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Urban landscape challenges and mitigation proposal for Metropolitan city

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Abstract - -*Urban landscapes are constantly undergoing transformation on account of exponential population growth, hence land use pattern. The world at large has indiscriminately exploited natural resources and has placed a tremendous strain on the environment. The depleting natural resources and environmental pollution is warming the earth, raising sea levels, and endangering our biodiversity. According to the United Nations, cities consume two thirds of global energy use.76% of the world's energy-related carbon dioxide (CO2) are also emitted by cities through transport, industry, and building and construction related activities. The metropolitan city of Guwahati, Assam, is the gateway to North-East India is one such case characterized by a phenomenal urbanization in last few years. There are apparent thermal environment fluctuations and environmental degradation in this city causing loss of biodiversity and climate change and greater damage due to disasters. A prevalent situation such as this poses both challenges and opportunity for the architects in particular and the construction industry as a whole. It is vital to look into realistic measures to diminish the impact of our built forms in urban landscape, and make them further resource and energy efficient. As climate alteration and resource limitation become glaringly apparent, it is must for a proposal to adapt and respond to this situation with comprehensive measures. Most people consider Green Agenda as merely something that is in vogue. This research will review the existing Green measures and suggest proposal for the city of Guwahati.*

***Key Words*: Energy; Green buildings; Urban landscape; Passive Design; Urban heat island effect; Disaster**

1. INTRODUCTION

Guwahati is the South-eastern part of Kamrup District situated between 25.43 and 26.51 North Latitude and between 90.36 and 92.12 East Longitude. Located on the banks of the Brahmaputra River, it is the largest commercial, industrial and educational centre of the N-E region. The city is situated on an undulating plains with Southern and Eastern sides of the city surrounded by hillocks, the terrain also boasts of swamps, marshes, water bodies like Deepor Beel, Silpukhuri, Dighali Pukhuri, etc [2].The total population of Guwahati UA/Metropolitan region is 968, 549. As per the data released by Govt. of India for Census 2011, Guwahati is an Urban Agglomeration coming under the category of Class I UAs/Towns. A survey conducted by a UK media outlet, shows Guwahati as the 100 fastest growing cities of the world, and is the 5th fastest growing among Indian cities.

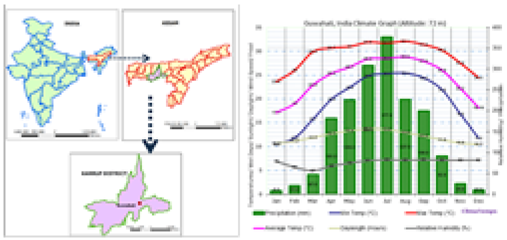

Fig-1.Location map and climate details of Guwahati (Source: Internet)

It is the largest city in the North-East Region and along with being educational and commercial hub. Urbanisation has caused total landscape transformation of the city which is already susceptible to many natural disasters such as earthquakes, flooding and landslides.

The climate of the state is characterized by a warm and humid feeling. As the tropic of cancer runs through the state, the climate is temperate but pleasant. The monsoon brings heavy rains to Guwahati. The average temperature is 31.5°C to 24.7°C in summers and 24.9°C to 12.5°C in winters. The city has four well-defined seasons, summer, monsoon, winter and spring. Winter season is from October to March and spring starts from April and this is the best time to visit Guwahati. A mild and moderate climate never given to extreme cold or heat is the main feature of Guwahati's climate. [2]

1.1 Repercussions of Urbanization

Urbanization and rural-urban migration are having a severe impact on land use patterns and energy consumption in growing cities like Guwahati. Rampant construction and indiscriminate land acquisition for residential and commercial units have become a trend. The rapid rate of urbanization has its effect on the vegetation cover, thus led to depletion of green belts on the city periphery hillocks, altering the character of eco sensitive land. Rapid population growth, high migration rates and change in land use pattern of the city due to uncontrolled development activities have harmed the ecology and environment of the city. Illegal construction on hills has been one of the major causes for landslides and threat to this city with high seismic activity.

The erratic climate behavior due climate change has leads to increase in event of flooding and landslides.

