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MSC IN ENERGY FOR SUSTAINABLE SOCIAL DEVELOPMENT

CENTRAL CAMPUS

A
REPORT
ON
CLIMATE CHANGE, BUILDINGS AND ITS INFRASTRUCUTRE

Submitted To:

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Background:

This report is prepared as a part of internal assignment of elective course 'Climate Change and its impact on energy'. Despite the fact that the given title was "climate change, building and infrastructure", this report specially focuses on interrelationship between buildings and climate change. The infrastructures like transportation, Water supply, sanitation, energy and communication are each a very vague sphere in itself and hence requires a detail study. In other hand each of these topics has been researched and thoroughly addressed by other groups. Thus in order to avoid the superficiality and bring some considerable depth in the work, within the given time frame, the report exclusively deals with buildings.

Introduction:

Climate change is the alteration of world's climate caused by human activities through fossil burning, deforestation and other practices that increase the concentration of greenhouse gases in the atmosphere." (Ale, 2016). Climate Change here in this report signifies those changes that contribute by Building and Construction Sector.

According to Wikipedia (wikipedia, 2016): 'A **building** or **edifice** is a structure with a roof and walls standing more or less permanently in one place, such as a house or factory. Buildings come in a variety of sizes, shapes and functions, and have been adapted throughout history for a wide number of factors, from building materials available, to weather conditions, to land prices, ground conditions, specific uses and aesthetic reasons.' Here in this report building signifies both public buildings like community hall, administrative halls, malls etc. and private buildings like residential buildings.

Infrastructure can be defined as "the physical components of interrelated systems providing commodities and services essential to enable, sustain, or enhance societal living conditions. (Wikipedia, 2016). In this report, two way relationship of buildings and climate change has been considered. Firstly, while synthesizing the contribution of building to Climate Change, energy being prime source of GHG emissions, energy is considered as only one infrastructure. While in another relationship: impacts of climate change in building sector and infrastructure, other infrastructure that are closely related with building construction like transport, communication, energy has also been considered.

Objective:

General Objective:

- To understand the relation between climate change and buildings

Specific Objectives:

- To learn the contribution of buildings on the climate change
- To learn the impacts of climate change on buildings and infrastructure
- To discover different mitigation and adaptations strategies

Methodology:

The methodology involved here is limited to the literature review only. Different international journals, national pilot studies, policies and class lectures have been reviewed to prepare this report.

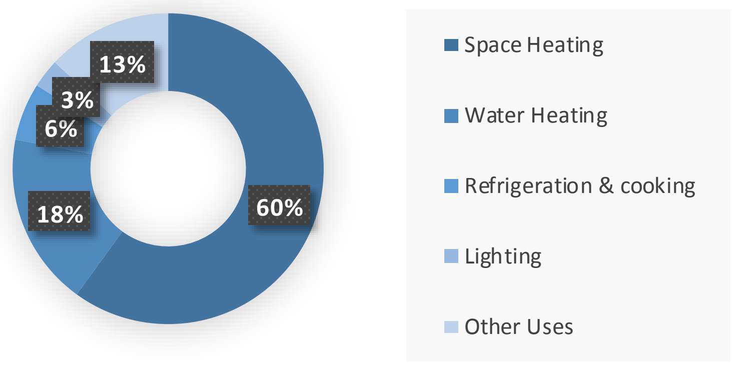
Findings:

Contribution of Building and energy used in Climate Change:

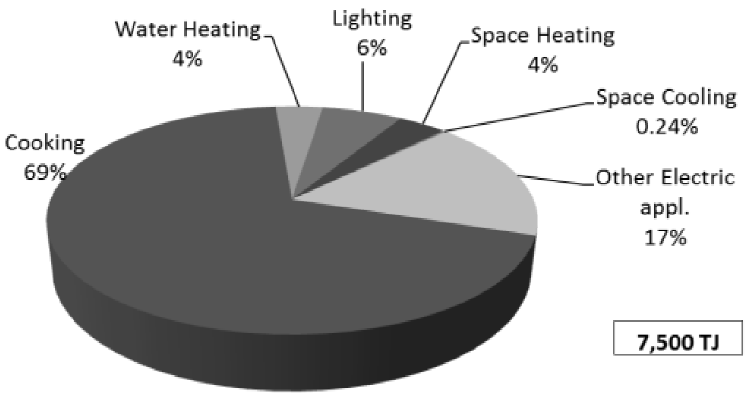
- From different sources, some facts has been revealed on how Building and energy used has been contributing the Climate change:
- **40 %** of global energy use, **1/3rd** of global GHG emissions are contributed by building sector in developed & developing countries
- The data of 2010 shows that **32%** of global final energy use, **19%** of energy-related GHG emissions are from Building sector
- The Life Cycle Assessment of building has shown that **80%** of GHG are emitted during operational phase whereas rest **10-20%** in manufacturing & transportation construction, maintenance renovation & demolition.
- According to AR5, the accurate number of GHG emissions was found out to be 8.6 million metric ton CO_2e
- The trend from 1971 to 2004 has shown that the CO_2 emission has grown at the rate of 2.5%/year for commercial buildings and 1.7% /year for residential buildings
- Though some other non CO_2 gases like halocarbons, CFCs, HCFCs and HFCs are emitted due to their application for cooling and refrigeration, the main source of GHG emissions is from energy consumption in the buildings

The operational energy in residential sector is mostly occupied by space heating in the developed countries whereas that in the cooking in the developing countries.

