan., 2016, Feb 02) (Figure 4).

The humid continental climate is dominant in Beijing (Köppen-Geiger classification: Dwa) which shows the severe and dry climate in winter whereas the hot climate in summer. Beijing shows significant temperature variation of 3°C at day and 7.7 °C at night during winter, whereas 30.2 °C high to 20.1 °C low temperature during summer. Spring and autumn are the comfortable and beautiful seasons in Beijing, where the temperature range is (19.2 °C to 6.6 °C) and (18.3 °C to 7 °C). Precipitation and sunshine of Beijing on average is 576.9 mm and 2707 hour/year. The climatic data of Beijing provided by an online server is extracted and analyzed.

![Figure 5](Climatic data of Beijing, China, Psychrometric chart and thermal comfort zone based on California Energy Code)

According to the California Energy Code comfort model. (Figure 5) shows the climatic data obtained by analysis. This analysis provides the necessary information about the comfort zone in Beijing which is 10.13%, indicating that in extreme climatic conditions, more energy is needed to maintain a comfortable living situation.

### 2.2.2 The climate of Kathmandu Valley, Nepal

Nepal is a small country, where the altitude of the country affects the weather. Nepal’s altitude range is 60m to 8848m, where temperature varies with altitude. In Nepal, there is a significant variation with a small distance from south to north elevation, resulting in a small area of different climatic zones (Figure 6). Nepal experiences five different types of weather as listed below:
Tropical and Subtropical
This climatic condition can be observed under an elevation height of 1200m.

Temperate
The temperate zone lies between 1200m to 2400m elevation.

Cold
The cold climatic zone can be observed between 2400m to 3600m elevation.

Subarctic
The subarctic climatic zone can be observed from the elevation of 3600m to 4000m.

Arctic
The arctic climatic zone lies above 4000m elevation.
The climate of Kathmandu valley is governed by humid subtropical climates (Köppen-Geiger classification: Cwa), which results in temperate summers and dry winters (Köppen-Geiger classification, 2017). The average annual temperature in the valley is 18.3 °C. Kathmandu shows a significant change in day and night temperature in the winter significantly by 3 °C to -7.7 °C, while summer temperatures vary from 27.3 °C to 11 °C. Spring and autumn temperature is more or less the same with temperatures ranging from 27.3 °C to 11 °C and from 26 °C to 12.3 °C. The average precipitation in the valley is 1343 mm and average sunshine is 2556 hours per/year(Adam Peterson, 2018, Nov 01; Köppen-Geiger classification, 2017). The Kathmandu valley data are analyzed using a psychrometric chart based on the California energy code. (Figure 7) shows the climatic data after analysis using the online software. The psychrometric chart shows different zone based on temperature data and indicates the required energy consumption for the region that is not comfortable. According to the obtained results, the valley has a comfortable zone of about 15.49%.

2.2.3 Beijing settlement

Archaeological discoveries show that the site of modern Beijing has been the site of settlement for more than 3000 years ago. Its history as the capital of China extends to the Jin, Yuan, Ming and Qing dynasties. In 936 Liao-Nanjing dynasty establish five sub-capital on the southern part of present-day Beijing. In 1153, Beijing became the main capital of the Jin- dynasty under the name of Jin-Zhongdu, which made Beijing a popular destination for its diverse construction environment. In 1267 Kublai khan founded the yuan dynasty on the northeast of Jin-Zhongdu, which is commonly known as Dadu. Dadu is the first planned city formed in the old Beijing that forms the basis of today’s central Beijing. The word “Hutong” is commonly used for the well in the yuan dynasty which gives the hutong a tendency to dwell. After the collapse of the yuan dynasty in 1368, the capital moved to Nanjing by the order of new Ming emperor. In 1421 third Ming emperor reinstall the city plan of Dadu and established a capital in the name of Beijing. After the successful reformation of capital back to Beijing. In 1644 by Qing-Ming dynasty continued its planning and shaped Beijing as a rectangular grid, street surrounded by the monuments and temples(Yutaka et al., 2004). Figure 8 (a) and (b) refer to the transformation of Beijing habitation and the arrangement of hutong in ancient times.
2.2.4 Kathmandu valley settlement