1.2 Demographic Impact

Guwahati city has experienced considerable population growth in the past few decades although the decadal growth rate seems to have a declining trend over the years. The population of Guwahati city including the urban agglomeration decadal growth of 18.29% from 8,18,809 in 2001 to 9, 68, 549 in 2011. 10% of the population in 2011 falls in the age group of 0 to 6 as compared to the national average of 13.12% and the state average of 14.47%.Besides the main population residing in the city, 10% is floating population which comes for daytime activities [1].Migration has been a continuous phenomenon for this city in the past few decades. Economic opportunities, social and political reasons mainly govern migration of people to the city. Better urban services as compared to rural areas such as educational and medical facilities, greater employment opportunities due to growth of industries and other secondary & tertiary sectors leading to migration. This has caused illegal settlements with encroachments on hills or fragile lands. The recent increase in slum areas is an indication of increased migration in Guwahati [2].

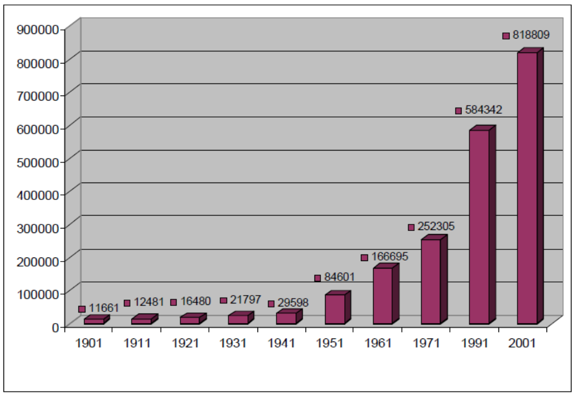

Chart -1 .Population data from 1901-2001(Source: Census of India and Guwahati Municipal Corporation)

1.3 Environmental impact

The climate parameters such as temperature and rainfall have shown fluctuations and erratic behaviour over the past few decades increasing the occurrence of disasters. Data for the past 14 years (1997-2011) obtained from the Regional Meteorological Centre, Guwahati shows that both maximum and minimum temperature are increasing in the city. The extreme temperature values as seen from the 14 year data (TERI) has recorded as high as 40oC (Tmax) in 1999 and as low as 6.4oC (Tmin) in 2007.

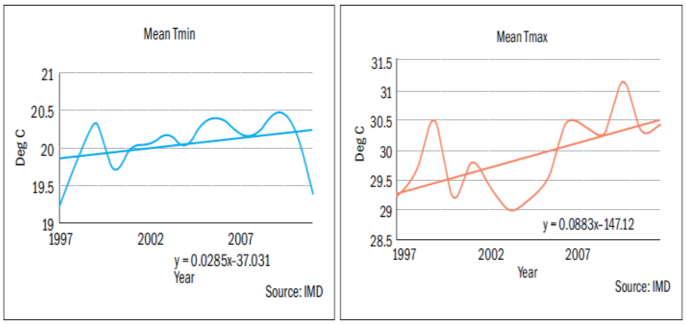

Chart -2. Temperature fluctuations (Source: Indian Metrological Department and TERI)

The daily rainfall data from Indian Meteorological Department Regional Meteorological Office, Guwahati from 1982-2011 was averaged to get monthly values. The data was analysed for the monsoon months as well as for the entire year. A decreasing trend of seasonal as well as annual rainfall over the city is seen. It was also observed that although there has been a decreasing trend in the overall seasonal rainfall as compared to the long term average but there has also been an increase in extreme rainfall events resulting in more rainfall in short duration. This can be one of the attributing factors for urban flooding.

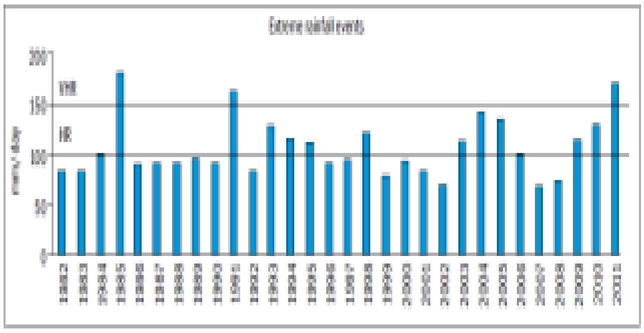

Chart -3. Rainfall Data (Source: TERI)