Distribution of Residential Energy of Developed Countries



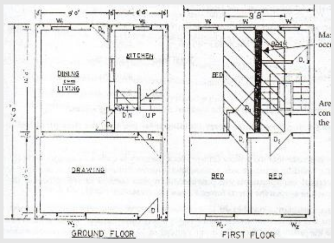
Distribution of Residential Energy of Least Developed Countries (Nepal)



Tentative calculation of Carbon dioxide emission during cement manufacturing for housing recovery

No of houses required for reconstruction: 609,938 no of houses ((NPC, 2015)

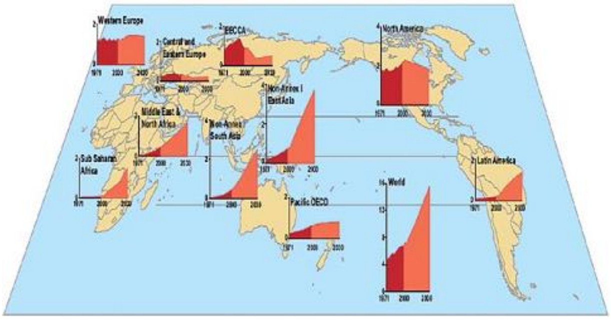
Two types of model houses selected:

Types of house	Cement based house (Rural)	RC frame house (Urban)
	 Figure 1: Rural house Source: (DUDBC, 2015)	 Figure 2: Low Cost Urban house Source: (Shrestha, 2012)
No of house	496,368	113,570 (18.5%)
Amt. of cement (kg/house)	15,550	40,928,828
Total amt. of cement (kg)	7,718,522,400	4.64+12e
Total	4.66+12e	

- $CaCO_3$ -> CaO + CO_2; by product CO_2
- 1 g of $CaCO_3$ = 0.44g of CO_2 (0.4985 emission factor in IPCC, 11% error)
- 0.26 ppm of CO_2 released during manufacturing of cement during reconstruction

See at annex

Future Forecast:



Dark red: Historic emission

Light Red: Projections 2001-2030

Figure 3: CO_2 emission from building including through the use of electricity - IPCC High Growth Scenario

High Growth Scenario developed by IPCC projected that Carbon dioxide emission will increase almost by double in 2030 (UNEP, 2009). Likewise another forecast done on the basis of AR5 shows that CO_2 emission can double or even triple by 2050. In future the energy demand shall increase especially in air conditioning and in transport in building sector because firstly population will grow, secondly more people will have access to adequate housing and electricity because of increased wealth. It has also been quoted that without additional mitigation policies, the global energy demand for air conditioning is projected to increase from nearly 300 TWh in 2000 and to 40000 TWh in 2050 (Chalmers, 2014).

Mitigation Strategies

Its relief to know that building sector has highest potential to mitigate GHG emission because of its long tail nature. 'Long tail' nature of building sector signifies that average of small savings from large no of buildings is greater than the average of savings from small no of large to medium end use units. It is also mentioned that with proven and commercially available technologies, the energy consumption in both new and existing buildings can be cut by an estimated of 30 to 80 % with potential net profit during the building life span.

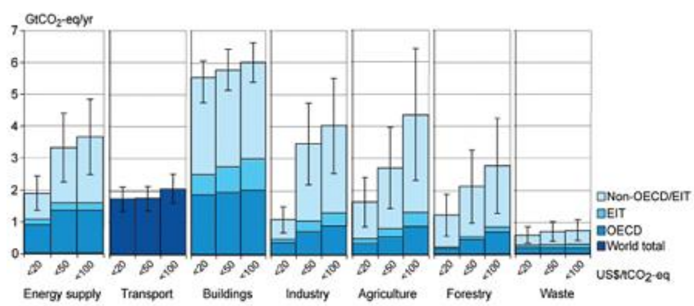


Figure 4: Estimated economic mitigation potential by sector & region using technologies and practices expected to be available in 2030

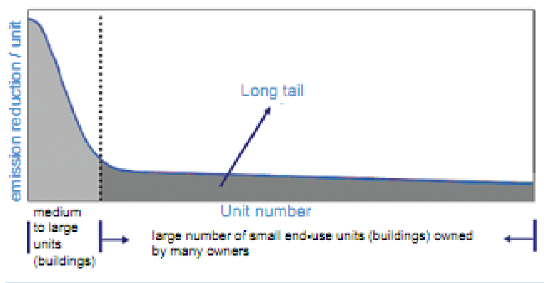


Figure 5:long tail nature of building sector

The primary mitigation strategies as stated in "Climate Change: Implication for Buildings" (Chalmers, 2014)are as follows:

Carbon efficiency:

Switching from fossil fuels and traditional biomass fuels to the modern renewable energy can significantly reduce GHG emissions. Also integrated model suggest that electricity sector decarbonisation offers lower cost mitigation gains than the direct emission cuts in energy end –use sectors.

Energy efficiency of technology:

High performance building envelope and introducing day lighting into the building by design can reduce the use of operational energy in order to maintain the thermal comfort and visual comfort. Likewise energy efficient appliances and smart meter can also reduce the energy use and simultaneously GHG emissions as well.

Example: Carbon efficiency in cooking of urban areas of Nepal (Gupta, Shrestha, Singh, & Tuladhar, 2016)

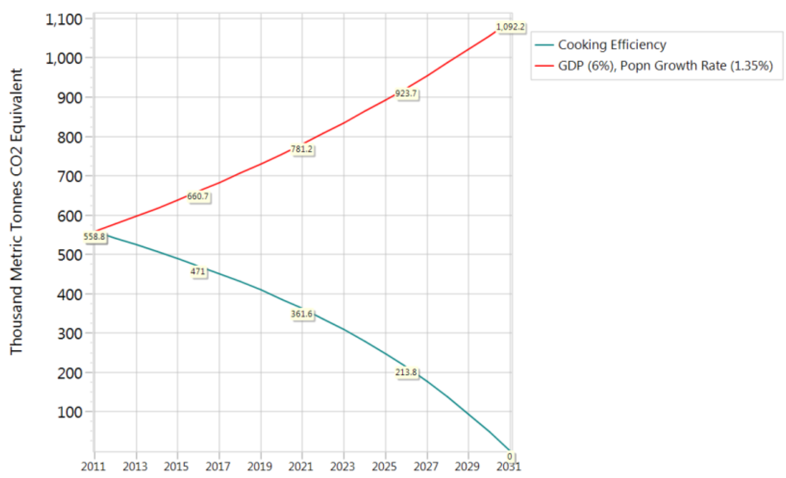


Figure 6: GHG emissions of all cooking fuels

The graph shows that when the energy for cooking is switched from the kerosene, LPG to hydro based electricity, the reduction of GHG emission on year 2030 will be 1092.2 thousand metric tons of CO2e. Also, the energy use also reduced by 237 %.