There are three districts in Kathmandu Valley, Kathmandu, Patan and Bhaktapur, where during the Lichchhave period human settlement start. During that period, various settlements, roads and other infrastructures constructed, which show the development of economy, art and architecture. Homes and other infrastructure in that period are built in such a vision, that it can use renewable resources for development. The Human Settlement Plan of ancient times uses primitive tools and equipment to meet the demands of that period. Water fetching facilities, open or closed bridges

Figure 8 Settlement of Beijing: (a) Transformation of Beijing settlement (b) Hutong arrangement (Source: (Yutaka et al., 2004))

Figure 9 Kathmandu valley settlement during ancient period: (A) Kathmandu, (B) Bhaktapur, (C) Patan (Lalitpur)
and canals are constructed for rainwater, while sanitary systems are primitively processed, such as digging holes in the pit. While the valley experiences rapid urbanization without planning and design, on the other hand, population growth and lack of land make the valley obstructive and crowded. Figure 9 (a), (b) and (c) are the settlement of Kathmandu, Bhaktapur and Patan districts.

### 2.2.5 Tourism in China

China is popular for regions with culture and history of over 3000 years. It is made up of 56 different nations of culture and history with different cultures, customs, and people according to their respective provinces or regions. (Wang, 1997). China shows giant strides in the world for tourism. The tourism industry in China generates huge revenues that support and improve economic and social development (Industry, 2010). The traditional courtyard house in Beijing is home to its own identity which is related to the history, diversity, and culture of Beijing. This identity of Beijing attracts national and international tourist to satisfy their curiosity as well as to experience and be part of the existing historic home (Rapoport & Duncan, 1981). The traditional courtyard house of Beijing is often called the hutong or siheyuan. Hutong is employed by Yuan ruler Kublai Khan which suggests “route to the well” (Li & Zhao, 2001). The National Tourist Administration of China (NTAC) in the early 1990s promoted the promotion of vernacular as a tourist attraction. This hutong tourism is becoming popular every day and attracting tourists. Various tours and travel agencies, restaurants, transportation and other industries are running which take advantage of publicity and hutong tourism. On the other hand, they provide rentals of the hutongs with various amenities and remuneration, which improve the hutongs and their living standards. These facilities and remuneration have implications for the preservation and maintenance of their homes, and create a long-lasting source of revenue for the country. The tourism industry is contributing to the development of vernacular house and protects them for the future.

### 2.2.6 Tourism in Nepal

Although Nepal is a small landlocked country, Nepal is also known for its “Birth Place of Buddha”, “The land of Everest” and also “the land of Temple”. This identity glorifies Nepal in the eye of the tourist. Tourism started long ago in Nepal but successfully recognized after the 1950s with a successful attempt at Mount Everest. Nepal celebrates tourism as another religion after Hinduism and Buddhism because it directly or indirectly influence the prosperity of
Nepalese citizens (Thapa, 2012). There are wonderful architectural monuments, paintings and sculptures in the golden history of Nepal which are recorded during the period of Lichchhave and Malla. During this period rich economy, culture and architecture were experienced. Lichchhave period established in 400 A.D., there are different traditions, ethnic groups, cultures, festivals that still operate in Nepal (Sharma, 1976). Chinese tourists visited Nepal and inspired in that period after observing the art and architecture, and describe them in the manuscript (Satyal, 1988). In those periods people build their houses with different art and architecture skills, which is still unique and attractive. The materials and skills used in that type of residential houses are hard to obtain at present, which forces the current generation to think about the integrity of the design during that period.

2.2.7 Chinese Ideology

The meaning of FengShui according to Chinese ideology is the process of arranging or designing in a systematic way which helps to improve living as well working environment. It is the philosophy derived from ancient Sage, Fu Hsi, (Chen, 2007; Xu, 1998) whose discovery is based on heaven and earth. His finding consists of natural law and cosmic forces which influence the moods and rhythms continuously for the security and wellbeing. It is believed the FengShui model can provide Qi, which is positive energy can be blown away by the cold wind (Feng) and accumulate by the rainwater (Shui). To acquire a positive and healthy environment, one should design their living or working environment in such a way that the Qi should be protected by cold wind and accumulated by the water (ADHIKARI, 2006; Chen, 2007; Xu, 1998) figure10.