1.4 Impact on Natural /Manmade Disasters

Flooding events have become quite common in Guwahati in past few years and considered to be a typical situation of manmade hazard, characterized by urban flooding. This is due to a number of issues like lack of drainage, unmanaged solid waste, reclamation of low lying lands and unchecked/ unplanned urban growth, hill cutting, etc. Another reason is the increased intensity of rainfall occurring in a very short duration According to the city assessment report5, backflow of the water from the River Brahmaputra, due to blockage in the drainage system through Bharalu, Khanajan and Bondajan, causes floods frequently every monsoon. The river is at a higher level than the level of the drains leading to the retarded outlet of the water (Master Plan) Also, there is heavy siltation and dumping of garbage in rivers

As per Disaster Management data of Assam , landslides are a frequent phenomenon in Guwahati because of flooding and the soil characteristics. The increasing frequency of landslides in past few decades have become a concern for the city especially around the low lying hills. Encroachment and growth in settlements on these hills has caused slope modification thereby making them more vulnerable. The degree of risk to the city due to climate change can be found directly proportional to the current situation of the erratic and unplanned urban systems like services, infrastructure, housing and land use planning.

Assam lies in the eastern-most projection of the Indian Plate, where the plate is thrusting underneath the Eurasian Plate creating a subduction zone and the Himalayas. Thus the state of Assam fall under the seismic zone V making the entire State prone to earthquake of moderate to very high intensity. The State has experienced two major earthquakes in the year 1897 and 1950. The intensities of these two earthquakes were 8.7 and 8.5 on the Richter scales respectively. Between 1920 and 1980 as many as 455 earthquakes 15 of magnitude 5 on the Richter scale were recorded in the region, an average of 8 per year Combined with earthquakes, the vulnerability profile of the city is further threatened by haphazard and uncontrolled growth .Huge urban population combined with poor quality and ill-maintained infrastructure, low quality building stock, and lower resilience of the high–density society increases the risks to earthquakes in the urban centres. Moreover, urban infrastructure is often designed and constructed without satisfying minimum safety.

1.5 Impact on Energy demand

The demand of primary energy is expected to grow due to sustained economic growth with the increase in building, transportation and industrial sectors. The energy consumption due to growing demand for floor space, to accommodate urban migration is expected to increase. The increase in energy intensity per unit area of floor, combined with an increase in floor area, has placed heightened pressure on energy demand for buildings. Major part of the energy used in residential buildings is consumed for space heating, cooling and lighting .Table I shows that domestic consumption of electricity is the largest.

Table -1: Sector wise electricity consumption (in MU) for 2009-10

Sector	MU
Domestic	274.77
Commercial	173.06
Industrial	145.70
Public Lighting	2.74
Agriculture	0.12
Others	91.71
TOTAL	**688.10**

2. PROPOSAL FOR BUILDING DESIGN

Urbanization is a phenomenon which is inevitable part of economic and demographic progression. For city like Guwahati which is not only growing at an unprecedented pace but also is a disaster prone area, the built forms and settlement design should be in consonance with safety codes and green agenda. For utilization of solar energy passively, the has to designer shape urban blocks and open spaces to Human thermal comfort with respect to Air temperature, Radiant temperature, Air speed, Humidity, Metabolic rate and Clothing insulation. The warm and humid climate of Guwahati is characterized by haze which is a source sky glare is due to the moisture in the air. The landscape has typical rich vegetation patterns which can be used in ways to improve the thermal comfort .As land surface does not heat up due to shading, it has to be organized so as to not obstruct air movement and circulation. The temperature difference between day and night is minimal. The designer has to adopt measures which avoid heat absorption and heat storage. The use of low thermal mass and highly reflective outer surfaces structures are useful. However, by efficient design the indoor temperature can be kept remain relatively cool. Natural air movements to be tapped to provide evaporative cooling and enhance comfort levels so that the use of mechanical devices is reduced considerably and energy efficiency is achieved. Also use of sun to generate energy for individual unit can reduce dependency on the central supply of non-renewable energy. The following steps recommended for as a mitigation proposal.

2.1 Housing

In Warm and Humid climates such as that of Guwahati, shape and orientation are essential aspect in curtailing solar heat gains. The massing can provide shade to itself or other blocks to further diminish solar heat gains. Solar heat gains increase radiant temperatures thus making interiors warm as well. The orientation of a building influences the level of solar radiation which receive on the buildings' façade directly as well as shading and the performance of solar envelope (Chwieduk and Bogdanska, 2004; Mingfang, 2002). The best form for minimizing solar gains is by elongating the north and south walls, creating a major east-west axis. Eastern and western exposures and glazing to be minimized, as shading is complex for longer periods of direct radiation because of the low sun, and may require special devices. Southern and northern exposures can be shaded by roof overhangs and chajja. A variation of 15 to 20 degrees from true south is satisfactory with respect to thermal performance of small buildings.

