CLIMATE AND CONSTRUCTION

-AN IMPACT ASSESSMENT

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1.1 Introduction

This assessment report looks at the linkages between climate change and the construction sector in three different geo-climatic regions of India- wet-hilly, coastal and semi-arid - based on which, it goes on to identify gaps which need to be addressed through capacity building at three levels – policy makers, building professionals and building artisans. The target of building capacity at these levels is to steer the construction sector towards a Low-Carbon and Climate Resilient (LC-CR) development pathway. The principle questions which the report seeks to answer are concerned with

- Critical resources and issues in the construction sector in the selected study regions,
- Criteria for selecting appropriate low carbon building materials and technology,
- Key policy and technology gaps/ barriers for low carbon construction and
- Capacity gaps at policy, design and construction levels to enable low carbon construction.

The report presents a brief global and Indian perspective on the carbon intensity of the construction sector and issues of climate vulnerability in the South Asian region. This is followed by a detailed description of the three study areas in Himachal Pradesh (wet-hilly), Orissa (coastal) and Madhya Pradesh (semi-arid) in terms of the Climate, Natural Resources and Building Construction Practices. Subsequently, an analysis of the study regions has been carried out to identify the critical issues in each region which need to be addressed through capacity building at the three levels. The report concludes with the learning objectives which must be met through training programmes in the three regions, in response to the identified gaps in capacity building. The guiding principles for the three levels of training are

- Policy makers – how to integrate climate change and associated concerns of low carbon growth into planning for the built environment,
- Building professionals – how to respond to low carbon construction imperatives through appropriate building design and choice of materials and technologies, and
- Building artisans – how to construct buildings using low carbon and climate resilient building materials and technologies.

1.2 Wet hilly region - Himachal Pradesh

The wet hilly region in Himachal Pradesh has a rich natural resource base of forests and water. It regularly faces natural hazards like cloudbursts, flash floods, landslides and being in a seismically active zone, also faces imminent threats from earthquakes. Rich in limestone, cement is one of the biggest industries here and also a big source of environmental degradation and pollution. The region has a rich tradition of climate responsive vernacular architecture based on timber, soil and stone. However, increasing rate of urbanization has resulted in high density construction with RCC frames and burnt brick masonry, thereby displacing traditional practices.

The state has a conducive environment for low carbon growth by targeting to become the first carbon neutral state of the country. Renewable sources of energy are being promoted and directives have been issued to incorporate passive solar design features in buildings. At the policy level, sustainable management of forests is critical not only to maintain a healthy carbon sink but also regulate the supply of timber for construction practices which are native to the region. Production of cement, being one of the biggest industrial activities in the state, must be tackled with appropriate policy measures, focussing on minimizing the inevitable degradation and emissions. Increased adoption of solar passive buildings is important to ensure that operational energy requirements in the winter season are minimized – this needs strengthening, both at the existing policy level and at the level of architects and engineers to incorporate the features at the building design stage. The traditional low-carbon construction practices of the region need to be revived at the design and planning level through composite techniques which combine traditional materials with contemporary building design and materials.

1.3 Semi arid region - Madhya Pradesh

The semi-arid region of Madhya Pradesh has been made resource deficient through relentless deforestation and the resulting soil erosion. In addition, erratic rainfall and the naturally high temperatures predominant in the region have also made water scarcity a prime threat. The climatic extremes prevalent in the region are heat waves and below normal rainfall, which is likely to increase the frequency of droughts if appropriate measures are not taken at this stage. Being rich in mineral resources, the state faces a huge challenge in sustainable extraction of resources. Stone, one of the biggest resources is also a common building material. As a result, stone crushers in the state have become a major source of stone dust - a waste material and an environmental hazard. Traditionally, buildings are constructed using stone, burnt clay bricks and tiles. There is a rich tradition of brick architecture, which is now declining in favour of building elements which use cement concrete and steel. Sandstone slabs on steel girders are a common roofing technique for construction of flat roofs.

There are some very early stage policy related developments in the state which aim to promote cost-effective and environment friendly building technologies in rural areas, primarily under the Chief Minister Rural Housing Mission. Water management and regeneration of water resources is a critical issue to be addressed both at the policy level and integrating water recharge structures at the construction level. Emissions from brick kilns need to be addressed by promotion of cleaner brick firing technologies and part replacement of conventional fuels with industrial wastes such as sponge iron dolochar. In order to regain severely eroded forest cover, forest management needs to be addressed and also linked to use of sustainably harvested timber in construction. The area of stone mining and polluting stone crushers is also significant for low carbon growth. In the face of imminent heat waves, passive design of buildings for cooler indoor conditions is a prime measure to move towards lesser electricity consumption for indoor cooling, particularly considering the growth and urbanization of small towns. Also, considering a preference for flat roofs, even in rural areas, building design and engineering needs to incorporate low carbon roofing techniques in place of conventional RCC.

1.4 Coastal region – Orissa

The coastal region in Orissa is characterized by high temperature and humidity and a high frequency of cyclones and floods of varying intensity, almost every year. The problem is exacerbated by the rise in maximum temperatures, with heat waves also being witnessed in the coastal belt. Apart from temperature, the major climate change impacts in this region are increase in sea level and shifts in rainfall patterns leading to floods and loss of subsistence resources. Being a mineral rich state is resulting in rapid industrialization with problems of uncontrolled mining, thinning of forest cover and soil degradation. Rural habitat in Orissa is largely built with unstabilized earth, stones and thatched or tiled roofs, which have very low resistance to the frequent cyclones and floods. With the rising number of thermal power plants in the state, there has been a surge in use of fly-ash bricks.

At the policy level, there is recognition of the potential of industrial waste materials like fly ash and blast furnace slag. There is also a move towards integrated development of the bamboo sector. Both at the policy and the design and construction level, structural safety of buildings against cyclones and floods are a top priority to avoid sudden large scale reconstruction measures which are a heavy draw on resources. Being a bauxite rich state, utilization of the waste ‘red mud’ for building material production has huge potential and needs a favourable policy support. This also needs to extend to other industrial wastes and their use in the building sector. A GHG inventory of major industrial clusters is also important for low carbon development. The design of buildings needs to take into account extreme heat which is becoming fairly common. Also, use of bamboo in structural application needs to be highlighted in the design practice.

2 Climate Change and Construction

The construction sector meets one of our basic needs i.e. habitat and shelter. Buildings are constructed to shelter people from the worst effects of weather and climate, mainly uncomfortably hot or cold temperatures, wind, precipitation and humidity. Building construction and operation activities have extensive direct and indirect impacts on the environment as the sector is very resource intensive. The resource footprint during sitting, construction and operation of buildings as well as during extraction and manufacture of building materials is enormous. The sector also contributes substantially to climate change through the large green house gas emissions.

On the other hand, the impacts of the changing climate are also keenly felt by the sector. As the climate changes there is a danger that current buildings in terms of design, location, use of building materials, and technology etc. may not be suitable keeping in mind the various impacts like rising sea levels, increased occurrence of severe weather events, increasing natural disasters, severe water shortages, etc. Also, building materials choices are important in sustainable design because of the extensive scope for impacting sustainability by reducing the embodied energy of the building materials during their extraction, processing, transportation, utilization, and even thereafter.

This section explores the links between climate change and construction globally and the implications at a regional level, focusing on small towns and rural spaces in South Asia. It also highlights the need for the study in developing a knowledge base and understanding impacts for future action.

2.1 Global Perspective

The construction sector worldwide currently accounts for more than 11 per cent of the global GDP and is expected to reach 13.2 per cent of world's GDP by 2020, growing by 67 per cent from the present $7.2 trillion to $12 trillion by 2020. As per estimates, seven countries – China, USA, India, Indonesia, Canada, Australia and Russia – will account for two thirds of growth in global construction to 2020[1]. South Asia[2] is the fastest growing region in the world after East Asia, with a growth rate of over 5 per cent per annum. As an emerging market and economy, there is an influx of investment in the infrastructure / construction sector. The strong economic growth, rising population and rapid urbanisation are key drivers for accelerated construction. In the larger economies of India and Pakistan, the sector is growing at over 9 per cent per annum. Though the current resource and carbon footprint of the region is not very large, the predicted, acceleration in construction activity will substantially contribute towards appending it.

