SUSTAINABLE URBAN DEVELOPMENT AND BIODIVERSITY

Abstract

The sustainable urban habitat should cater to the economic prosperity, community needs, social security and environmental awareness of the population while maintaining the human comfort and biodiversity. The resource thirsty urban lifestyles put a stress on non-renewable sources of water, energy, forests- flora and fauna and land. India has geographical area of 3,287,263 square kilometre, a forest cover of 20.6%[1] of total geographical area and only 2.48%[1] area under tree cover totalling to an aggregate of 2461 million trees[1]. The urban sprawl has consumed the peripheral areas of the cities and devoured fertile agricultural fields, but still India has fair area under forest cover. India's forests serve as a major sink of CO_2. The estimates show that the annual CO_2 removals by India's forest and tree cover is enough to neutralize 11.25 % of India's total GHG emissions (CO_2 equivalent) at 1994 levels[2]. This is the most recent year for which comparable data is available for developing countries based on their respective National Communications (NATCOM) to the United Nations Framework Convention on Climate Change (UNFCCC)[3].

India's population as per latest estimates is approximately 120 Crores (2011) and assuming a family size of 5 members the total no of household required are 24 Crores. The average area of each house if assumed as 50 sqm, total area required for habitat is 1200 Crore sqm or 12000 Square Kilometre. This is 0.36 % of total geographical area of India and it can be achieved without disturbing nature.

To establish an ecological and sustainable design strategy, we must propose urban development adjoining forests but at an optimal distance from these. Within the urban habitat the plantation design for city centre, roads, parks, gardens and urban forests should be proposed to include the suitable native species. This paper aims to evolve an ecological design strategy by establishing the measurable and immeasurable value of trees in the landscape, carbon sequestration and water requirements therein.

Keywords: Urban Habitat, Tree cover, Biodiversity, Ecological Design, Carbon Sequestration, Embodied Energy Values, HUDCO

1. Urban Habitat

1.1 Sustainable Urban Habitat

The core components of sustainable cities are equability, livability, resilience and inclusive nature. Greener cities have the intrinsic capability of accommodating urbanization which is an irreversible global phenomenon. Since about 30% of the world population lives in cities the urban habitat should be made more livable, so that it offers better quality of life, healthier environment and safer habitat as a basic human right. The climate change impacts and prevailing development practices are affecting the urban habitats in many adverse ways. The "United Nations Framework Convention on Climate Change" (UNFCCC) was signed by 150 nations in 1992 to mitigate the serious effect of human activities on human settlements and ecosystems. The commitment of the UNFCCC is to reduce Green House Gases (GHG) emissions and enhance GHG sinks and reservoirs.

1.2 Urban Habitat and Climate Change

Change in land-use from Forests and Green-fields to urban land-use is happening at a very rapid pace. Over the past 150 years, deforestation has contributed about 30% of the CO_2 build up in the environment. The "Land Use and Land Use Change" is highlighting the habitat fragmentation due to colonization, logging, agriculture, mining etc. Automobile dependence and industrialization is polluting the air and adding GHG to the environment. The increase in GHG emissions are resulting in following: [4]

- Rise in ambient temperatures are making the summers intolerable and the demand for energy in cooling increases. The last 30 years have been the hottest so far. The change in pattern of ecosystems is displaying a northward shift of 100km since the weather patterns are moving up the latitudes.
- Ozone Layer Depletion is affecting Human and Animal health, Terrestrial plants, Aquatic ecosystems, Bio-geo-chemical cycles and air quality.
- Severe climate events like heat waves, cyclonic winds, storms, floods, droughts and wild fires are on the rise due to changed climate and disturbance of ecosystem. The atmospheric concentration of CO_2 is exceeding the safe level.
- Rise in sea levels: The flooding of lowland coastal areas though minor now may increase with rise in sea levels.
- Melting Ice Caps: For every 1° C rise in temperature the snow line rises by 100m.