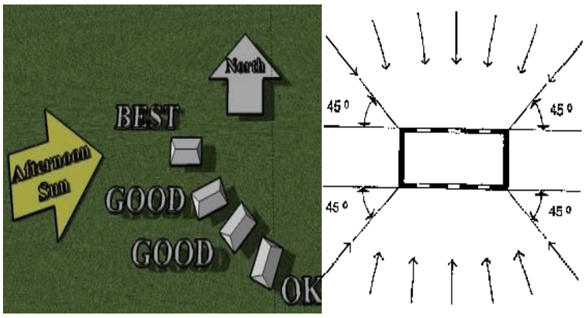

Fig-2. Orientation of built form for good ventilation and reducing solar heat gain

There are a lot of benefits of optimal building orientation (Pacheco, 2012) enhances energy consumption of the building, provides appropriate daylight and reduces the energy consumption for artificial light. It also creates potential for additional savings from more complex passive solar techniques and increases the performance of solar collectors. Finally is an inexpensive technique which could be applied in the initial steps of building design

Constructions with a high thermal mass and a long time lag are to be avoided because it would result in undesirable re-radiation of heat at night. Walls, both external and internal, should have minimal heat storage capacity. The design and location of walls not to obstruct the airflow and reflect radiation, where solar radiation strikes the outer surfaces by making it light coloured. Shade the walls and use light and thin materials such as timber or, even better, bamboo matting are recommended for walls and partition.

For Guwahati's warm-humid climate the roof is recommended to be preferably pitched to allow heavy rains to run off with large overhangs protect the walls and openings from radiation and precipitation. As direct radiation strikes the roof surface it should be insulated along with reflective like the white roof with light (white) colour or materials such as broken white tiles etc. The intense diffuse solar radiation calls for buildings that have large overhanging roofs and wide shaded verandahs with screens, lattices, grills.

The high humidity and warm temperatures in for Guwahati climate necessitate maximum natural ventilation. Natural ventilation refers to air movements that takes place across or within buildings devoid of the aid of any mechanically devices such as fan or air conditioning. Large openings, not only in the external walls but also in the internal partitions for free passage of air for cross-ventilation through the interior. A more efficient solution is that of single-banked rooms with access from open verandahs or galleries. The wind direction is mainly northwest to southeast, and long-side of buildings should be arranged across this direction. When not possible to orient the building for best ventilation then the wind can be diverted by vegetation design and structural elements, such as parapet, walls, and fins. Whenever conflict between optimal solar orientation and wind orientation, solar considerations are given importance.

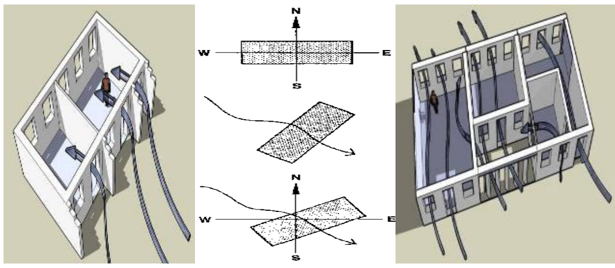

Fig-3. Optimization of the orientation and wing walls to direct wind

In warm humid areas windows should be large and fully open able, with inlets of a similar size on both sides of the room allowing a proper cross-ventilation. Door shutters also incorporate louvers or grills. Windows should be at both windward and leeward walls. It is a good precedent to have windows on the adjacent walls for good ventilation with building side perpendicular to the wind but a tilt of 20 to 30 degrees from perpendicular will not weaken interior ventilation. As per experiments conducted the wind at an incidence angle of 45 degrees reduces when the interior velocities to be 15-20 percent lower than when wind perpendicular to the inlet. When the windows are on opposite walls, a 45-degree incidence angle gives the maximum average indoor air velocity and better distribution of indoor air. For windows only on one side of the wall, vertical projections called as wing walls can create artificial pressure and suction zones for improving ventilation on the windward side of the building. Unequal inlet and outlet sizes can induce higher air velocities. Casement windows allow for larger opening size are better than Sliding windows louvered windows and pivot windows as they reduce the opening sizes. The use of glass for windows and openings will need sunshades for in reducing heat gain, reduce solar glare, provide rain protection for opening windows, and to serve as part of a maintenance strategy. Shading devices should be much larger to provide great coverage, obstructing most of options from the conventional horizontal, vertical, or egg crate projections, and more advanced technique are Automated (linked to daylight sensors and/or sun tracking systems) shading devices should be exploited and selected as best suited to design and budget .