The building and construction sector contributes up to one third of the global annual green house gas emissions. In absolute terms, the IPCC Fourth Assessment Report estimated building-related global GHG emissions to be around 8.6 million metric tons CO_2 equivalent in 2004. Buildings also consume over 40 per cent of all energy used and account for the largest share of natural resources used at 32 per cent, in terms of land use and material extraction. Given the massive growth in new construction especially in emerging economies and the inefficiencies of existing building stock worldwide, if nothing is done, greenhouse gas emissions from buildings are expected to more than double in the next 20 years[3]. Add to this, the increase in activity due to reconstruction processes to rehabilitate climate refugees –especially due to freak weather events - and the resource and carbon footprints of the industry sky rocket.

With its high climate vulnerability, South Asia has been assessed as one of the world hotspot for natural hazards. The region is already experiencing an array of climate change impacts,

[1] PwC, 2011. Global Construction 2020.
[2] The South Asian region includes the Indian subcontinent and the Maldives islands
[3] UNEP-SBCI, 2009. Buildings and Climate Change : Summary for Decision Makers

including glacial melt, forest fires, rising sea levels, floods, droughts, mountain and coastal soil erosion, landslides, windstorms, saline water intrusion, sea surges, and cyclones. Between 1990 and 2008, more than 750 million people—50 per cent of South Asia's population—were affected by at least one type of disaster, resulting in almost 230,000 deaths and about $45 billion in damages[4]. Floods account for over 50 per cent of the more than 900 disaster events reported in the region in the last 4 decades. Droughts though only account for 2 per cent of the total number of events, hit the most number of people; over 50 per cent of the total disaster-affected population. Bangladesh and Nepal experienced the highest number of disaster events. But due to its infrastructure density, India had the biggest share of damages —$26 billion or over 50 per cent of total damages for the region[5].

This is a region where the global responsibility for addressing climate change should be particularly stressed and one can clearly make a case for how countries that have contributed relatively so little to the causes driving climate change stand to lose so much from its adverse effects.

2.2 Indian Perspective

The construction sector is among the fastest growing sectors in India today, recording a growth of 156 per cent from 2000 to 2007 while providing emploment to 18 million people directly. It has been steadily contributing about 8 per cent to the national GDP[6] over the last 5 years. The current size of the construction industry in India is estimated at USD 70.8 billion[7].

The sector emits about 22 per cent of the total annual CO_2 emissions. 80 per cent of the construction sector emissions result mainly from the products / industrial processes the four energy intensive building materials i.e. steel, cement, bricks and lime. This impact is set to only increase with a housing shortage of about 40 million houses in the rural spaces alone, for the Twelfth Five Year Period of 2012-2017.

The National Housing Policy of India (1998) recognized the unsustainable consumption of natural resources like land, water, soil, energy, forests and minerals in construction. But due to lack of information and research in this field, no specific actions were taken to reduce or mitigate the damage. Also the huge existing capacity gaps have been a barrier to address these issues.

More recently, as a response to the global attention on climate change, the Indian Government in November 2009 ahead of the International Climate Summit in Copenhagen has announced to voluntarily reduce its emission intensity by 20-25 per cent on a purely domestic level between 2005 and 2020.The Twelfth Five Year Plan also focuses on achieving a low carbon inclusive growth[8].The National Action Plan for Climate Change (NAPCC), 2008 provides clarity on key measures required to achieve low carbon development[9]. The National Mission for Enhanced Energy Efficiency and National Mission for Sustainable Habitat propose solutions for buildings and urban infrastructure. A neglected aspect is climate proofing i.e. adaptation measures in the habitat sector against natural disasters at planning and design level. Another lacuna is the lack of attention towards the 70 million (population) strong rural spaces and small towns which are emerging as areas of high growth

[4] World Bank. 2009. Why is South Asia Vulnerable to Climate Change?
[5] Asian Development Bank 2010. Climate Change in South Asia: Strong Responses for Building a Sustainable Future
[6] At constant 2004-05 prices
[7] Source: Economic Times Data, Nov. 08
[8] Parikh K. 2011 Interim Report of the Expert Group on Low Carbon Strategies for Inclusive Growth, Planning Commission, Government of India
[9] Low-carbon development sometimes referred to as low carbon growth, broadly refers to efforts to decouple greenhouse gas (GHG) emissions from economic growth.

2.3 Need for Study

Climate risk has major potential impact on economic development; many of the measures that can be adopted to strengthen countries' and regions' resilience to those risks are themselves economic development measures[10]. Attention is now shifting towards a low carbon climate resilient development that looks at both mitigation measure against climate change and adaptation measure to deal with the impacts of the change. The movement towards a Low Carbon, Climate Resilient (LC-CR) development pathway is dependent on creating an enabling environment focusing on three key factors of knowledge (building a technology base), finance (devising innovative mechanisms) and policy (strengthening the institutional framework).

The contribution of the construction sector to climate change and its vulnerability to climate change impacts exposures ranging from physical infrastructure damage to occupant safety is well established. Building resilience and adaptability in terms of capacity of a building to continue to function and operate under acute conditions, such as extreme temperatures, sea level rises, natural disasters, etc with the optimum use of available natural resources is a great challenge. On the other hand, UNFCCC has identified the sector as being one of the cheapest avenues for mitigating climate change.

There is a need to identify the range and extent of climate change impacts on the construction sector and the gaps in the current development scenario to address these impacts. There is also a need to encourage long-term planning and policy in areas such as spatial planning to reduce vulnerability, which will require strong institutions, good governance and effective policy enforcement. The first step is creating a knowledge base. While concepts like energy efficiency, embodied energy, disaster risk reduction, resource efficiencies and carbon footprint are independently discussed at various fora, there is a need to integrate them into the planning and design of habitat structures. This study attempts to consolidate knowledge and identify gaps at the policy, planning, design and construction phases in a step towards low carbon climate resilient construction.

[10] Economics of Climate Adaptation Working Group, 2009. Shaping Climate-Resilient Development A Framework For Decision-Making

3 Research Methodology

This section presents the methodology followed in this research study to understand the links between climate change (impacts) and the construction sector as well as the adaptation and mitigation measures to address these impacts in rural and semi urban spaces in three selected geographical areas in India i.e. Coastal, semi-arid and wet hilly.

3.1 Research Questions

In order to do so the document attempts to answer the following questions

- In the context of predicted climate change impacts, what are the critical and vulnerable resources and issues in the construction sector in the selected regions?
- What are the criteria for selecting appropriate building materials and technology to move the construction sector towards a low carbon growth path?
- What are the key policy and technology gaps and barriers for low carbon climate resilient construction?
- What are the capacity gaps at key levels of policy, design and construction in the building sector to address the issues of low carbon construction?

3.2 Methodology

This research has been carried out with an emphasis on the three selected geographical regions in India i.e. coastal region, semi-arid region & wet-hilly region to identify the impacts of climate change and natural disasters on the construction sector at planning or policy level and design level as also the vulnerability of construction sector to the various impacts of climate change and natural disasters.

This study is essentially qualitative in approach. The research is based mainly on the literature review and secondary data collection from various sources. The overall approach of this research is aligned towards selection of appropriate planning measures, building materials and technology to demonstrate the integration of 'climate change' in to design, planning and construction practices in rural areas and small towns.

Four key building blocks of the construction sector i.e. Material, Technology, Design & Planning and Scale - have been considered for an in-depth study. These aspects have been studied against the backdrop of climate change impacts and the current growth scenario including current policy and resource status in each of the three zones. Once the impacts have been observed, a filter of LCCR potential will be used to identify critical issues and existing capacity gaps to eventually lead to the learning objectives of the 9 modules.