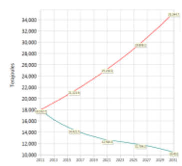


Figure 7: Energy Demand for cooking

System Infrastructure Efficiency:

Through improving whole system of infrastructure of building, GHG emissions can be cut off. Some of the methods are passive building design, active design, individual retrofits etc. the effects of retrofits can vary according to the type of building. For e.g.: it was found that energy retrofitting of detached single- family homes cut the total energy use by 50-75%, multi –family housing cutting cooling energy use by 30% and heating energy by 60% in developing countries; Commercial building HVAC energy use reduced by 25-50% and 30-60% for lighting. Also it is already a proven theory that vernacular buildings are energy efficient than the modern buildings. Regarding this, Prof. Bajracharya has written than compare to modern residential buildings, the traditional buildings were 1-2 ^{o}C warmer in winter and 1-2 ^{o}C cooler in summer (Bajracharya, 2014).

Service Demand reduction via Behavioral and lifestyle changes:

Behavioral change in consumers is one of the major aspect of demand-side management. It can effective if the provision of changing the energy behavior is mandatory than voluntary specially in this present plight where energy use related to building are projected to increase as driven by people moving out of poverty and changing patterns of consumption. Some of tools that can assist the service demand reduction are carbon pricing, carbon trading, and building codes.

Barriers:

Even if the mitigation strategies are known to the experts and policy formulators, there are plenty of barriers which hinders to head towards Climate Change mitigations (UNEP, 2009):

Economic / Financial Barriers:

Economic or financial barriers refer to those barriers when the ratio of investment cost to value of energy saving is more than or equal to 1. These barriers happen when there is higher-up front costs for more efficient equipment or there is no energy subsidies, there is lack of access to financing.

Hidden Costs/ Benefits:

Hidden costs are not directly captured directly in financial flows. For e.g.: poor power quality even after switching to electricity form fuel wood, weak performance of solar batteries etc.

Market Failures:

Because of market constraints there are some problems while trading-off between specific energy efficient investment and energy saving benefits. Imperfect knowledge about energy efficient technology, unavailability of energy efficiency equipment locally are some examples of the market failures.

Behavioral & Organizational Barriers:

To replace the old habits with newer energy efficient practices is not abrupt. It takes time, awareness and willingness. Most of time especially in residential buildings, it is difficult to get to motivate the people to use energy efficient technology because of their prejudice that only person, only my family can hardly make any change in big picture. Also replicating the success stories to different context is also troublesome while transitioning the energy expertise.

Information Barriers:

Lack of information provided on energy saving potentials and its benefits to the consumer,, building managers, construction companies, politicians is one of major information barrier. In least developed country like Nepal where database and data are hardly updated, it is difficult to quantify the ultimate results.

Political & Structural Barriers:

Because of characteristics and structure of political decisions, it is often difficult to pace up the climate change mitigation campaign. Most of the dime the process of drafting policies and legislation is too slow. The lack of co-ordination between one government organization to another also contribute to the conflicting situation which demotivates the energy efficient investors.

Building Blocks for Mitigations:

These building blocks are essentials for implementation of mitigation strategies that are firstly to be done. Also these building blocks reduce the barriers and their effects. Here are some building blocks that are highlighted in 'Building and Climate Change' (UNEP, 2009) are as follows:

Energy performance Requirements and Indicators:

Climate change mitigation from building sector should start from the policies when it's an entirely new concepts based on the latest discoveries and technologies. There should be indicators where every house can be categorized into different ranks on the basis of the energy performance of the buildings. The parameters should be developed in every country depending upon its own consumption pattern, major sourced energy etc. Building codes like one Nepal has for earthquake resilient buildings should be developed for energy and GHG emission as well. Once the codes are made mandatory, multi stakeholder that are related to the buildings like investors, construction companies, inhabitant, demolishers etc. are ought to practice energy management tools and procedures. One of case study on fine- tuning of energy use helped reduce 20-50% energy in sustainable buildings of Malaysia (UNEP, 2009). The transparency of national GHG emission should be maintained through sector wise. In case of Nepal, national GHG inventories based in 2000/2001 showed that energy is primary GHG emitter (MOSTE, 2014).

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Data and Information about the size and Characteristics of the Building Sector:

Nepal has categorized its building into four main groups (MoFALD, 2072):

- Category A: one with the latest technology
- Category B: having gr. Fl. Area > 1000 ft^2, no of storey > 3, structural span > 4.5m
- Category C: having Gr. Fl. Area < 1000 ft^2, no of storey < 3, structural span < 4.5m
- Category D: those which have not been included in category A, B, and C; made up of bricks, stone, earth, bamboo, etc. no of storey < 2

Even there is categorization of buildings, existing stock, their frequency, their density, climate, land topography are not known which prevent to formulate site specific guidelines.

Capacity to design and implement energy efficiency measures:

Capacity to design and implement energy efficiency measures can be increased only when followings essentials are there:

Data collection, analysis and use: Data collector, appropriate machines and equipment should be suffice to research.

Enforcement of regulatory policies: Through mandatory building codes and standards, one can bound every dwellers to the mitigation of Climate change.

Technical knowledge and skills: Climate Change mitigation experts, qualification for raters and certification of auditing companies are to be developed at first.

Consultative Frameworks for policy making and communication: Different stakeholders related with the building and construction sector should have a platform where they can communicate with each other and help formulate realistic and flexible policies.

Case study of France: The Grenelle de I'Enivonment was a multiparty summit which took place over several months in mid-2007 and concluded that late October 2007. It involved non-governmental organizations, union representatives, employers, local authorities, and French government officials etc. This Grenelle resulted in a number of important recommendations for the building sector, including:

- For new buildings, primary energy use is expected to be under 50 $KWh/m^2/yr$ by the end of 2010 for public and tertiary buildings and for all new buildings by the end of 2012. The ultimate goal for 2020 is for all new buildings to be passive or energy-positive, meaning buildings will generate more energy than they consume.
- For existing buildings, an ambitious target of 38% reduction in overall energy consumptions by 2020 was adopted, with a special set of actions for a public buildings. To support this process, a complete set of financial schemes has been implemented or reinforced. For example the 'Zero Rate Eco-loan' , which provides loans to property owners of up to 30,000 Euros over 10 years.

Impacts of Climate Change in Building and Infrastructure:

The impacts has been analyzed in three different levels: global, national and local.