In Residential Design the arrangement of rooms depends on their function and thus orientation. The rooms on the east side are warm in the morning and with less thermal mass, cool down in the afternoon. Rooms on the west side are cooler in the morning and heat up in the afternoon. Rooms facing north and south remain relatively cool if provided with adequate shading. Thus, the layout of the rooms if designed with function and in relation to the time of the day they are in use, the energy requirement will reduce.

It is important to take advantage of natural daylight for indoor spaces while minimizing solar heat gains so as to reduce the need for artificial lighting thus energy saving. Use of window openings at appropriate heights, skylights and/or atrium spaces, minimizing floor plate depth are all effective strategies that can maximize daylight by, to bring natural daylight into spaces. In general, clerestory lighting (indirect light) is better than providing skylights since glare and solar heat gains are reduced. Daylight glazing is most effective above 2,100 mm and enables natural light to penetrate deeper into spaces. Vision glazing is typically applied between 750 mm and 2,100 mm to accommodate sitting and standing occupants. Least use of full glazing saves in material cost and reduces amount of solar radiation entering into the space through the glass

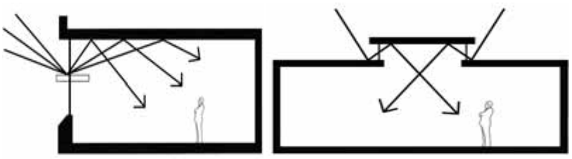

Fig-4. Glazing for day lighting Optimization

The principles of maximum shading and ventilation is needed for outdoor space. Tall shading trees and reduced ground vegetation are important elements.

External ground greenery is the most effective strategy to protect against heat build-up and control ambient temperatures at a macro level. External landscaping at ground level may be in the form of trees, palms, shrubs and turfing. The landscaping with water bodies such as fountains as a mean to add 'blue architecture' to the overall 'green' effect of the development.

Use of green roofs as it provides thermal insulation and also is habitable space for people and animals, thereby promoting biodiversity. These also help to slow storm water runoff and improve its quality.

Tall buildings with large the facade area are becoming a necessity to meet the need of growing population. Vertical landscaping on the external walls will reduces heat transmission into the building, promotes flora and fauna if installed on the east and west facades and protects the facade from weathering and forms aesthetic feature wall. This cover functions as a second skin which provides:

- Protection against solar radiant heat,
- Cooling by a ventilated space between green cover and wall or roof,
- Reduction of glare and reduction of noise, by sound absorption,
- Reduction of dust, by filtering the air,
- Stabilization of the microclimate,
- Protection of the wall and roof surfaces from wind and driving rain

3. Proposal for Neighbourhood Planning

The conscious design of urban forms and external associated space is necessary for a settlement pattern at neighbourhood level to response to Guwahati type of environment and disaster management

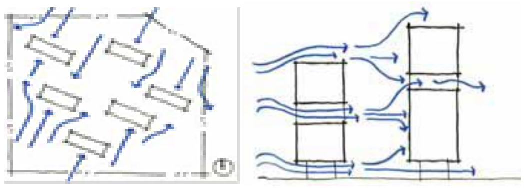

Fig-5. Building layout and design for ventilation Optimization

Good natural ventilation depends on the macro-environment adopting strategies at neighbourhood level such as:

Construction preferred on sloping sites of hillocks near the crest of the hill and on the windward side.

For Creating flow paths the open spaces should be linked and plazas to be created at road junctions.

Buildings should be laid out in rows with the lower heights in front and towards the direction of the prevailing wind to create better wind flows

For sufficient air circulation, buildings should be scattered and staggered with sufficient free spaces between them. This allows airflow which provides ventilation for cooling. Buildings must be spaced to allow winds to reach the ventilation openings along with the terrain, surrounding vegetation, and other nearby structures may be designed to "channel" or redirect wind into the building

Floods are common in lowland locations and building preferably raised on stilts (disastrous for earthquakes but good for passive design). This also allows air to move unobstructed.