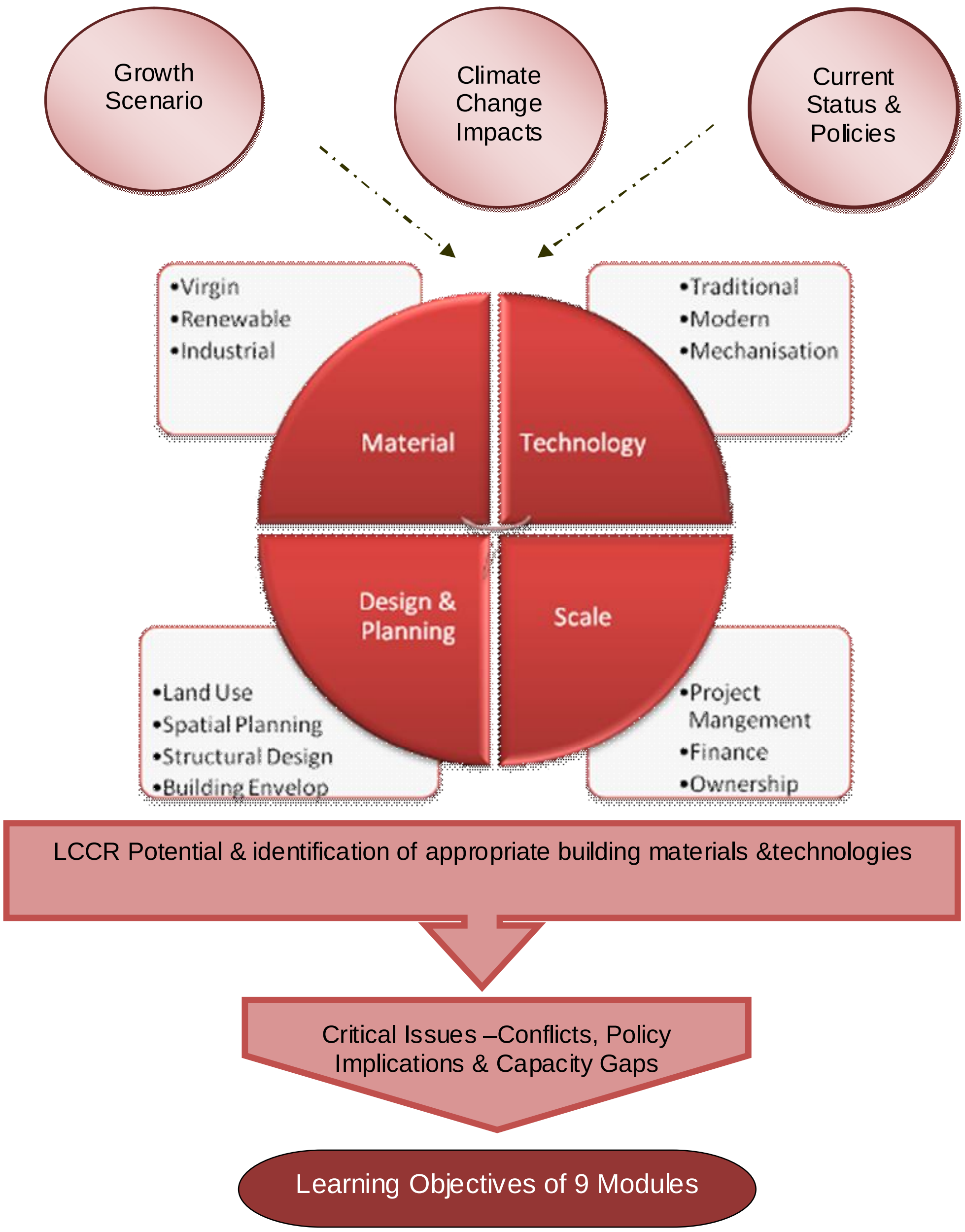

Figure 1 : Methodology Process Flow

3.3 Geographical Context

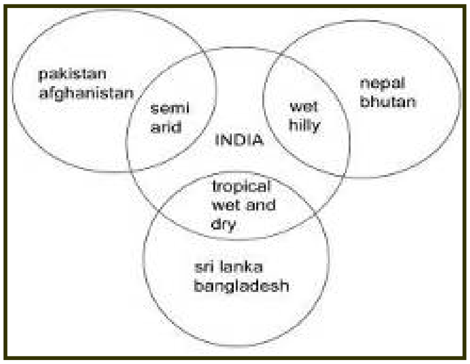

Figure 2 : India and its surrounding countries with similar climatic conditions

India is divided into 6 geoclimatic zones[11]. These regions in India face the same risks in terms of projected climate change impacts and threats to natural resources as those other South Asian countries due to similar socio-economic conditions in addition to common climatic and topographic characteristics. Three of these zones i.e. wet hilly, semi-arid and coastal have been selected such that the lessons leant in these areas can be widely replicated in the entire South Asian region.

These three zones are more vulnerable to direct and indirect impacts of climate change as the projected changes in climatic conditions are more dire and the stress on natural resources in these regions are much higher. In recent years, enormous pressures have been put on South Asia's ecosystems to support the ever-growing demand for natural resources. The most affected areas are coastal and marine ecosystems, forests and mountainous regions and the flora and fauna within them Projected sea level rise could flood the residence of millions of people living in the low lying areas of South, Southeast and East Asia such as in Viet Nam, Bangladesh, India and China[12]. Also in semi-arid and arid regions of Asia, grassland productivity is expected to decline by as much as 40 – 90 per cent combined with reduced precipitation, threatening to undermine food security[13].

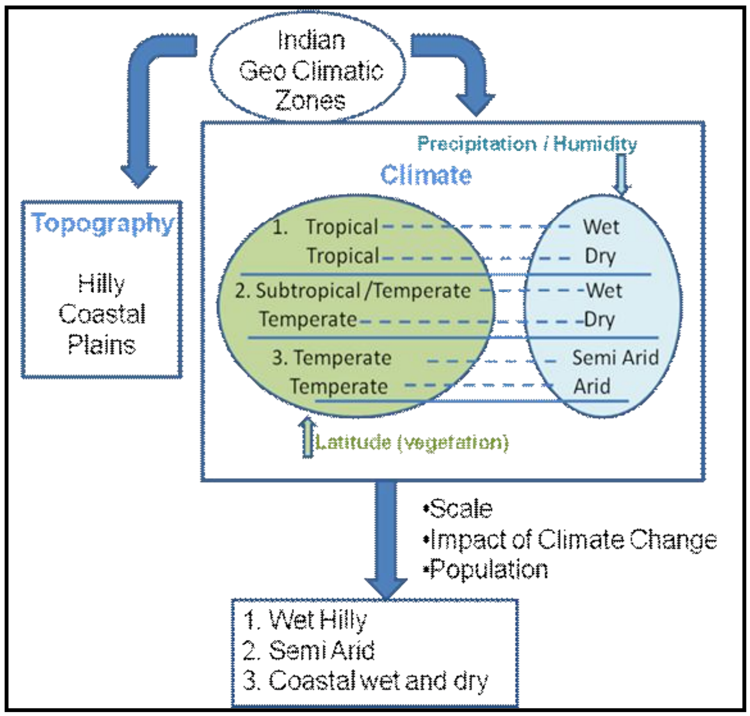

Figure 3 : Selection of Study area regions

In addition, water and air quality are deteriorating while continued increases in consumption and associated waste have contributed to the exponential growth in the region's existing environmental problems. Their vulnerability also increases because of having a much larger area and number of people residing in these areas. Based on these parameters the three states selected under these zones are

1. Wet Hilly region : Himachal Pradesh
2. Semi Arid Region : Madhya Pradesh
3. Coastal Region : Orissa

[11] A geoclimatic zone comprises of a topography factor and a climate factor
[12] Wassmann et al. 2004, Stern 2006,Cruz et al. 2007
[13] http://unfccc.int/resource/docs/publications/impacts.pdf

4 Study Area Profile

This section presents a profile of the three selected states – Himachal Pradesh, Madhya Pradesh and Orissa - that fall under the chosen geoclimatic zones of wet hilly, semi-arid and coastal respectively. It highlights the key project climate change impacts in the zones with a special focus on the natural resources. Traditional construction practices and changing trends are also touched upon for each of the zones.

4.1 Himachal Pradesh

The state of Himachal Pradesh (HP) is situated in western Himalayas and spread over a total area of 55,673 km^2 with an elevation ranging from about 350 m to 7000 m above the sea level. As per the Census of India - 2011, the total population of the state is 68,56,509 with a decadal population growth (2001-11) of 12.81 per cent and population density of 123 per km^2. being one of the most vulnerable ecosystems of the world, impacts of climate change are seriously felt in Himalayan regions. Also the lives of people in this region are closely intertwined with the natural resource base. Himachal Pradesh faces an urgent need to adapt to the expected impacts of this global phenomenon. These include threats from glacier retreat, extreme weather events, water stress, increased drought and floods, increased incidences of vector borne diseases[14].