Global Scenario:

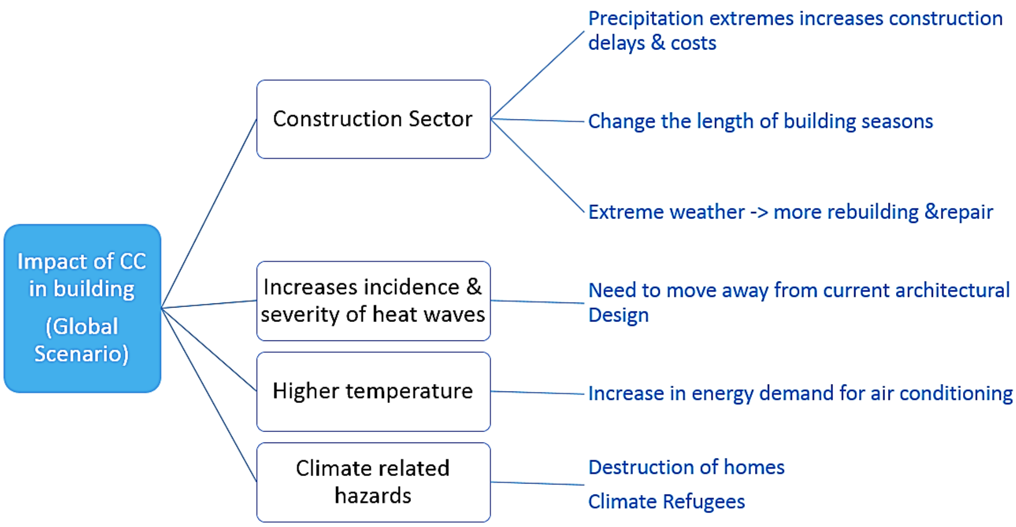


Figure 8: Impacts on Global scenario

After understanding the contribution of building sector in the Climate Change, its time we understand the impacts of climate change on buildings. Climate change is global phenomenon and no sector can remain unaffected. There are significant impacts of Climate Change in Building and Construction Sector as well. The change of different elements of climate like precipitation, temperature etc. there is change in the length of constructing seasons. Extreme precipitation increases the construction delays and costs especially when construction of structural member, exterior works are to be done. Also extreme weather like

Figure 9: Story of climate refugee from International Mountain Museum, Pokhara

flash rainfall cause the more repairing and rebuilding at most. Increases in solar incidence and severity of heat waves, there is need to move away from current architectural design. The design of newer buildings should be such that it can adapt to the change in climate. Since it is globally accepted that the earth's surface temperature is increasing by 0.74°C since 1850. It is annually increasing by 0.06% (Ale, 2016). The impact of temperature rise in tropical climate is severe. Hence there is increase in demand for air conditioning. It is even projected that the increase in energy for air conditioning can increase up to 4000 TWh in 2050 (Chalmers, 2014). Likewise there are different climate hazards whose frequency are increasing with climate change like, flash floods, droughts, landslides in higher elevation, cyclones and sea floods in coastal zones can directly destruct the buildings. That causes to thousands of climate refugees. a story form International Mountain Museum, Pokhara says that under five feet of sands of his village Juddhagunj, lies the old settlement (neighborhoods, fields, memories) of Brahmdev Yadav. His parents were also displaced by the Koshi and forced to migrate to Shripur from Saptari.

National Scenario:

"The Climate Change Risk Atlas" 2010 ranked Nepal as the fourth most vulnerable country in the world after Somalia, Haiti and Afghanistan. (MoSTE). Despite having only 0.4 percent of the total global population and being responsible for only 0.025 percent of total GHG emissions in the world, Nepal will be affected disproportionately, especially from increasing atmospheric temperature. Nepal has experienced an average maximum annual temperature increase of 0.06°C. (NLC, 2011) The increase in average annual temperature on the high Himalayan slopes is greater than in the mid hills and Terai plains. This increase is also higher than the global averages. Rising temperatures cause Himalayan glaciers to melt and form lakes with a high probability of breaching and causing flash floods (Shrestha, 2012). The rate of increase of average winter temperature is higher than that of summer and is high enough to change ecosystem functions, plant production cycles and ecosystem services. Changes in the annual rainfall cycle, intense rainfall and longer droughts have been observed. The number of days with 100 mm of heavy rainfall is increasing. The pattern of monsoon rainfall– both in volume and season – is changing; the number of heavy rainfall events in western Nepal has increased while rainfall season in eastern Nepal has become more erratic. The number of winter showers is decreasing and summer rain is falling later than in the past. (MoSTE)

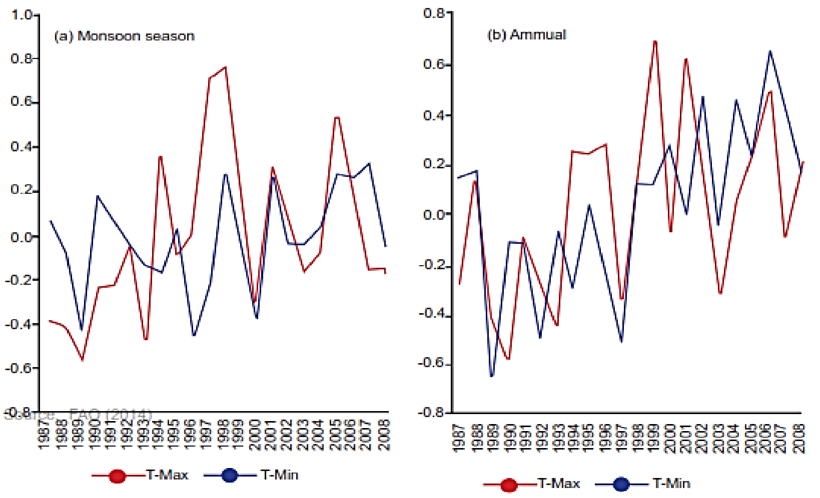


Figure 10: Maximum and minimum temperature trend (1987-2008) in Nepal (MoSTE)

A recent study indicates that 1.9 million people are vulnerable to climate change in Nepal, and an additional 10 million people are increasingly at climate risks. Climate-induced disasters have repeatedly damaged infrastructure like roads, bridges, community and public buildings, schools etc. Around 2.45% of GDP has been estimated to be lost by disaster every year. The livelihoods of more than 80% local people of hilly region are heavily depending on climate sensitive area such as agriculture, forest and livestock and on other natural resources such as water & irrigation. Most of the people living in the mid and far western regions amongst the most vulnerable, a situation closely correlated with the poverty index in those areas. (NPC/UNDP/UNEP, 2011).