Buildings should be as permeable as possible to channel airflow to the blocks in the back row and tall buildings to have spatial arrangement of built form is necessary to increase stagnant air movement to improved air flow. This can be done with elevation configurations that allow air to flow by creating voids in the built form at different levels. The arrangement of the blocks should be staggered such that the blocks behind are able to receive the wind penetrating through the gaps between the blocks in the front row.

The existing green space in and around the city should be interconnected and integrated to form a complete green infrastructure.

The layout of streets at neighbourhood level should have public spaces, streets, squares and footpaths protected from sun and rain. Squares and passages should be covered, without impeding cross-ventilation. Street spaces should be long and straight to facilitate air movement and lined by high, shade-providing trees. Certain species of trees (e.g. rain trees) create a canopy effect. They should be planted at a close distance so that the crowns form a wide hall-like space, creating a comfortable microclimate.

An unshaded pavement exposed to the sun heats up and can reach very high temperatures. A vegetal cover of the ground keeps the environs comparatively cool and contributes to a cooler outdoor microclimate. The greenery absorbs heat and cools the area through evapotranspiration. It provides pleasure from an aesthetic sense and will have direct benefits in reducing energy consumption and sizeable amounts of carbon emission. Encourage planting edible plants to form part of the greenery (urban agriculture). This can increase the amount of fresh vegetables and fruits available to people living in cities. Larger benefit exist for the community such as the creation of small businesses that can be owned and operated by the community to sell home-grown vegetables and fruits.

Buildings should be placed preferably on southern or northern slopes, ideally facing away from the equator as east and west slopes receive more radiation compared to north and south slopes.

Built-up areas cause local temperatures to rise due to surface absorption and radiation of solar heat, resulting in heat island effects thus increasing the need for cooling therefore energy demand of a building. The open and green space, greenery and shade provided as well as material selection and treatment of roof areas are strategies that can help to mitigate these effects.

Minimizing the developmental footprint (building footprint, roadway, walkway, parking areas, or other hardscape) of a project has can control heat island effects and storm water generation. The overall intent for a green building is to minimize its impact on its site, surrounding environment and resources which is why minimizing impervious surfaces and maximizing green and open space are key initial steps towards meeting that goal. Strategies to minimise the development footprint include designing a taller building with a smaller footprint, and provide in multi-storey parking ,stilt parking specially designed for earthquake) to reduce the area required for parking and roadway which usually are impervious surfaces. Open grid paving slabs that allow for plant growth should be considered when surface car parks are designed for. These allow grass to grow over as well as allow for surface rainwater runoff to infiltrate into the ground. Both reduce heat build-up in the hard surface. Good site planning can keep internal roadways and other associated accesses (i.e. loading or services) to a minimum

4. Proposal for Diaster Mtigation

4.1 Earthquake mitigation

Design buildings as per earthquake-proof building codes and by-laws. As an architect simple forms without vertical set back should be designed for safety consideration

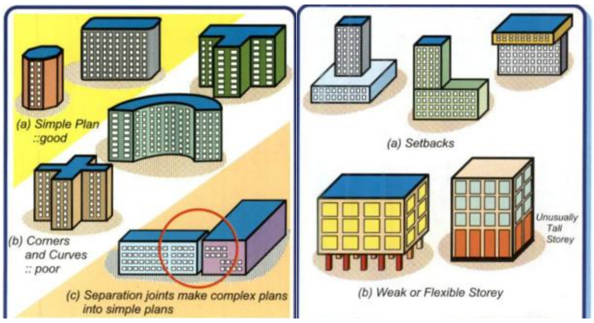

Fig-6. Simple plan shape for earthquake prone areas at left and next to it forms not suitable for earthquakes (Source: www.bmtpc.org)

As building on stilts is a traditional response to this flood prone land which used to be light bamboo and wood wattle daub structures. This trend is even followed in the modern concrete buildings as well and this stilt area is extensively used for parking. Open ground storey buildings are called soft storey buildings, as this ground storey may is soft and weak with only columns and no infill walls making it less rigid as compared to other adjoining storeys, above or below structure of the building. The soft or weak storey usually is at the ground storey level, but it could be at any other storey level too. It can be disastrous during an earthquake and lead to collapse of the entire building. Where ever such problem is found, the weak story is reinforced to make it stronger than the floors above by adding shear walls or moment frames. Moment frames consisting of inverted U bents are useful in preserving lower story garage access, while a lower cost solution may be to use shear walls or trusses in several locations, which partially reduce the usefulness for automobile parking but still allow the space to be used for other storage. The existing buildings can also be retrofitted by adding proper shear walls or bracing to the soft stories