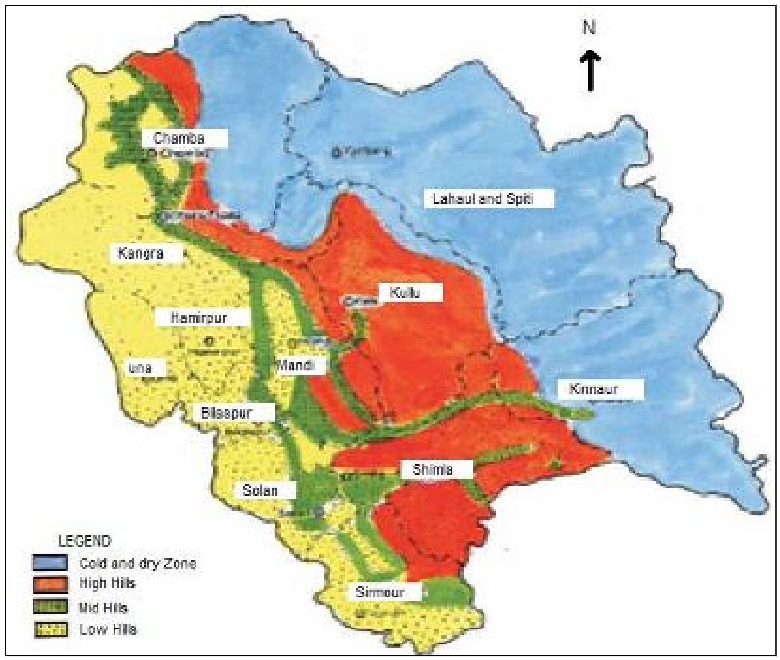

Figure 4: Agro-climatic zones of Himachal Pradesh

4.1.1 Climate

Himachal Pradesh falls under the wet hilly climatic zone. It exhibits considerable variation in the distribution of rainfall and temperature due to varying aspects and altitudes. Precipitation declines from west to east and south to north with an average rainfall of 1111 mm. An average 3 m of snow is experienced from December to March at elevations above 1800 m. Temperature decreases from west to east. Night temperatures in winters can fall to -3 to 4^{0}C. The relative humidity is usually high in the months of July, August and September varying between 76 to 95 per cent.

Figure 5 : Damage caused due to floods in Mandi district of HP, 2005

Climate Change Impacts

The major projected impacts of climate change in

[14] http://www.hpenvis.nic.in

Himachal Pradesh are increase in mean monthly air temperature, melting snow caps ,more intense precipitation events leading to increased mudslides, landslides, floods, diversion of water systems, soil erosion, surface water quality deterioration and a threat to the natural resources like forests. All these impacts have direct or indirect implications on construction industry in terms of availability of building resources, building damages due to disasters, reconstruction process, etc.

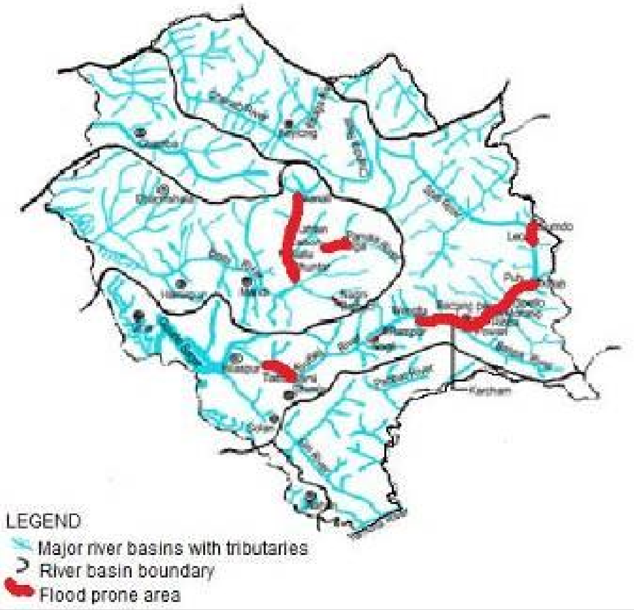

Figure 6: River basins and flood prone areas in HP

According to the International Centre for Integrated Mountain Development (ICIMOD), global warming in Himalayan region has been much greater than global average. The average temperature of the Shimla has increased by about 1^0C during last 100 years and the average snowfall in the state has decreased from 272.4 cm in the year 1979-80 to 72.20 cm in the year 2003-04[15]. The rainfall is projected to increase during the months of June to September which may lead to increased occurrence of floods and increased flow into the rivers and dams. The occurrence of the floods is going to have direct impact on the spatial planning/ land use planning in terms of location of buildings and also and the design of the buildings.

Natural hazards are a matter of immediate concern to Himachal Pradesh as every year the state experiences the fury of nature in various forms like cloudbursts, flash floods, landslides, snow avalanches, droughts, etc. Roads are repeatedly damaged, blocked or washed away. Huge amount of building damages have also been observed due to various natural hazards.

As per the State of Environment report, Himachal Pradesh, 2007, the damage potential of magnitude 8.0 on Richter scale to the housing in Kangra district has been worked out by referring to what happened in 1905 earthquake .The following scene has emerged:

- Completely collapsed houses – 136,000
- Partly destroyed and partly with large deep cracks – 263,000
- Without partial collapse but with large cracks – 916,000
- Those with small cracks, repairable with evacuation – 358,000
- Those with only fine cracks and no damage – 143,000

Floods are one of the most frequent natural disasters which the state experiences every year. Often flash floods caused due to cloudbursts, glacial lake outbursts and temporary blockade of the river channels have been also observed. As a result of breaches in embankments and damage to various utilities such as irrigation / flood control schemes and houses are also observed. A major flash flood in Kinnaur, Kullu, Mandi, Shimla and Sirmaur districts of Himachal Pradesh in June 2005 affected 31,598 Ha and caused damage to 837 houses[16].

[15] ENVIS Newsletter, 2008. Climate Change : Himachal Pradesh's Perspective.
[16] GoHP, Revenue Department, 2005

The hills and mountains of Himachal Pradesh suffer landslides during monsoons as well as high intensity earthquakes. Himachal Pradesh falls under the seismic zones IV and V with very high risk earthquakes of magnitude 8 and greater. Huge amount of building damages have been observed in last few decades due to earthquakes in this region. The vulnerability of Himalayan ranges, has been swiftly increasing in the recent decades due to inappropriate activities, such as deforestation, road cutting, terracing and changes in agriculture pattern requiring more intense watering and increased urbanization. Landslide prone areas should be avoided while locating new settlements or buildings and those which are already occupied should either be resettled or protective measures should be undertaken.

4.1.2 Natural Resources

Natural resources in Himachal Pradesh have a direct relationship with its physiographic conditions including relief, drainage, climate and geology which in turn influence availability of natural building materials, type of soils, vegetation, availability of water resources, etc.

Water Resources

These resources include glaciers, perennial streams draining in to rivers, water bodies including natural lakes and manmade reservoirs, innumerable water springs and large stocks of sub soil water. The state is drained by nine major river systems with the total catchment area of 55,673 Km^2.

Minerals

As per the land capability map of Himachal Pradesh, only 21.4 per cent of land is suitable for agriculture, 37.9 per cent of land is suitable for grazing and forestry and remaining 40.7 per cent of land is permanent snow covered as protection of water supplies[17]. This indicates that soil is a very critical resource in Himachal Pradesh and thus there is a need for alternative building material in place of clay bricks.

Limestone is the most heavily quarried (open cast mining causing substantial degradation of land) mineral of the state and provides raw material for the three major cement plants. The cement plants and extraction of lime stone in state has caused large scale destruction of natural resources and turned the green hills barren. In addition, cement plants have been availing complete tax holidays - Income-tax as well as Sales tax exemptions, causing loss of crores of rupees to the state exchequer.

As per the river bed mining policy for the state, about 47.3 km^2 (i.e. 0.085 per cent of the state) is involved in river / stream bed mining and approximately 35 lakh tonnes of sand, gravel and boulders are extracted annually from river/streams to meet the demand of road construction, bridges, building material, etc. A Pune based NGO working in Himachal Pradesh say that main reason in sudden change in rain pattern in Himachal is attributed to the reckless and unscientific mining and quarrying combined with construction of big power projects, cement plants, roads and buildings. The dust, smoke and silt coming out of these plants have also become heavy source of pollution. The study also reveals that because of environmental imbalances over 50,000 hectares of land has seriously been affected by mining and other construction activities. The large scale destruction of state's forest wealth by illegal and legal mining has resulted in severe drought and flash floods in past few years. (Sood.R, 2007).