The transport sector is the major contributor of Carbon Dioxide (CO2) emissions in Nepal, which accounts to 45% of the per capita emission produced in the country. Although per capita emission of CO2 (133 kg in 2011) in Nepal is lowest in terms of the World average of 4,504 kg/capita, the current trend suggests that the fossil fuel emission growth of 395% over the last decade has been considerably higher than the world average of 49.3%. In other hand major proportion of transportation budget on maintenance. Expenditures increased fourfold from 2006 to 2010. NRs. 3.30 million US$ (2005/06) to 27.34 million US$ in 20011/12 and NRs. 40.18 million US$ (2012/2013). (UN, MoPIT, MOE, UN ESCAP, 2015). Similarly in the context of water supply and sanitation, the coverage is about 85% in basic water supply and about 63% of basic sanitation. Potential impacts of climate change, the situation for the water supply and sanitation systems is complicated poor quality of system 50% of Nepal's 38,000 water supply systems are not functioning properly. Poor Quality, Technical error in design, Lack of Maintenance, Loss of forest cover, indiscriminate removal of sand from river bed, clay mining from valley floors and soil erosion in the high lands have caused serious threats to surface water availability. The Government of Nepal (GoN) has considered the climate adaptation as national agenda of high priority in 2009 and hence initiated a number of activities to enhance the technical and institutional capacity of social, economic, and institutional sectors in order to minimize the vulnerability and improve the resilience of the population. With the vision of a country spared from the adverse impacts of climate change, by considering climate justice, through the pursuit of environmental conservation, human development, and sustainable development all contributing toward a prosperous society the Nepal law commission came up with **the climate change policy 2067 (2011)**. (NLC, 2011) Some of the policies directly dealing with the building
, infrastructure and livelihood has been listed below.

I. Climate adaptation and disaster and risk reduction
    a. Linking and implementing climate adaptation with socioeconomic development and income-generating activities to the extent possible

II. Low carbon development and climate resilience
    i. Developing and promoting transport industries that use electricity (electric train, rope way, cable car etc.)
    ii. Climate resilient construction of bridges, dams, river flood control and other infrastructure

III. Access to financial resources and utilization.
    i. Utilizing the financial resources available climate adaptation, adverse impacts mitigation and low carbon development activities, as well as for food, health and livelihood security of victims of water-induced disasters

IV. Capacity building, peoples' participation and empowerment.
    i. Developing and mobilizing skilled manpower, Inclusive Planning, utilizing climate adaptation and adverse impact mitigation-related traditional and local knowledge, skills, practices, and technologies.

V. Study and research
    i. Developing appropriate technologies for mitigating the adverse impacts of climate change ; water conserving technologies, f clean and green technologies,

VI. Technology development, transfer and utilization
    i. Developing and increasing the sustainable utilization of clean and green technologies

VII. Climate-friendly natural resources management
    i. Conserving soil and water through measures such as source protection, rain water harvesting, and environmental sanitation

VIII. Strategy and Working Policy

i. Prohibiting the development of human settlements in climate vulnerable areas (landslide-prone areas, flood-prone river banks, etc.)

IX. Financial Aspect

i. Allocating at least 80 percent of the total budget from Climate Change Fund directly to program implementation at the community level.