1.3 The Indian Scenario

Trees have an important bearing on the ecological system and in India number of trees are increasing and area under trees is also increasing, so India's position in terms of ecological vulnerability is less. Plantation of appropriate tree species like Banyan and Neem along roads and in city centres, medium sized trees like Kadamba, Arjuna and Pilkhan in office and institutional plots, Lemon, Maulsari, Mango, Loquat and Amaltas in neighbourhoods leverage biodiversity in the urban habitat. Even small scale efforts of terrace gardening improve the urban microclimate. However, the International Panel on Climate Change warns that the climate change shall have a greater adverse effect on India because the economy is growing and urbanization is rapid. Therefore, managing scarce resources like water, energy and forests is of utmost importance. By adopting western style development we shall only replace the concrete jungle with a glass jungle which would further add to GHG emissions. Thus evolving an indigenous strategy suited to the geographical, social and climatic conditions in India is advisable. (For trees scientific names, refer table no 3)

India's National Plan on Climate Change has set out Eight "National Mission" and one amongst these is "National Mission for a Green India". [5]

- *The Green India programme suggests:*
- *Training on silvicultural practices for fast-growing and climate-hardy tree species*
- *Reducing fragmentation of forests by provision of corridors for species migration, both fauna and flora*
- *Enhancing public and private investments for raising plantations for enhancing the cover and the density of forests*
- *Revitalizing and upscaling community-based initiatives such as Joint Forest Management and Van Panchayat committees for forest management*
- *Formulation of forest fire management strategies*
- *In-situ and ex-situ conservation of genetic resources, especially of threatened flora and fauna*
- *Creation of biodiversity registers (at national, district, and local levels) for documenting genetic diversity and the associated traditional knowledge*
- *Effective implementation of the Protected Area System under the Wildlife Conservation Act and National Biodiversity Conservation Act 2001*

2. Biodiversity

2.1 Trees are Beneficial to Cities

In New York in 1994 the value of the city's trees in removing pollutants was estimated at US$10 million per annum. Planting 11 million trees in the Los Angeles basin saves US$50 million per annum on air conditioning bills[6]. Manchester University's Adaptation Strategies for Climate Change in the Urban Environment Project has found increasing green spaces in cities by 10%, reduces surface temperatures by 4° C due to water evaporation (Transpiration) into the air from trees and other vegetation (Fisher 2007) [7]. Trees act as a wind barrier and reduce wind speeds when designed as a wind barrier. Trees hold and absorb water during intense rainfall thus easing the load on the storm water system in the cities. There is also a very important function of trees in adapting to climate change because trees sequest CO_2. Urban trees are assets that should be preserved and maintained properly. The youthful trees in suburban areas sequest more carbon and offers the ecosystem services manifold than native forests. However, the urban forests are valuable stocks of the carbon that these hold in their mass. Apart from this, trees provide economic, environmental, social, personal and religious benefits to the human race.

2.2 Economic Value of Trees

Under the Clean Development Mechanism (CDM) emission reduction projects in developing countries can earn certified emission reduction credits. Hence emission reductions have taken an economic value. The CDM has buyers in the European Union and Japan, which India may target. In India very little data and research has been done for the economic value calculation of our green cover. Recently Delhi Metro Rail Corporation has en-cashed the CDM of their project of construction of Delhi Metro Rail Project at Delhi, India.

2.2.1 Calculation of CO_2 Sequestered by Trees

The United Nations Environment Programme (UNEP) [8] has presented indicative figures for the CO_2 sequestered by an average tree as 12 kilograms and such a tree emits enough O_2 for a family of four for a year. If the average life span of a tree is assumed as 20 years it sequesters 240 kilograms of CO_2 equivalents (CO_2e) in its lifetime and this is the carbon dioxide absorption capacity of an average tree. A carbon footprint of 1 ton of CO2e can be thought of as requiring the planting of approximately 4 trees.