Forests

Forests are very important natural resources in the state. As per environmental policy guidelines of the Department of Environment, Science and Technology, Government of Himachal Pradesh, of the total area of 55,6773 km^2, 66.43 per cent is legally defined as forest land[18]. Actually, of this 36.84 per cent of the area is pasture/alpine land or above tree line where

[17] National Bureau of Soil Survey and Land use Planning, Nagpur
[18] State of Environment Report, Himachal Pradesh, 2007

no conventional timber forest can generally be grown. Therefore, conventional forests can occupy only 29.5 per cent of this area. Out of this, only 22.49 per cent is under tree cover as against the 66 per cent defined under the National Forest Policy for forest cover in hilly areas. The Forest department has admitted that over a period of last one decade 9,00,000 trees were cut, out of which 6,00,000 were done legally and the rest illegally by various power projects, cement plants and likewise.

Timber is/was extensively used in the vernacular architecture in the region, as the forests of the deodar wood and other mixed forests were easily available. Deodar wood has been used traditionally to impart stability to tall structures. The walls of some of these structures are raised on the horizontal wooden frame work called Cheols.

4.1.3 Building Construction Practices

Himachal Pradesh has a rich tradition of vernacular architecture and building construction practise. The traditional dwelling has evolved over the ages and has been influenced by various factors such as climatic response to environment, cultural and social pattern, locally available construction materials etc.

Figure 7: Stone slate roofing

The building construction apart from the newer RCC framed building in larger towns, follows the traditional pattern of load bearing walls in burnt bricks, stone or sun dried clay blocks (adobe) with sloping roofs in high rainfall areas and flat roofs in the dry areas. The predominant materials used in the roof are thatch and reeds, tiles and shingle, metal and ac sheets roof along with the concrete slab roof at some places.

The tough weather conditions and limited supply of building materials has resulted the usage of mud, stone and wood in varying degrees. Similarly, the seismic proneness led the traditional building technologies to adopt implementation of building stiffness through framed construction in timber, tying roof and walls, distribute load through many building systems.

In some parts of Himachal Pradesh, there is a popular use of the Dhajji wall construction. In this construction system, the walls are made of timber frames with in-fills of light thin panels made by close packaging of mud mortar, stone and ballast. The traditional Dhajji wall (framed wall) construction mode of the region was subsequently improvised by the British for making their colonial edifices.

Spurred on by policy decisions, there has been some movement on constructing building based on principles of passive solar architecture especially in government buildings. More common among them are solar thermal collectors, greenhouse/solarium and trombe walls.

Figure 8: Traditional Dhajji wall construction in Himachal Pradesh

4.2 Madhya Pradesh

Madhya Pradesh is a resource deficient semi-arid region with the total geographical area of 3,08,144 km^2. As per 2011 census, the total population of Madhya Pradesh is 7,25,97,565 million with 75 per cent of population residing in rural areas and average population density of the state is 196 persons per km^2. This region is highly prone to acute water shortage and drought and there is a need for proper conservation of water and forest cover. Climate change provides challenges around both urban and rural fronts for development in Madhya Pradesh.

4.2.1 Climate

Madhya Pradesh lies in the 'composite' zone of India which characterizes most of the central Indian region. The intensity of solar radiation is very high in summer with diffuse radiation amounting to a small fraction of the total. Maximum heat gain takes place through the roof when the temperature peaks between 2 and 3 pm. The maximum daytime temperature in summers is in the range of 32 – 45 ^{0}C, and night time values are from 27 to 32 ^{0} C. In winter, the values are between 10 to 25 ^{0}C during the day and 4 to 10 ^{0}C at night. The relative humidity is about 20 – 25 per cent in dry periods and 55 – 95 per cent in wet periods. The region receives strong winds during monsoons from the south-east and dry cold winds from the north-east. In summer, the winds are hot and dusty.

Figure 9: Degraded land

Climate Change Impacts

The major projected impacts of climate change in Madhya Pradesh are higher maximum temperature, heat waves, shifts in rainfall pattern; leading to acute shortage of water resources, droughts, increased risk of forest fire, degraded soil cover, increased runoff in some river basins, water logging, etc. They may have direct or indirect implications on building industry in terms of availability of water, increased damage to building foundations due to ground shrinkage, etc.

There is no clear increase in temperatures in the state in recent years but the summary decadal trends in rainfall suggest below average rainfall trends[19]. The annual rainfall in the state has reduced from 1148.5 mm in 2003-04 to 416.17 mm in 2007-08[20]. The increasing demand for water for human consumption, agriculture, industries, coupled with recent decline in rainfall have led to supply problems. Betul, Datia, Dewas, Dhar, Jhabuva, Khandak, Khargaon, Shadol, Shahjapur, Sidhi, Ujjain districts of Madhya Pradesh are frequently affected by droughts[21].

4.2.2 Natural Resources

Water Resources

The state with 5 major river systems, viz. Narmada, Tapti, Mahanadi, Chambal and Indrāvati, has one of the best watersheds. Unfortunately, the unique wetlands are facing tremendous ecological stress primarily because they are visualized only as a source of water, ignoring their vitality as a holistic biotic system. Incidentally, some of the pockets of major mineral resources are located in the highly fragile origin points of our rivers of the country.

Minerals

Madhya Pradesh is one of the richest state in mineral resources. The exploitation of mineral resources is the economic backbone of the state as well as a major cause of environmental

[19] State of Environment report, Madhya Pradesh
[20] District Statistical handbook,2007
[21] http://saarc-sdmc.nic.in/pdf/drought

degradation in terms of loss of forest cover and cropland, accelerated erosion, silting of water bodies, air and water pollution etc.

Madhya Pradesh is a store house for black and multicoloured Granite in addition to Granodiorite, Syenite, Gabbro, Dolente, Pyroxenite and Peridotite which are available in Shahdol, Betul, Seoni, Balaghat, Chhatarpur, Tikamgarh, Datia, and Shivpuri districts. There are about 35 cutting and polishing Industries working in the state. Flagstone is one of the major building stones present in the state with deposits spread over Guna, Shivpuri, Datia, Tikamgarh, Vidisha, Rewa, Panna, Sagar, Chhatarpur and Neemuch district.

Limestone deposits are located in Jabalpur, Rewa, Satna, Mandsaur, Morena, Damon, Sidhi and Dhār districts. The major consumer of Limestone is in the cement industry, There are 7 major cement plants in the state with a total production capacity of 37.78 million tonnes[22]. This is 14.74 per cent of the national production making Madhya Pradesh the leading producer of cement in the country.

One alarming fact is the growth of stone crushers in Madhya Pradesh, which not only indiscriminately quarry and destroy the natural resource base, but also dump stone dust on good agricultural land, thereby rapidly converting it in to wasteland. The high suspended particulate matter (SPM) around these units is also a cause of concern for health and human well-being.

Forests

Forests are one of the most effective weapons in combating climate change. The trees and plants of the forests absorb huge amount of CO_2 and thus sequestrate CO_2 acting as carbon sinks. One acre of fairly dense forest can sequestrate one metric tonne of CO_2 in a year.

Though the recorded forest area of the state is 34.84 per cent of its total geographical area, as against 19.5 per cent for the country, the forest area has decreased at the rate of 473 km^2 per year from 1956 to 1994. Besides rapid degradation, the uneven distribution of forests in the state (Northern and Western parts have very poor forest cover) also calls for a rational forest management strategy. With the disappearance of vegetal cover aggravated by high winds, soil erosion set in and took a heavy toll of the rich top soil, converting forests and pasturelands of the state into wastelands, covering almost 16 per cent area[23].Extensive deforestation in the hilly regions of the state with consequent erosion of valuable top soil, is not only threatening the livelihood and security of inhabitants of these areas, but is also causing serious damage downstream.

4.2.3 Building Construction Practices

Buildings in Madhya Pradesh have been traditionally made by Stone and brick, because of abundance of natural stone and clay. However distinct architectural variation can be seen from region to region.

The foundation is usually made of random rubble which is abundantly available locally. The skill involved and the level of productivity is high in this area of building works. The walling again shows the application of random or ashlar rubble. However country made clamp fired bricks are used in equal amount at places where soil is less rocky and clay is available.

Figure 10: Extensive use of bricks in building construction

[22] 2000-2001

[23] State of environment report-Tikamgarh

Figure 11 : Traditional building in villages of Madhya Pradesh

In roofing, country tiles and sandstone on steel girders has been predominantly used. However, local village level clamp burnt bricks and tiles placed overlapping on wooden under structure is typically used to construct houses in least cost, but resulting in high embodied energy at the dwelling unit level. The durability of these roof structures is also marginal.