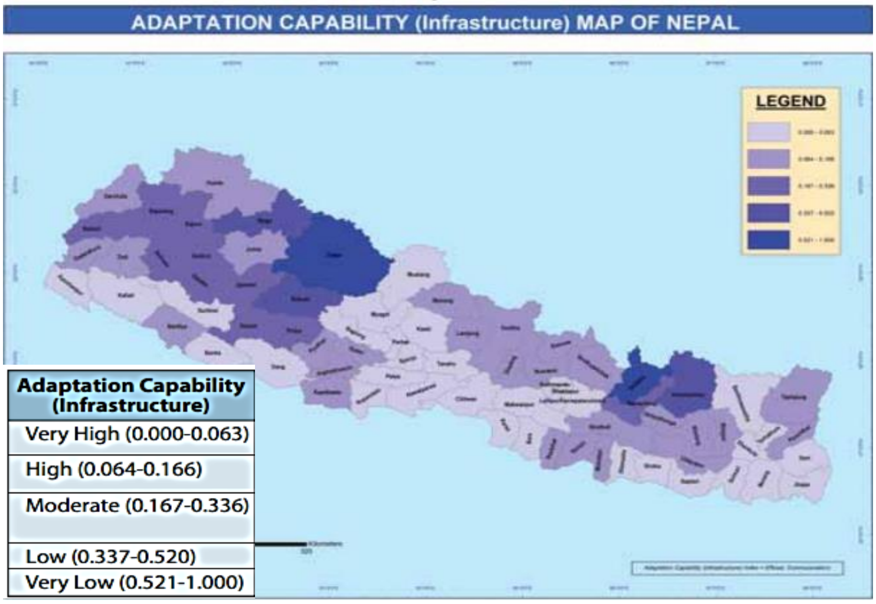
X. Risk

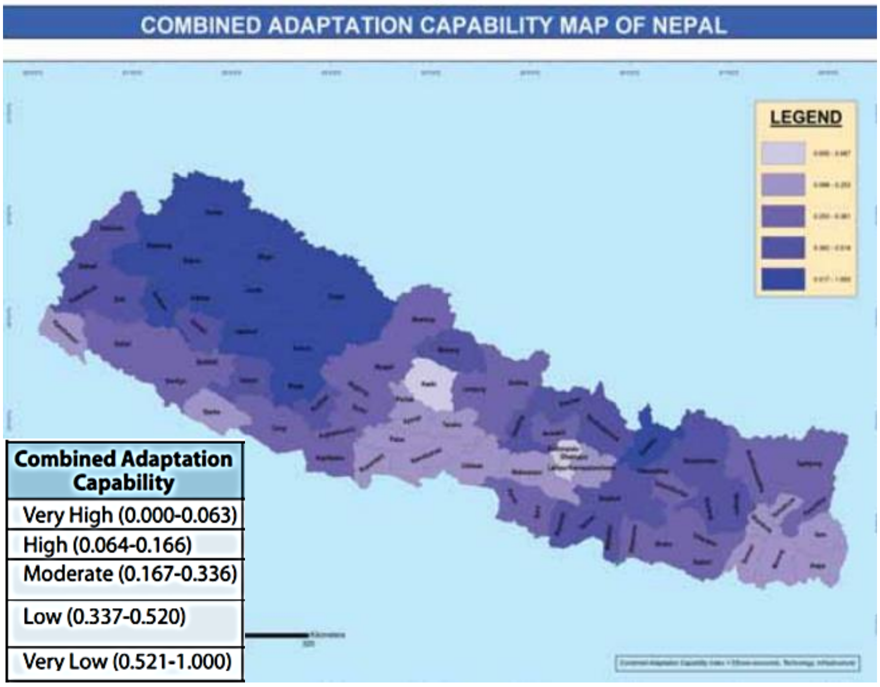
i. Limited reach of climate adaptation and capacity building programs to targeted communities and groups

ii. Lack of coordination for the implementation of policies and programs, inability to manage necessary technical and financial resources.

iii. No prioritization of technology development and utilization and capacity building of human resources.

Adaptation Capability:





(NAPA, 2010) Road and communication were selected as the indicators of infrastructure to determine the adaptation capacity. The density of the road and the communication coverage of landline telephone in the districts were the considerable factor for the determining the index where both components were given equal weightage. However from the map it can be observed that the districts at the Himalaya regions like mustang and Sankhuwasabha has been identified as the district with very high adaptive capacity similarly other many district over this region has been identified as district with high or moderate adaptive capability where as in fact they are very vulnerable to climate change and several challenges are associated with the adaptation. The limitation in the result could be because the density of road and communication infrastructure is very low compared to other district and so is the need for the adaptation. .

(NAPA, 2010)Similarly for combined adaptation capability, Technology (0.25) Socioeconomic (0.5) and Infrastructure (0.25) were taken as the indicator with their respective weightage to determine the capability index. As the socio- economic factor has been the major aspect the district such as Kathmandu, lalitpur and kaski with sound socio- economic condition have very high adaptive capability whereas the district in far western, mid-western and eastern side of central region has very low adaptive capability due to the prevalent low socio-economic condition as well as gender and caste based vulnerability. In other hand the influence of technology is also significantly low over these districts.

Cases studies of adaptation from different ecological Zone of Nepal (MoSTE):

The case study discussed below reflects the adaptation scenario with the indigenous traditional and local knowledge. According to Mukhopadhyay (2009) "indigenous knowledge is knowledge unique to a given culture or society, acquired through accumulation of years of experiences of local people passed on from generation to generation" and IPCC (2010) describes Indigenous Traditional Knowledge as an "invaluable basis for developing adaptation and natural resource management strategies in response to environmental and other forms of change." The case studies are of the three different regions viz. Terai, Hill and Mountain.

Case 1: Eastern Terai Community-Based Flood Management, Lakhanpur VDC Jhapa

The VDC is situated in shallow and fragile Bhabar region which is highly hazard prone. It is regularly inundated and flooded by Ratuwa and Geuriya River water causing significant loss of lives and properties. The floods started in 1976 displacing 38 households. Local residents believe that the flooding was triggered by conversion of forest lands into human settlements and agriculture land which started as early as 1975 in upstream areas. Irregular and unpredictable rainfall has been reported with each passing year. Similarly, even in the winter season the mosquitoes were encountered whereas before three years no such events were ever witnessed.

The **indigenous practices used** are houses with elevated plinth level (i.e. up to 1m higher) above the ground, ceilings are provided with hooks to hang clothes and valuables during inundation. People use local materials of bamboo and mud or cement for making walls, wooden frames are being replaced by bamboo frames, and thatch roofs by galvanized iron (GI) sheet – all cheaper and less hazardous materials. The traditional building of earthen dams using dry boulder materials and sand sacks are being reinforced by planting grasses such as Imperata cylindrica & Andropogon sp. along the vulnerable banks of rivers threatening the settlements. All

Figure 12: Houses with elevated plinth level

Figure 13: Youth in construction works

these structures have ample use local knowledge in terms of site selection, selection of construction materials, and local participation. To reduce flood risks gabion wires filled with stones, cement mortar stone walls, and cement concrete slabs are used to block flood water entering houses and settlements. As not all flood disaster can be prevented, VDCs have allocated land to resettle the displaced people.

However some mal-adaptation has also been reported, also. The community had built irrigation canal diverting the river water from under the bridge. But they had to quickly close the canal since flood water entered through the canal due to such events now the people have less belief in their indigenous knowledge. In other hand technically and financially, the solution is out of scope at the local level.

The other issue is, as the VDC is located next to a fast growing town of Damak, the municipality has constructed spurs all along the city side of the river bank to protect its population diverting river toward the village settlement which is increasing the vulnerability of the village. Thus we see there is lack of co-ordination and inclusive adaptation measures which can only be solved with the support from the national level.

Case 2: Flood Disaster Risk Reduction and Management, Mahottari

The district headquarter town of Jaleshwor and surrounding villages suffer from chronic flood problems due to overflowing seasonal rivers and streams. The main reason for the flood is continuous deforestation and degradation in fragile nature of Chure hills in the North and construction of embankment by India along the Border in South. The unregulated excavation of stone and sand aggregates in the Chure hills and upper basin to supply construction industries both in Nepal and India hugely adds to the natural flood vulnerability by facilitating the spreading of destructive flood water and damaging of roads and bridges.

Figure 14: House with elevated plinth level

In addition to this, due to the prevalent of social vulnerabilities among different castes, age groups, and Socioeconomic levels within each village & households and gender specific vulnerability, the poor and marginalized people are more affected by the disaster. Rich households in semi-urban Jaleshwor are increasingly building *pakka* (concrete) types of houses. The villagers own mostly kacha type of houses and do not want to build the pakka house with the fear of loss thus they are adapting their houses to 'live with flood' In fact in order to reduce the financial loss they have avoided owning valuables in their home. The new houses have high plinth level and placing bhakari (food storage bins) on the raised platform to preserve seeds and grain. Villagers are involved in embankment building initiatives and planting trees and grasses on the slopes of the embankments to strengthen them. Temporary bridges using bamboo poles are constructed to maintain temporary movement of people and light goods during flood season. Labor migration to foreign country which is becoming one of the most popular coping/adaptation strategies. People are moving to safer places, mostly either on the high grounds or in neighbor's house or in community identified shelters. From the district, 40,532 people were working abroad in the year 2011 (CBS 2011).