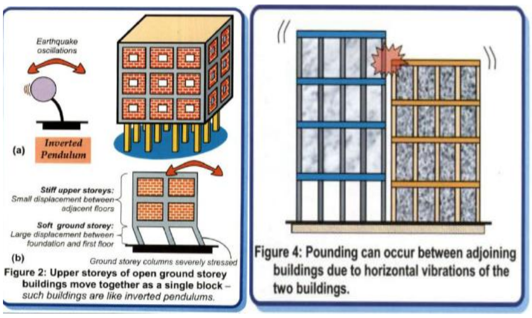

Fig-7. Fig 10. Arrangement not suitable for earthquakes (Source: www.bmtpc.org)

The buildings should not be constructed to close to each other as shown in the figure above as it can lead to serious damage due to pounding.

4.2 Flood mitigation

Landscape development proposal for climate mitigation will lead to green field sites being developed thus reducing the impervious surfaces which encourage runoff and less rainwater to be absorbed on site. Landscape development and climate mitigation techniques illustrated earlier in the paper will also curtail, over a period of time erratic short span downpours.

The existing hard surfaces like streets, roads, parking lots etc. increase in storm water generation therefore increases the runoff into drains and receiving water bodies. This can cause harm to water quality since water runoff from impervious surfaces normally contains high levels of particulates (Total Suspended Solid (TSS)) in addition to a range of contaminants including oils, metals, fuels, and phosphorous. Also increased runoff puts additional stress on existing drainage capacities and leads eventually on a rainy day with heavy downpour to flooding.

Dense vegetation allows maximum infiltration of rainwater into the ground because raindrops are intercepted by forest canopy reach the ground slowly in the form of Aerial Streamlets through the leaves, branches and stems of trees. These streamlets infiltrate easily into the spongy soil layer formed by the leaf litters. But in the absence of forest and other vegetation covers, raindrops strike the ground surface directly. This direct strike during a heavy downpour the rainfall exceeds the limits of infiltration soon promotes runoff which reaches the rivers through rivulets and streams and causes the floods.

Increased surface runoff also accelerates the rate of soil erosion and landslides thus increasing the sediment load of the river. This processes result in gradual rise in the riverbed and reduce the water accommodating capacity of the river.

As early as 1960s, urban planners began to recognize that wetlands buffer regional infrastructure and housing against flooding. As per Columbia University Green Roof Project Submission Date (July 26, 2007)in May of 2006, the community of Lawrence, Massachusetts received 8.7 inches of rain over several days, resulting in an estimated $19 million in flood damages. At the same time, communities along the Charles River, including Boston and Cambridge, received 9 inches and suffered almost no flood damage. The protected wetlands provide a wide range of other water quality, recreational and economic benefits as well. Thus wetland systems are most effective cost effective alternatives in buffering communities against flooding.

Maintenance of wet lands and river front Development of the Brahmaputra river and flood control measures include taming the menacing river such as to delay the return of runoff resulting from torrential rainfall to the river to hasten such as the discharge of water as sinuous and meandering river retard with the quick disposal of water to divert the flow of water to low-lying area. Artificially constructed channels bordered by artificial dykes to reduce the volume of water through a series of engineering devices

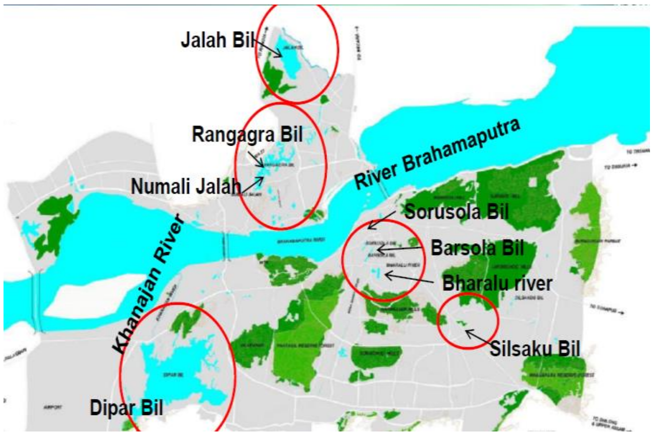

Fig- 8. Map showing location of wet lands (Source: TERI)

Dumping of garbage in drains to be prohibited by authorities as it clogs the drains and aids in flooding.