Majority of buildings in the rural areas are built in load-bearing construction techniques using bricks in lean cement or mud mortar and/or stone masonry, often laid dry. Within this structural system, arches are frequently used as spanning elements in many districts of Madhya Pradesh and in some cases for ornamental main entrances, wherever the skill level exists. The older bricks are being replaced with kiln bricks and the country tiles are giving way to flat roof structures using cement based roofing such as reinforced brick concrete and reinforced cement concrete.

Figure 12 : Semi-pucca house with composite mud and stone masonry wall and country tile roof

4.3 Orissa

Orissa is situated in the east coastal region of the country. Its geographical area is almost 4.74 per cent of India and its population is 36.7 million[24], about 3.57 per cent of India's population. Orissa's major challenges lie with threats associated with the waterfront. For more than a decade now, it has experienced contrasting extreme weather conditions: from heat waves to cyclones, from droughts to floods. In the last four years, calamities have claimed more than 30,000 lives. They have not only become more frequent, but have hit areas that were never considered vulnerable. A large number of disaster risks are inherent with being a coastal area with the advent of climate change. Orissa needs to manage its water resources efficiently and mitigate the disaster scenarios that it is threatened by.

4.3.1 Climate

The state has tropical climate, characterised by high temperature, high humidity, medium to high rainfall and short and mild winters. The normal rainfall of the state is 1451.2 mm. Floods, droughts and cyclones occur every year with varying intensity. In the past, the state's western region routinely experienced high temperatures and frequent droughts. In the recent decades, Orissa's climate has been changing for the worse owing to the combination of factors such as deforestation, extensive construction activities,

Figure 13 : Map showing the Agro-Climatic zones of Orissa (zones 3 and 4 represent the study areas)

[24] 2001 Census of India

uncontrolled mining, elimination of water bodies and extensive carbon consumption.

Climate Change Impacts

The mean daily maximum and minimum temperature of the state is gradually increasing. Weather department statistics indicate that while global mean temperature rose by 0.5 degree Celsius over the past 50 years, in Orissa it rose by 1 degree Celsius. In last 10 years, the highest recorded temperature average has increased by 4.4 to 6.6 degrees Celsius, and the average of the lowest recorded temperatures has decreased by 3-5.1 degrees Celsius in the various parts of the state[25]. Earlier western Orissa was a known calamity hotspot, but now the coastal areas are also experiencing heat waves. Bhubaneswar now has a mean maximum temperature above 40°C, which is comparable to Sambalpur located in the interior[26]. A heat wave in 1998 killed around 1500 people, mostly in coastal Orissa, a region otherwise known for its moderate temperature.

> Orissa has been declared disaster-affected for 95 years out of the last 105 years: floods have occurred for 50 years, droughts for 32, and cyclones have struck the state for 11 years. Since 1965, these calamities have not only become more frequent, they are striking areas that have never experienced such conditions before. The 1999 super cyclone affected places like Bhubaneswar and Nayagarh, which were never traditionally cyclone-prone. While the 2001 drought parched fields in coastal districts, the unprecedented floods of 2001 submerged 25 of the state's 30 districts. From 1901 to 1981 there were 380 cyclones, of which 272 resulted from depressions in the Bay of Bengal. 29 of these cyclones were devastating.
> *Source: www.infochangeindia.org*

The major impacts of climate change in coastal districts of Orissa are increase in sea water temperature, increase in sea level and shifts in rainfall pattern leading to increased flood risks, increased coastal erosion, changes in fresh water availability, salinisation and acidification of soil, storm flooding, loss of renewable and subsistence resources, etc. Trend analysis of climate change in Orissa suggests that six coastal districts namely Balasore, Bhadrak, Cuttack, Khurda, Puri and Nayagarh, interior districts of Mayurbhang and Kandhamal and possibly one western district of Kalahandi are expected to receive more rainfall, while all other districts would get less rainfall.

With sea level rise, many coastal systems in Orissa will experience increased levels of inundation and storm flooding, accelerated coastal erosion, seawater intrusion into fresh groundwater and encroachment of tidal waters into river systems. Floods have become an annual affair with the 2001 monsoon leading to the worst ever flood recorded in Orissa in the past century, as 25 of the 30 districts were inundated affecting one-third of the state's 30 million residents. Ironically, Orissa suffered one of its worst droughts in the same year. It affected the lives of 11 million people in more than two-thirds of the state's districts, engulfing earlier drought free districts like Sundergarh and Kendrapada.

Figure 14 : Damage caused due to cyclone in Orissa

The intensity and frequency of cyclones have gone up in coastal Orissa in the past century. In 1999, two cyclones hit the state in quick succession which devastated 14 out of 31 districts with a wind speed of 220 to 300km per hour and with a rainfall of 400mm to 867mm. This cyclone affected as many as 12.57 million people, 1.73 million hectares of agricultural

[25] www.infochangeindia.org/environment news/150-years-Orissa
[26] www.orissafactsheet.org

land and damaged 1.65 million houses, fully or partially[27]. A likely increase in sea surface temperature by 2-4°C will be accompanied by a corresponding 10-20 per cent increase in cyclone intensity[28].

4.3.2 Natural Resources

The rate at which mineral and water guzzling heavy industries are being pushed in the state; forest cover is thinning and soil degradation increasing. In mining and industrial districts like Raygada and Jharsuguda, agricultural land is shrinking.

Water Resources

With an annual rainfall that offers 23.46 mham (metre hectare metre) of water per year, 11 major rivers that have a total yield of 78190 million cusecs and a ground water potential of 23.279 lakh hectare meters, Orissa can rightly be described as opulent in water resources. But the water resources in the state are becoming polluted.

Minerals

In last 13 years (from 2011), severely degraded land in Orissa increased by 136 per cent, barren land by 69 per cent and land converted to non-agricultural use by 34 per cent[29]. Many parts of Orissa, specifically the western and southern uplands, are already displaying symptoms of desertification (process of loss of land productivity). Soil erosion due to forest degradation is the serious issue in the 52 per cent of the state's total geographical area.

Along with the states of Bihar and Madhya Pradesh, Orissa is one of the most mineralised states in India. The major minerals available in Orissa are Bauxite (in the form of laterite stone which is extensively used in the construction industry as a building material), Dolomite, graphite, sandstone and coal. Various rocks, which are quarried in Orissa, as dimension stones, include granite, marble, sandstone, limestone, slate, laterite and khondalite. Quarrying for dimension stones in the state is yet to cross the take off stage. A total number of 329 quarry leases have been granted in the state in Ganjam, Koraput, Kalahandi, Bolangir and Keonjhar districts of Orissa. Most of the stone quarries of the state are located in the areas where tribal population and forests have a big presence.

Forests

Orissa has a recorded forest area of 58,226.17 km^2 which occupies about 37.39 per cent of the state's geographical area. According to 'State Of Forests Reports', published by Forests and Environment Department, between 1986 and 2003 actual forest cover shrank by 4,797 km^2.

An overview of the annual revenue incurred from timber and fuel wood, varieties of NTFP[30]s (including Sal seed), bamboo, *kendu* leaf suggests that revenue earnings from timber has registered a sharp decline from 42.4 per cent in 1985-86 to 5.23 per cent of total forest revenue in 1999-2000[31].In recent years, the wasteful exploitation of such natural resources is posing potential danger to economy and environment, besides threats to livelihood and security of millions of forest-dependent poor .Of late, the fast depletion of forest resources both in terms of quality and quantity has begun to receive serious attention of development planners, policy makers and the government.

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27 Planning commission,, Government of India. 2002. Orissa Development report.
28 www.infochangeindia.org
29 www.infochangeindia.org/environment news/150-years-Orissa
30 Non Timber Forest Produce
31 State Development Report, Orissa

4.3.3 Building Construction Practices

A large number of houses at the village level in Orissa are found to be kutcha house (traditional term in India meant 'Raw' and for building meant 'Non-Stabilized Earthen') which have thatched and tiled roof. While a lower amount of semi-pucca; and pucca house also exists in these areas. The under structure for *kutcha* and semi *pucca* houses also uses bamboo in abundance because of its indigenous property and local availability.

Figure 15 : Thatched roofs in villages of Orissa

The semi pucca and pucca houses often use laterite in the foundation and in many places up to the plinth level. While there is the established trend of load bearing structures in semi pucca and pucca houses, the walling material used in these houses are usually country burnt red bricks. These days, there is surge in production of fly-ash bricks because of rising number of thermal power plants and so the availability of fly-ash.