Figure 15: Food Storage at elevated ground

Even though the local participation on the construction work was praiseworthy, the embankment has brought up some new issues. It has blocked natural drainage affecting the indigenous irrigation system. Also, water logging problem in farm lands along the embankment has affected the crop production. The communities are although using their indigenous knowledge and practices such as construction of bio-engineering flood mitigation measures, flood warning and disaster preventing notice boards, and changing their forest and agriculture land management practices, they realize that indigenous practices and technologies alone cannot prevent and manage extreme weather related loss and damage. In fact the top-down measures where government supported the projects with the utilization of all indigenous knowledge and practices could make more effective and prevent mal-adaptation.

Case 3: Indigenous Flood Protection and Management, Sindhuli (Hilly)

Ranibas and Dandi Guranse VDCs; The settlements located on the northern slopes of fragile Chure hills are frequently devastated by flash floods of Kamala, Marin and a number of Khahare khola (rivers) that flow down from the Chure hills bringing flash floods during monsoon season. After the hill settlers moved in, massive deforestation occurred and flood problem started. The devastating flood events in 2012 destroyed a large area of fertile agriculture lands, damaged or swept away close to 50 houses, and killed several people. Similarly Water springs including a popular natural spring, have dried up. If water sources are dried up permanently, the community will have no option but to move since there are no alternate sources around. In recent years, a new problem of landslides has been threatening the community. "Previously soils, sands, and pebbles used to flow in flood water now whole mountain come crashing down"

Figure 17: Tree log along the river bank

People have constructed check dams, trash dams, bamboo and log reinforced flood barriers and gabion walls to control flood and protect agriculture land. The villagers in general are coping with the annual disasters using their own knowledge and local resources to adapt to the changes and disasters. During flooding season, they dig series of holes and put tree logs in them along the river banks in order to protect the farm land from large boulders and to slow down the sediment laden flood wateSimilarly in case of housing, Ghumaune Ghar used to be more common in the older days in sindhuli when it used to rain longer, the roof with slope in all four sides, facilitated drainage off more rain thus prevented getting into the rooms and windows. This kind of design helped in keeping hailstones and rainfall sideways. Also these kinds of houses used to have shorter height and kept the rooms warm. However, now it is more common to find Pankhe ghar in the Ranibas settlement area. Pankhe ghar have slopes only on two sides, so if it rains longer there is a chance for water to get in the house. But this kind of house have higher roof with more height making room more airy. People reported that it has become hotter these days so they prefer to have houses with tall

Figure 16: Traditional house; four sided sloped roof

Figure 18: Adopted two sided sloped roof

roofs. Another change that can be found in the houses these days are the size of windows, now people keep bigger windows in the house because of hotter days. Also windows are designed to open outside now days as earlier windows opened from inside.
Similarly some of the mitigation measures has been taken; Tree plantation program has been initiated through community forest and private forest program. As the communities gradually realized the importance of zero grazing which has reduced flood damage. They have been successful to do continue with the banned open grazing. The women now practice `cut-carry-feed' system of stall feeding of their animals using the community rehabilitated and managed forests which actually has proven to be a win-win situation as the forests are both protecting the settlements and supplying adequate quantity of animal feed.

Some more examples of Local adaptation in Hilly Region:

Figure 19: Traditional Golo ghar and Modern House at Ghalegaon, Lamjung

The human settlement in the ghalegaon of Lamjung reflects traditional and local touch in the structure design and the construction of community as well as private houses and public infrastructure. Previously the major construction materials used were grasses for roofing; woods for windows, doors, and beam; and rock/stone slabs for flooring and pavements with stones and mud as the plastering materials. These days, the trend is using modern construction materials such as bricks, cement, iron and galvanized tins for walls and roofs which was indeed needed in order to withstand harsher weather. Ghalegaon used to be known for its famous *golo ghars* (round houses) designed for keeping the occupants warm inside it .These houses have two layers of compartments for better protection from extreme wind blow and snowfall. However, during the last 10 years as the local climate has been warming, people are changing their housing structures and designs to rectangular types that provide more air circulation, privacy and space for family members. These houses are also two storied and often have balconies so that they are suitable both to hot summer months and cool winter months. The *golo ghars* are being redesigned and modelled as tourist attraction.
The local communities have used the inevitable changes to their advantage by remodeling the heritage building for tourism that has been providing increased income to the local people besides preserving their indigenous cultural knowledge

Mountain Region; Excerpts from News paper

…… Because Mustang is facing less snowfall and more rainfall these days, traditional houses made up of mud construction are deteriorating fast. ……In order to save from this, use of CGI sheets for roof construction and the methods are also different. (Sharma, 2016)

The number of "climate refugees" is increasing as about 150 people from the high lands to lowlands (Mustang district) were encouraged to resettle due to adverse impacts of climate change (NPC/UNDP/UNEP, 2011)

Figure 21: Residential bldg. (Ghangha Construction)

Source: (Gupta, Kirat, & Tuladhar, 2016)

Figure 20: Glimpse of Mustang

Source: (Regmi, Raut, & Gyawali)

Conclusion:

Infrastructure for the built environment is typically designed and constructed to be operational over a long time period, meaning that knowledge of future conditions and integration of that knowledge in building and infrastructure, design and operations are essential. (Claire wash, 2007)

There is no doubt that though building sector is one of the highest GHG emitter and energy consumer, it possess highest potential to mitigate GHG emissions. From different mitigation strategies, building sector can mitigate their energy consumption and energy related emissions by 30 to 80%. Meanwhile it should also be considered that the most emitter phase of building in its lifecycle is operational phase, mostly because the lifespan of building in operation is far more than that of the any another phases. Even a load bearing construction can survive upto 50 yrs. Hence the prime concerns should be in reduction of energy and GHG emission during operational phase. For that the homework should start form the inception of the buildings. A conscious decision in designing the layout, material selection, utility technologies can significantly reduce the energy consumption as well as GHG emissions. In order to implement mitigation strategies, one should develop the required infrastructure as well which is mentioned here as 'building blocks' of mitigation strategies. Both top down and bottom approaches are essential for this. Co-ordination from every stakeholder from grass root level to the stakeholder of policy level can together practice mitigation strategies. The conjoint of different level stakeholders is necessary in different phases of mitigation like data collection, formulation of policies and many more.