Construction bioswales instead of concrete drains which are densely vegetated open channels constructed with gentle slopes to allow runoff to be channelled, slowed down reducing run off and filtered by vegetation. The runoff that passed through the bioswales can be directed away for re-use or to public drains.

Building Code are needed for formulation for the minimum elevation to which a structure must be elevated or flood proofed is Design Flood Elevation (DFE) the minimum elevation to which a structure must be elevated or flood proofed based on flood agencies report.

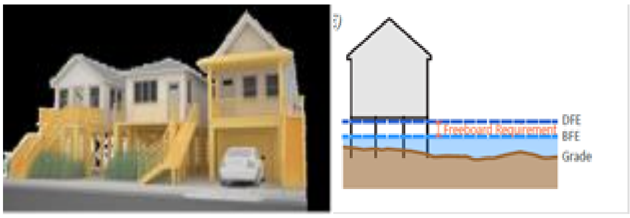

Fig -9. Building elevations for flood prone areas (Source: www.nyc.gov/retrofitting)

4.3 Landslide mitigation

Planned development with consideration to ecologically sensitive hillocks can reduce losses by avoiding the hazards and reducing the damage potential by landslides. Landslide risk can be reduced by five approaches used individually or in combination to reduce or eliminate losses:

- Restricting Development in Landslide-Prone Areas is the most effective and economical Land use planning methods. This can be skilfully done by removing or converting existing development and regulating new development in unstable areas.
- Excavation, construction, and grading codes have been developed for construction in landslide-prone areas.

Landscape development, forest protection and afforestation of landslide prone will curtail and mitigate landslide impact and frequency of landslides. As a large-scale deforestation in various purposes such as agriculture, raw materials for factories, for domestic and commercial use ofwood is perhaps the most important anthropogenic factor of the cause of flood and landslides in the Guwahati. All these

- chain effects of deforestation and related increased surface runoff, increased soil erosion and landslides

5. Proposal for Energy Demand Management

With increasing population the primary energy demand has also increased manifold. So in order to manage the ever rising energy demand with demographic progression the following need to be implemented

- The passive design features for built forms and landscaping from proposed in the earlier section will not only help mitigate climate change mitigation but also curtail energy demand for cooling load and lighting.
- The use of PV system can reduce carbon footprint as it generates electricity without emitting any greenhouse gas or other pollutant. In Indian sunny climate, time taken for a PV module to generate the equivalent of its embodied energy – is typically less than 2 years (as per calculations by experts). Si PV modules typically have 25-years of power warranty, thus can compensate equivalent to their embodied energy many times over during active service. The average solar radiation over Guwahati is around 4.69kWh/m2 /day and the tilted daily solar radiation at an angle of 30o is 5.18kWh/m2 /day which makes it a good prospect for establishing solar power plants and use of solar panels. PV modules should be installed on roofs at just over 10o tilt facing south. However, it is better to mount the modules at slightly steeper angles – at least 30o for frameless modules and at least 10o for modules with frames, to enable better rainwater surface runoff. Installing any steeper than around 30o can cause reduced energy generation.

6. Conclusion

The urbanization is a complex phenomenon with a multitude of issues and is here to stay and multiply manifolds with time. The issues that are associated with it, are very complex and vary from region to region. For Guwahati city itself there are a multitude of complex issues other than the ones taken up for mitigation in this paper. The concerns that have been addressed are the ones which can be to a large extent mitigated by design through professional architects and landscape architects by timely intervention and environmental responsiveness. The climate change and frequency of disasters as seen in this urban zone are further heightened by rate of urbanization. The antagonistic impact of urbanization can be reduced in a phased manner through these conscious intervention of the above professionals.

Fig-10. Mitigation Proposal (Source: Author)

Thus the study carried out in this paper for the Guwahati can be concluded with a more comprehensive definition of the Green Agenda:

"The smart design manipulation in order to take advantage of climatic conditions at building and neighbourhood level along with appropriate landscape design to fashion indoor and outdoor for climate and disaster mitigation is true green agenda for present and future generations." Author

Most mitigation proposals are achievable with conscious efforts and the above Green Agenda can achieve realistic results and is not a mere fad and something that is in vogue.

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BIOGRAPHIES

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