However, at the same time it is important to note that in the coastal region probably due to ecological factors most houses in rural areas are kutcha thatched roof houses including quite a few of the well-to-do households of the village. In contrast, in the tribal districts, the rural poor prefer to go for kutcha tiled roof houses, as those are less vulnerable to fire during summer season. Also, there is little guarantee of the availability of thatched straw required for roofing of the house every year before the onset of the monsoon as these districts are frequently affected by the problem of drought and crop failures. The tribals make country tiles called khapar in Oriya on their own without depending upon the potters.

Figure 16 : Building construction using Laterite and sand stone in Bhubaneswar

5 Analysis

This section presents the critical issues in connection with the construction sector which can be inferred about the three geographical regions from the facts which have been presented in the previous chapter. Further, areas for capacity building across policy and design/planning levels in the three regions are also identified. At the third level of 'building artisans', the focus is on training in specific alternative materials and technologies, in accordance with the design and planning guidelines. Therefore, this level is not separately discussed in this section.

In spite of the stark differences in the regional scenarios of the three study areas, there are commonalities in the critical areas where capacities need to be built. Also, it is understood that capacity building across the three levels of policy, design and planning and artisans has to be complimentary in nature with the policy measures creating an enabling environment for action at the other two levels. These also form the criteria for deciding appropriate technology and policy measures for the selected regions depending on their context.

- Efficient management of natural resources – soil, water and forests (depending on the region), from the point of view of providing raw materials for construction with minimal environmental degradation
- Using low-carbon building materials to ensure a more judicious use of natural resources and energy-intensive materials like cement and steel
- Policy making and planning for resilience of buildings in the face of perceived threats from extreme weather events due to changing patterns of climate
- Utilization of regional industrial wastes in manufacture of building materials
- Integrating quality-upgrading features in traditional construction techniques of the region which invariably use natural raw materials by knowledge and skill enhancement
- Promotion of low carbon passive design measures to mitigate impacts of extreme temperatures due to projected climate change impacts

Across the three study regions, there is a need to build capacity at the policy level for assessing the 'carbon trajectory' of building practices in the region. There is a need to equip policy makers with a tool/ methodology, using measurable indicators, so that a carbon inventory for the region can be created and future scenarios understood in terms of carbon emissions emanating from the construction sector.

5.1 Himachal Pradesh

At the outset, it is significant that the state has created a conducive environment for low-carbon growth by targeting to become the first carbon-neutral state of India through the CLAP Programme (Community Led Assessment, Awareness, Advocacy and Action Programme for Environmental Improvement and Carbon Neutrality). In an attempt to conserve environment and reduce emissions connected with electricity generation, the State Government is actively encouraging renewable energy sources. The State Government is planning to bring out a Solar Energy Policy for speedier harnessing of this natural source to meet the ever increasing energy demand. Another significant move is to devise a 'passive solar housing' action plan as a means to promoting passive design to reduce pressure on conventional heating sources like fire wood, coal and electricity. Government buildings are seen as front-runners to incorporate and demonstrate the viability of passive solar features in buildings in the region. The state forest department has also recommended a separate 'Bamboo Policy' for the state, pertaining to the National Bamboo Mission. The forest area under bamboo cultivation is targeted to be densified and bamboo production is to be promoted as a lucrative business for farmers.

Policy Level Issues

- Sustainable forest management is one of the main aspects at the policy level. Forests are one of the chief natural resources of the state, with 30% of the area of the state comprising of conventional forests, from where timer can be harvested. Illegal felling of timber is a problem which worsens the already widening gaps between demand and supply of wood products. Sustainable management of forests, keeping in view the balance between harvesting and regeneration of timber is required. There is already an afforestation drive in the state to more than double the forest area – this is linked both to enlarging the carbon sink of the state and ensuring sustainable utilization of timber for various products related to construction.

- Further building up on the move towards a bamboo policy, there needs to be promotion of bamboo based building elements which can be a highly suitable for roof under structures and also composite construction techniques.
- In alignment with the 'Solar Passive' housing programme being promoted by the government, designs and construction techniques which makes buildings more energy efficient need to be propagated at a larger level. This is very important in a scenario where space heating is needed for almost 6 months in a year from October to March. This will also include solar-based technologies such as solar thermal water heaters to meet the hot water demand without excessive use of electricity or fuel-wood based options.
- The state has a large number of cement plants and the resultant extraction of limestone in the region has a large scale environmental impact, both in terms of the physical footprint at quarrying sites and the resultant carbon emissions and dust. Although, factors governing scale of cement production are beyond the scope of the project, a co-ordinated policy-level action plan which involves the cement industry to control emissions is important.

Design and Planning Level Issues

- As per trends observed in the Himalayan region, global warming has been much more appreciable in the region than the global average, with higher than normal rainfall projected in future. Therefore, occurrence of unpredictable floods becomes a probable hazard. This must be taken into account at the planning level/ land-use for adequately safe siting and structural design of buildings.
- The traditional architecture of Himachal Pradesh has largely given way to conventional RCC frame buildings with burnt brick masonry. Although it is impractical to reverse the trend completely, integration of traditional techniques into current building frames has great potential for low-carbon development. This issue is intricately connected to the planning of zones with respect to height of structures. Low-rise buildings typically use less high energy materials like steel and also allow for traditional techniques, for instance stone masonry, to be adopted.
- There is high potential for various techniques of earth-based construction, particularly the durable technique of Compressed Earth Blocks, to succeed in the region. These have been traditionally practiced in the region and are also more climate responsive than conventional brick masonry.
- In alignment with the policy support for sustainable availability of timber for construction, complimentary capacities need to be built-up in strengthening the use of timber frames and building elements in buildings, which has been a traditional feature. In the same vein, the use of bamboo based elements in building construction is also a suitable low-carbon alternative.
- In order to maximize the 'solar passive' advantage, the sloping roofs, predominantly constructed with metal sheets should be made more insulating. Also, integration of solar thermal collectors should be considered at the design stage. Passive techniques like the 'trombe wall' which has successfully been demonstrated in the Himalayan region should be actively considered for building envelopes.

5.2 Madhya Pradesh

The policy environment of the state is in the initial stages of creating an enabling structure for adoption of low carbon construction measures. The recently launched Mukhya Mantri Gramin Awas Mission (Chief Minister Rural Housing Mission) targets capacity building of artisans in the economically backward semi-arid Bundelkhand region of Madhya Pradesh towards sustainable building construction practices. The project is being implemented by Madhya Pradesh Rural Road Development Authority (MPRRDA) and aims to create model community buildings constructed with cost effective and environment friendly building technologies, in each district of the state. There has also been interest in evaluating the embodied energy and carbon intensity of building materials and practices.

Policy Level Issues

- The state has faced regular droughts in the last decade, made worse by the erratic patterns of rainfall. This has created a severe depletion of water resources and created significant water-stress. Regeneration of water sources in order to secure adequate water availability should be clearly addressed at the policy level.
- Since burnt clay bricks are the most common building material for wall construction in the state today, there needs to be a co-ordinated policy to ensure that 'clean' brick production measures are adopted by industry. This will certainly involve creating an inventory of emissions from the brick sector and setting targets for emissions reduction. Policies should focus on creating incentives for brick producers to reduce emissions through measures like more efficient kilns, partial replacement of primary fuels with industrial waste materials of high calorific value, etc.
- Over the last five decades, the state has lost a large share of its forest cover to indiscriminate deforestation, which combined with high winds has eroded top soil and converted forests to wastelands. The large number of wastelands today, needs a rational regeneration policy which, besides increasing the carbon sink of the state, also has the potential for providing natural building materials. The regeneration can also involve bamboo plantations which has a growth cycle to ensure availability of bamboo for habitat practices.
- Due to the stone resource distributed throughout the state, mining of stone for the construction sector takes place at a large scale and leaves a massive ecological footprint, generates waste and also adversely impacts the hydrological system. This mining activity needs to be regulated with an integrated policy which not addresses rate of extraction, but also restoration of mined areas and effective utilization of wastes generated by the activity.
- The alarming number of stone crushers in the state have not only contributed to rapid depletion of the stone resource base, but are also the cause of environmental pollution in the form of suspended particulate matter (SPM). The cleaning up of stone crushing to reduce pollution levels is critical. The stone dust generated by stone crushing is a viable alternative for coarse sand in construction activities and therefore must be adopted at a much wider scale in the construction sector.