Figure 10 Building site by good fengshui (Source: (Knapp, 2005))
Beijing's traditional courtyard house follows FengShui geomancy for the construction of their dwelling, which can be observed from their shape, size, orientation, position, and landform.

2.2.8 Nepalese Ideology

Vastushastra is the oldest philosophy or architectural science originated 7000-15000 years ago in the Vedic era followed by Hindus and also observed in the Buddhist style of architecture (ADHIKARI, 2006). “VastuShastra” derived from Sanskrit words which explain “Vastu” as building or existence of settlement created by people for their living and “Shastra” means traditional values that relate the idea of the settlement by creating social security, healthy environment and prosperous society (Patra, 2009). Management and designing of space and things according to VastuShastra in the construction of the house can improve the living as well as the working environment (ADHIKARI, 2006; Patra, 2009). Site Planning is based on the image of the Vastu Purusha shown in (Figure 11) which is seen as a man lying on the square grid. It is believed that each square in the Vastu Purusha resemble the Hindus God for different source of energy, so careful selection of space is needed to reverence deity for acquiring health, success, prosperity, etc. (Chakrabarti, 1998).
2.2.9 Chinese traditional courtyard house design and layout

Beijing has been the capital of choice for rulers and states for many years, as it is at the center of China's natural resources and easy access to water. To make Beijing a cultural hub of China, various rulers transfer their rich culture and traditions from generation to generation. This art, culture and tradition can be seen from the construction of their home. Siheyuan is formed by the making dwelling on four sides of the rectangular or quadrangle compound, while the central part is left blank for the courtyard design. The urban fabric of Beijing is made by series of siheyuan separated by lane in between them, which may be traced from the traditional kingdom of the Han (206 -220 B.C.) (Wang, 1997). There are four different types of courtyard houses based on its size and number of the indoor courtyard.

1. Two-courtyard house (small-size);
2. Three-courtyard house (typical, standard, or medium-size);
3. Four-courtyard house (large-size);
4. Five-courtyard house with a garden (large-size)

These houses are constructed based on the authority or position occupied by the person within the society. Beijing traditional courtyard houses are different from official houses as it is limited to three indoor courtyards (Chan & Xiong, 2007). There are different literature and studies of courtyard and house which constitute the equation of width to length ratio 1, while the building height ratio is 1.2-1.4 (Lin, Wang, Zhao, & Zhu, 2002; YUAN Shi, 2013). A typical Beijing courtyard house and a bird eye view of siheyuan are shown in (Figure 12 and 13).

Figure 12 Typical Beijing courtyard (Source: (Ma, 1993))

Figure 13 Bird eye view of siheyuan (Source: (Ma, 1993))

There are different research and studies for the material and design in the construction of the Beijing courtyard house. (Knapp, 2012) The concept of the Beijing courtyard house is based on
light materials that are also tough, durable and flexible, which provide resistance against the climate and natural hazards. The single-story building can usually be seen in Siheyuan which is on rammed earth or stone beds to stabilize the columns of the wooden frame. Timber is generally preferred as a structural material that can be obtained locally during that period for the construction of the house. The frame system of the housing can be seen, where wooden columns are connected to the wooden beam. The wall depends on the use of wood and brick. The exterior wall is made of brick, while the interior wall is made wood. This wooden frame is connected to the roof in the interlocking pattern, which ensures roof protection in case of natural hazards. One-sided and double-sided overhanging roofs can be seen in the house according to the condition of the house to offer shade for the tenants. The roof is made from wooden rafters and purlin covered with the burnt tiles that allow rainwater to drain away from the structure and also provide shade in the summer.

2.2.10 Newari traditional courtyard house design and layout

Since ancient times, the Newar community has been living in Kathmandu, Kritipur, Patan, and Bhaktapur which are the principal cities of Nepal. This city combined to form Kathmandu valley (S. Shrestha & Shrestha, 2009). Kathmandu valley has been the cultural town of the Newar community from the Lichchhavi period followed by Malla and Shahs, who design the old valley with a rich tradition, culture, art, and architecture. In ancient times, traditional houses followed the basic principles. The symmetry of the residence, while the courtyard is centrally placed either by constructing rows of the house in rectangle or quadrangle style. The structure of town fabric is arranged by series of small and enormous courtyards, also known as Nani or chowk separated by small width of lanes that formed honeycomb shape (Pant & Funo, 2004).