In reference to the witnessed increase in temperature, erratic and extreme rainfall patterns, the increased frequency of floods, glacier melting, landslides, and droughts, climate change has been a serious and immediate threat to development. It has in fact accelerated insecurities of food, water & energy, and challenged the efforts to protect massive number of people and properties from climate induced disasters. Despite the contribution of only 0.025 percent of the total global emission, Nepal is severely affected by the climate change. Thus only handful of mitigation works are within our scope leaving only the choice of adaptation.

At the national level, Government of Nepal has initiated a number of activities to enhance the technical and institutional capacity of social, economic, and institutional sectors in order to minimize the vulnerability and improve the resilience of the population. From the case studies discussed above, we see that in many VDCs people have successfully adapted their life style and commodities with the indigenous and traditional knowledge. However there are other few factors such as the rate of climate change, socio-economic conditions and technology that influences the adaptive capability of the people. If the effect of climate change is rather slow then people adapt with time however if it is rapid, it definitely comes up with heartbreaking disaster. Poverty, Gender and caste discrimination in other hand has accelerated the vulnerability. The way, poor and marginalized people are adapting; **live with flood** and struggling very hard for the basic need of life, it clearly indicates that the so formulated overwhelming policies, planning and finance has indeed not reached to the targeted population. Similarly the way how some VDCs have mal-adapted and in return are victimized by the result of their action it is crystal clear that the required co-ordination between the national level and local level is missing.

Thus in order to get the effective adaptive output, the serious committed work against the vulnerability enhancing factor is needed, Similarly the joint co-ordination between national level and local level with the necessary environment where the local indigenous knowledge and scientific engineering measures can together find an expression to come up with the effective and appropriate adaptive ideas is highly required.

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Annex:

Rural house (DUDBC, 2015)

Model SMC-2.3: STONE MASONRY IN CEMENT MORTAR — TWO-STOREY

CONSTRUCTION MATERIAL AND MANPOWER

LEVEL	MAN POWER		MATERIALS							
	Skilled	Unskilled	STONE	CEMENT	SAND	AGGREGATE	WOOD	ROD	CGI SHEET	GI SHEET
	Md	Md	Cu.m	Bags	Cu.m	Cu.m	Cu.m	KG	Bundel	Rm.
Up to Plinth Level	61	220	33	95	17	9	0	305	0	0
Ground & First floor	162	357	53	216	32	17	1.02	1487	0	0
Roofing work	41	15	0	0	0	0	1.91	0	4.50	11
TOTAL	263	592	86	311	48	26	2.94	1792	4.50	11

Nepal Housing Reconstruction Programme	TYPE OF HOUSE: MODEL SMC-2.3	SCALE: NONE	DATE:
	DRAWING TITLE: PERSPECTIVE AND ESTIMATION	DESIGNED BY: DUDBC	SMC-2.3 1/4

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Calculation of Cement of low cost housing (Shrestha, 2012)

:			Material per unit quantity					Material
		Quantity	Unit	Sand (cft)	Aggregat e (cft)	Cement (kg)	Brick s	Cement (kg)
1	**Flat Brick Soling**	182	sft					
2	**RCC works on foundation**							
	cement concrete 1:2:4	128	cft	155.4	310.816	3300		422400
	MS.rod	162	kg					-
	Formwork	72	sft					0
3	**Brick work in CM, 1:6 in foundation**	206	cft	10.6		2472.4	530	509314.4
4	**Brick work in CM, 1:6 in Super Structure**	400.5	cft	10.6		2472.4	530	990196.2
5	**RCC Lintel**							-
	cement concrete 1:2:4	17.75	cft	155.4	310.816	3300		58575
	MS.rod	47.79	kg					-
	Formwork	100.97	sft					-
6	**Rcc works for beam Slab Column**							-
	cement concrete 1:2:4	773.43	cft	155.4	310.816	3300		2552319
	MS.rod	2494.69	kg					-
	Formwork	2621	sft					-
7	**4 1/2 Brick work in CM. 1:5**	1392	sft	10.9		3178.8	530	4424890
8	**1/2" cement plaster 1:4 ceiling**	1682.5	sft	51.6		19002.1		3197113 4
								-
	Sal wood Chaukot		cft					-
	Total							4092882 8

Reference for quantity	Dar Bislesan , Sahari tatha bhavan bivag

Calculation of CO_2 emission:

i) $CaCO_3 \xrightarrow{\Delta} CaO + CO_2 \uparrow$

↳ eqⁿ of CO_2 as by-product

Mass of atmosphere = 5.2×10^{18} kg

Mean Molecular wt of air = 29

We have,

1 mole of $CaCO_3 \equiv$ 1 mole of CO_2

100 g of $CaCO_3 \equiv$ 44 g of CO_2

1 g of $CaCO_3 \equiv$ 0.44 g of CO_2

1 kg of $CaCO_3 \equiv$ 0.44 kg of CO_2

0.4985 kg of CO_2 per IPCC

- (11% error)

Now, 4.66×10^{12} kg of $CaCO_3 \equiv 2.05 \times 10^{12}$ kg of CO_2

that makes the ratio of CO_2 to air by mass

$$= \frac{2.05 \times 10^{12} \text{ kg of } CO_2}{5.2 \times 10^{18} \text{ kg of air}}$$

$$= 0.39 \times 10^{-6}$$

that is 0.39 of CO_2 ppm by mass

To calculate Volume ratio, We have Dalton's law;

$$\frac{V_{CO_2}}{V_{air}} = \frac{N_{CO_2}}{N_{air}} = \frac{m_{CO_2}}{m_{air}} \times \frac{M_{air}}{M_{CO_2}}$$

$$= 0.39 \times \frac{29}{44}$$

$$= 0.26 \text{ ppm of } CO_2 \text{ by Volume}$$