Design and Planning Level Issues

- The main implication of climate extremities in the state is higher maximum temperatures and heat waves. In the business-as-usual scenario, the only counter measure which will emerge as a result will be increased use of electrical appliances to maintain indoor comfort. While this will have its own limitations like sustained availability of power, it becomes important in this scenario to introduce passive design measures in buildings which minimize the heat ingress into the building interior. This can be addressed through a combination of design measures including shading measures for the building envelope, increasing the thermal mass of walls and roof and, in particular, external treatments to exposed roofs which are the biggest source of indoor heat.
- Water harvesting/ recharging measures across the region are a critical measure to be adopted by the built environment in order to reverse the downward spiral of water related

stress. This can be done through simple, low-cost design measures which integrate water recharging measures into the building design stage itself.

- There is an increasing trend to favour flat roofs in place of traditionally used sloping roofs, predominantly in the rural areas. The most common method is sandstone slabs on steel girders which is highly energy intensive and can be structurally rationalized in favour of low carbon building systems. There is great potential to use a range of alternative 'pre-cast' roofing options which cut down the consumption of high-energy steel and can also be made with better quality control.
- Particularly for rural housing, the use of burnt brick based load-bearing construction needs to be strengthened at the design/engineering level. There is good potential to integrate rich traditional brick practices of the region with contemporary design needs and, in the process, also cut down on the use of high energy Reinforced Cement Concrete (RCC) structural frames for low-rise residential construction.

5.3 Orissa

Being one of the most mineral rich states of India, the state government has begun to take a strong view of promoting sustainable industrialization and sound environment management practices. The State Government is actively promoting investments in new cement plants based on blast furnace slag and fly ash, which would be available in abundance due to the large number of steel and power plants coming up in the state. The Orissa Climate Change Action Plan (OCCAP) aims to lead the state towards a carbon conscious, climate resilient development path, with industry being the major focus area. Fly ash and blast furnace slag based industries utilizing a minimum of 25 per cent by weight as base raw material are seen as priority sectors. In addition to identified priority sectors like Industry, the OCCAP addresses activities that have cross cutting relevance in terms of climate change. With respect to cleaner building material it specifically mentions promoting Green Buildings, using alternative building materials such as fly ash and improved fly ash management. However, Brick-making units (except units making refractory bricks and those making bricks from flyash, red mud and similar industrial waste), though not eligible for fiscal incentives as industrial units are eligible for investment facilitation, allotment of land under normal rules, recommendations to financial institutions for term loans and working capital & recommendation for power. This is a progressive change from the policy of 2001 where brick manufacturing units were excluded from all incentives and facilitation. The state government has also set up Orissa Bamboo Development Agency for integrated development of bamboo sector in alignment with the National Mission on Bamboo Application (NMBA)

Policy Level Issues

- It is well established that the major impact of climate change in coastal districts of Orissa are increase in sea level leading to an increase risk of flooding, shifts in rainfall patterns and imbalances in fresh water availability. As observed in earlier natural disasters in coastal Orissa, the massive reconstruction efforts create a sudden peak in demand of building materials and resources. Therefore, structural safety and resistance to conditions of over flooding should be built into any development which takes place in the coastal areas.
- Being a bauxite-rich state, alumina extraction is a prime industrial activity in the state which produces large amounts of waste red-mud. Red mud is a recognized environmental hazard, yet it is also a material which can be used as an ingredient in brick production. Red-mud based bricks have been certified by the apex body Building Materials and Technology Promotion Council (BMTPC). There is an urgent need for policy level push towards the utilization of this industrial waste for building material production.
- In addition to red mud, there must be a favourable policy environment which promotes recovery and utilization of other plentiful industrial waste materials such as fly ash, blast furnace slag, sponge iron waste which can be an alternative fuel in burnt clay brick making, etc. An inventory of industrial wastes which can be used in building material production

must be made and given top priority in terms of promoting environment friendly and low-carbon building materials.

- Orissa also has a good bamboo resource distributed throughout the state which is 9% of the total bamboo forest cover in the country. In co-ordination with the Orissa Bamboo Development Agency, there needs to be a policy level recognition to this resource for its tremendous potential in the construction sector in the form of bamboo composite boards, roof under-structure for sloping roofs, stilted construction in flood prone areas, etc.
- Assessing GHG profiles of major industrial clusters (including bricks) is required to understand the carbon trajectory of the industry as well of the application of these products i.e. buildings.
- Given the threats that climate change impacts pose today, there is a need to mainstream these concerns into policies. Institutional realignment of the policy framework so that Industrial Policies integrate climate change considerations is required.

Design and Planning Level Issues

- Structural safety of buildings to withstand the increased intensity and frequency of freak storm events is paramount. Disaster resistant structural aspects need to be strongly integrated into the design practice, including low carbon options besides conventional RCC forms. Attention needs to be paid to zoning regulations which ensure appropriate siting of buildings.
- The design of buildings in the coastal areas needs to take into account not only threats of flooding but also of moderating extreme temperatures which have been become increasingly common in the last decade, as shown by the gradual incremental trend of rising maximum temperatures. So, for a low-carbon future scenario, there is a need to include resistance to heat as a performance standard for building design and construction.
- There needs to be much higher level of awareness and acceptance about the potential of industrial waste materials to be utilized in building materials, particularly bricks/ blocks for wall construction. The structural properties of these waste based materials must be properly understood so that their use in building construction can be regularized.
- In co-ordination with the Orissa Bamboo Development Agency, there needs to be an integration of bamboo-derived building materials and techniques in the conventional building design and engineering practice.

6 Learning Objectives

This section elaborates the learning objectives which will be addressed by the training programmes to be conducted in the 3 study areas. At the conceptual level, the guiding principles of the training programmes at the three levels are –

Policy Makers	How to integrate climate change and the associated implications into planning for built environment in alignment with low-carbon development
Building Professionals	How to respond to the climate related extremities through appropriate building design and choice of materials and technologies
Building Artisans	How to construct buildings using low carbon and climate resilient building materials and technologies

In accordance with the above guiding principles, the learning objectives of the training programmes are elaborated below

6.1 Policy Makers

- Understanding the regional activities which contribute to climate change and practical implications/ tangible threats of climate change in the given geo-climatic context.
- Recognizing the existing gaps at the policy level which need to be addressed in the context of climate change and low-carbon construction.
- Assessing the 'carbon trajectory' of building practices in the region – this will be done through a tool/ methodology, using measurable indicators, so that a carbon inventory for the region can be created and future scenarios can be understood in terms of carbon emissions emanating from the construction sector.
- Understanding the importance of and planning for sustainable management of natural resources which are exploited by the construction sector. The linkage of this factor with the requisite research and development agencies in the region should also be clearly understood.
- Creating an inventory of industrial and agro-waste generated in the region and gaining knowledge about its potential utilization in the production of building materials.
- Understanding the convergence/ integration that needs to be achieved between the various departments, schemes and programmes/ policies in order to effectively be on the 'low-carbon' path in the construction sector.
- Study of best practices in the construction/ habitat sector which can potentially mitigate the impact of climate change or can be useful as adaptive measures.
- Applying the above knowledge and understanding to an exercise (to be undertaken in the training programme) of making a district level development plan and identifying the corresponding action points for the construction sector.

6.2 Building Professionals

- Understanding the various activities in the construction sector and their impact on/ relation to their 'carbon emissions' footprint and their ability to withstand climatic extremities through deign and construction measures.

- Being aware of a methodology to quantify the 'carbon' effects of the choices for building design and construction applications in order to identify low-carbon and climate resilient design and construction technologies.
- Being aware of the various government departments/ schemes/ policy initiatives which can be conducive to low-carbon development in the design and construction sector.
- Being equipped with the general direction/ resources to enable realization of low-carbon and climate resilient built environment.
- Understanding a selected few design and construction measures that can be taken in the context of their own geo-climatic environment and be aware of the potential resources that can be tapped in order to apply them in their work.
- Being aware of the options available for utilizing industrial waste in their building material options and understanding the practical implications of their application in the building sector.
- Applying their understanding to design and planning approaches to be selected for their regional conditions in a workshop mode with other stakeholders from the building sector.

6.3 Building Artisans

- Understanding/ sharing the various building materials and construction techniques which are prevalent in their context and their relevance/ limitations/ possible improvement.
- basic understanding of the impacts of their choices for building materials and techniques and of the potential benefits in the form of their skill enhancement in techniques which are benevolent to the environment.
- Learning the practical application skills to undertake construction of buildings which use low-carbon building materials/ techniques in an actual scale – this would also include the financial estimates for the materials/techniques.
- Learning how their existing practices can incorporate features which make the buildings climate resilient and low-carbon.
- Being aware of the options available for utilizing industrial waste in building materials and their application in building construction.