The courtyards vary in size and shape depending on the place and place of residence in the Kathmandu Valley. In this paper, a type of courtyard is being selected which is commonly known as Nabahal Nani (Figure 14) located in the Patan city of Kathmandu valley. Nabahal courtyard is square measuring each side 34.56m with an orientation of the courtyard facing almost to the north, while the east-west road leads to the center entrance of the courtyard. According to the study of M. pant, the Nabahal courtyard has a swastika pattern with the religious belief in Hinduism and Buddhism. In his study he formulated a mathematical equation of \( n(y+c)+c=w \) for the design of courtyard, where \( w \) stands for wide of the courtyard, \( c \) stands for the corner frontage and \( y \) stands for the width of the longer frontage of the courtyard. The façade
wall is the combination of two walls joined by mud mortar which give aesthetic as well as durability in the façade and maintain a comfortable environment indoors during the summer and winter. The special backed brick (dachi-appa) was designed and assign on the exterior half of the wall to carry the load and provide an aesthetic appearance to the house. The internal half of the wall made from sun-dried brick, allowing heat transfer throughout the year to maintain a comfortable temperature (Maharjan). A typical Newari house is shown in (Figure 15). The Newari style house has three different types of interior or partitions walls consistent with the fabric like a bamboo (Paanh bhikha), wooden (Sipu bhikha) and sun-dried brick (Aanga). This wall arrangement provides the shape needed for interior shapes and even different functions (Suwal). Two and three-story buildings are very common to view around the courtyard having an intermediate floor height of 2.2 to 2.5 m which makes the house small in height so that the religious monuments and shrine visible from the distance (D’Ayala & Bajracharya, 2003). The ground floor of the house is rarely used for the living of the tenant but is occupied by the storage area, bathroom, and shop areas. In the construction of ground floor compacted earth with thick planks or bamboo is used for damp proofing, while mud is used as plaster and pointing on the floor. While other floors are constructed over the horizontal and vertical planks filled with packed earth and plaster with the mud paste for the finish. A similar technique is used in the

*Figure 14 Nabahal courtyard (Source: (Pant & Funo, 2004))*

*Figure 15 Newari house (Source: (Korn, 1977))*
construction of the roof, but additional burnt red tiles, including grooves, are interlocked with each other to make it resistant to weather (M. N. Shrestha, 1981).

3. **Results and Discussion**

3.1 **Sustainable Environment**

The climatic conditions of Nepal and China show variation throughout the year in the above mention facts and figures. The comfortable zone of China and Nepal is 10.13% and 15.49% in the psychrometric chart analysis, which indicates both countries need the energy-efficient design to overcome energy consumption. People of both countries are facing this type of climate from ancient times, so they designed their houses according to this climate. The orientation, site plan, central courtyard, arrangement of greeneries for shades, and art of placement of the object in the ideology of both countries helps to eliminate the uncomfortable climatic condition within the building. Locally available materials such as wood, bricks and mud for the design of both houses can be reused and recycled in the environment easily. This material doesn’t disturb the environment and is more or less the same in both countries to design their house for thermal comfort in the ancient period. This material used in the building provides a comfortable living environment, saving 10-20% (Bajracharya, 2014) energy and contributing to the sustainable environment. Population density, water crisis and management of the traditional house in both regions are almost similar. Rainwater harvesting will add advantage for the use and recharge of groundwater. In both regions, it has been observed that the house is facing a sanitary problem due to the single toilet or common toilet for the whole family, this problem should be treated properly with effective sanitary design.

3.2 **Sustainable Economy**

These vernacular houses of both regions have been built in ancient times, which are now important assets of the country. These houses not only generate an economy for the tenant but also the open door of opportunity for other people living in the neighborhood. This house doesn’t need promotion for attracting the tourist because of its own identity. Hutongs already attract tourists and researchers which makes the development of the hutong at the national level. It contributes to China’s economy and sustains its growth. The Newari traditional house also attracts tourists but less as compared to hutong because of the low management system. Although the number of tourists visiting Newari traditional houses is less, it has certainly contributed to Nepal’s economy. Sustainable tourism in the traditional courtyard house of both
nations can contribute to a sustainable economy.

3.3 Cultural and Social sustainability

Studies show that both nations still practice old ideology and build their homes for peace and harmony. They hold objects according to the art and direction described by the above ideology. This ideology teaches the tenant to respect their elders as the main person. This ideology preserves the cultural and traditional beliefs that their ancestors followed and transferred to future generations. Belief in ideology shows that cultural roots are unconsciously established from generation to generation. This ideology builds a traditional courtyard house in such a way that people of both nations live together in a cooperative house. They not only help their family members but also enjoy a mutual relationship with their neighbors, as they can often see each other. Meeting with family members and neighbors in daily life helps them get to know each other and move on to help one another in times of need. This coordination between the people living in the Hutong and Newari houses develops social security among them and preserves the culture of their ancestors in cultural and social stability.

The questionnaire was conducted in a small group of 30 people from both countries with an educational background in mobile-based software for the problem related to the traditional courtyard house and their solutions. This study aims to develop the traditional houses based on economic, environmental, social and cultural importance, so every factor is briefly touched so that the outcome generalized the issues and mitigation of such issues provides the long life of the history and culture. These courtyard houses are scientifically and logically designed in the content of the environment which provides the tenants with the opportunity for wellbeing and prosperity. With some practice and risk invasion, these traditional courtyard houses lost their originality and trends to shift toward small houses with congested places and irregular shapes which creates fragile structures. These small houses with irregular shapes and overburden structures defining today’s urban structures should be discouraged. Survey of the traditional courtyard house indicate some factors which make these traditional houses lose interest in the eyes of today’s generation are listed below:

- **Shifting of social gathering venue**

A human being is a social animal who needs people around them from the day they born until they die. In ancient days people are more social and helpful. They cared for their surrounding
people as they see those people around them usually in a specified place either in their houses courtyard or society courtyard. Special events related to the family or relatives are organized by their family members in their courtyard or the society courtyard, where they share works and duties. This gathering between the member and neighbors create a harmonious atmosphere between them and also share their traditions and culture with the new generation. However open space is turning into a new house which makes the courtyard houses limited these days. This shift the gathering toward the commercial places such as banquet, hotels and others. This gathering is more or less formal, where people enjoy but they don’t play or communicate as they do in their courtyard.

- **Household activity**

In ancient times, people needed a courtyard to do their domestic works, where they used to share their works and problem as a member, in which they lived together as members of a family or community. This type of activity helps them to know each other’s and maintain a social environment. These domestic chores are being carried out in the open courtyard of the house in the open environment which reduces energy consumption and also makes people healthy. With the invasion of the new technology and gadgets, people are being shifted with easy work which involves less time and effort for doing household activities.

- **Monetary Values**

With the pace of life, people are more concerned about money and their standard of living. They want to make money at any cost that motivates them to sell their values and cultures. These traditional houses are in a scientific arrangement that needs a rectangular or square area. The increased population density in a specific area results in the inflation of the market price of lands. Some people living in the traditional house have less economy status as compared to others.
which encourage some tenants of the traditional house to modify their houses into the small plot or rent their houses for commercial use or even sell their property for a living. (Figure 16) shows shifting of the traditional house into blocks of Nabahal. Beijing hutong is being destroyed to turn into the urban space from 1990 to 1999 which has affected the history as well as the social life of the resident as shown in (Figure 17). The resident lost their sense of belonging and their memory with the destruction.

- **Natural Disaster**

A natural disaster is a natural phenomenon results in loss of property, lives, and structures. This disaster also affects traditional houses to function in the future (Gaillard, 2007). The area which is affected by natural disaster has a direct impact on natural resources, urbanization, vulnerability and ultimately poverty (McEntire, 2001).

(Figure 18 (a)) shows the cracks and failure in the traditional house after the earthquake of Nepal 2015. Natural disasters can’t be stopped but can be mitigated by accurate measures. This correct solution can be retrofitting of the building with durable material which can provide strength to the unreinforced masonry. These traditional houses are flexible and easy to maintain after the earthquake due to its shape, size, and materials, but constantly prone to natural hazards make the people status economically unstable which encouraged them to create their housing in semi or permanent reinforced concrete structure. The reinforced concrete structure is safe if it is designed according to the housing department’s rules and regulation, which is expensive and consume.
time. To overcome the expense people choose the illegal way and make the structure semi-concrete (mud and cement masonry), which is risky for the people as well as for the development as seen in (Figure 18 (b)). In 1976, Beijing records 7.8 magnitudes of the earthquake, with its epicenter from the Tangshan town which is 180 km from Beijing. This earthquake caused huge damage to life and property. It also destroys many buildings and ancient towns. Documentation of status (Sapkota et al., 2020) is needed.

- **Abroad Opportunities**
The trend of migrating skilled manpower from developing countries to developed countries in search of different facilities, transportation, living and income. This shifting of a human resource over a long decade develops the global human capital but, on the contrary, it degrades the skilled manpower of developing countries, resulting in brain drain (Khadria, 1978). The deficiency of skilled manpower and an increased number of weak populations in any country creates unsustainable economic growth which results in poor development of any built environment.

- **Facilities**
These traditional houses are constructed in ancient times that were designed to suit their need at that period. In the modern era, there are different facilities and services which are considered as important as basic needs. This traditional house lacks some facilities due to old construction and design which doesn’t bind with new arrangements. So proper policy and planning should be made to provide more facilities for encouraging the tenant to protect the vernacular house. Public toilets are beneficial in the ancient period but with the rise of awareness and sanitation, people wish to have a separate toilet inside their house. These simple facilities can upgrade the living standard of the traditional house and are the center of attraction of visitors (Dahal et al., 2019).

4. **Conclusion**
The study of the traditional courtyard house indicates a great solution for the environmental, economic, social and cultural sustainability. Courtyard stands as one of the important elements in the traditional houses of Nepal and China, which provides ecological balance and regulates the flow of energies. This creates a comfortable living atmosphere during harsh weathers of summer and winter. The wide-open space in the middle of the dwelling creates cross ventilation of airflow as well as circulation of solar energy. Local material is the key ingredient for the traditional house which is economical as well as reusable. These materials are combined and
placed, in such a pattern that creates a solid structure in the façade of the building. While flexible and lightweight interior that facilitates easy heat transfer saving up to 10-20% energy supplies, creating thermally comfortable conditions for the tenants. The traditional courtyard house is ancient housing which has its own identity, it doesn’t need any advertisement or cost for its attraction in the eyes of millions of tourists having different perspectives for their desire to see. During the survey, it was noted that the traditional houses are facing a shortage of basic facilities and their structural conditions are getting worst which demotivates tenants to stay in their dwelling. Investment in building theme parks or new luxurious building for attracting tourist costs a great deal of money to spend, while existing ancient house needs comparably low budget for developing their basic facilities and maintenance. These areas, with basic amenities, make themselves known as a tourist destination for national and international tourists. This house can develop as a hotel or museum to exhibits their culture, tradition or any ancient art. Tenants, as well as other people living in the neighborhood, are self-employed with a growing number of tourists in their house for the experience of living in the ancient house, which ultimately results in the protection of these houses as well contribute to sustaining the economy and sociocultural of the country. As stated by, Our Common Future (OCF) (World Commission on Environment and Development, 1987, p. 251) “For the improvement of housing condition of any underprivileged members the policy of the government should remodel and re-arranged to get maximum output from the limited resources”.

In conclusion, any development to sustain the policymaking should involve the user of the object, so that they could feel the ownership and give their full effort for the rise and development of their object. While the implementation models should encourage different communities to learn and follow to enhance their environment, economy, society and culture.

References


Annex 1

a. Beijing Traditional courtyard house Model

Figure 19 Beijing traditional courtyard model drawn by author: (1) Sustainable Hutong (2) Sustainable detail (3) Sanitary design
b. Kathmandu valley Model House

Figure 20 Kathmandu valley traditional courtyard model drawn by author: (1) Sustainable Hutong (2) Sustainable detail (3) Sanitary design
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Conflicts of Interest

1 The author declares no conflict of interest

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