The rate of carbon sequestration depends upon the growth characteristics of the tree species, the conditions for growth, where the tree is planted and the density of the trees wood. It's greatest in the younger stages of trees growth from 20-50 years. The total green weight of the tree is determined and subsequently the dry weight of the trees is obtained. To determine the weight of CO_2 sequestered in the tree multiply the weight of the carbon in the tree by 3.67. The process as elaborated on an educational website is as follows [9]:

- Determine the total (green) weight of the tree: A kg
- Determine the dry weight of the tree= B kg
- Determine the weight of the carbon in the tree=C= (A-B) kg
- Determine the weight of carbon dioxide sequestered in tree=D=C*3.67 Kg
- Determine the weight of carbon dioxide sequestered in tree per year=D/Age of Tree

2.3 Environmental Values of Trees

The issue of greenhouse effect and climate change are often discussed at the world forums and it is observed that trees absorb lots of CO_2. The green spaces and tree cover which provide shade, digest the carbon, reduce heat island effect, control storm water runoff, bind the soil apart from various other environmental benefits are rarely valued/quantified over the process of development and densification. However, the efforts towards preservation of the Tree cover and

Biodiversity are changing rapidly. Some species of trees are planted along sea shores to prevent the ingress of sea water into the ground water and they are performing very well.

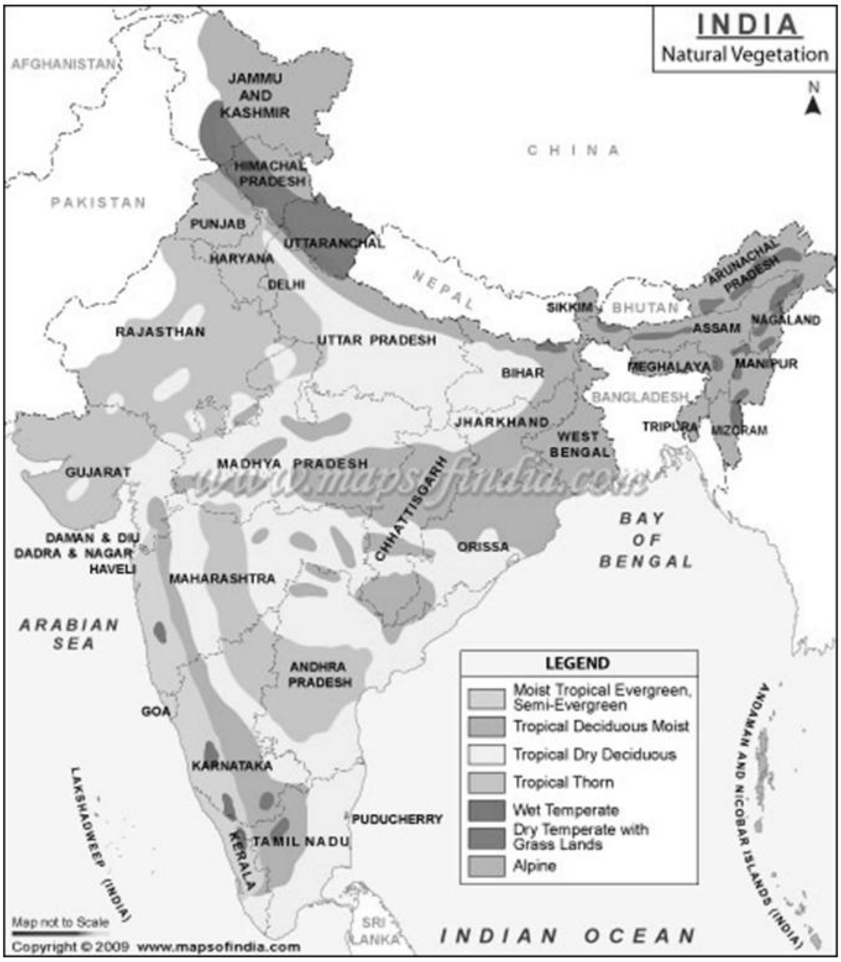
2.4 Cultural and Medicinal Value of Trees

The Rig Veda and Atharva Veda (Ancient Indian sacred books) lay down the importance of trees in human life as the reason for worshipping trees and sacred groves. The National tree of India –Ficus benjamina (banyan tree), is planted near temples and homes because of its religious, cultural and medicinal importance. The Ficus religiosa or Peepal or Bodhi tree is revered by Hindus and Buddhists alike. It is the longest living trees in the world and its leaves and bark have many medicinal properties. This tree is known to emit oxygen even at night. The Anthocephalus cadamba or Kadamba has historical and ecological importance. The flower and fruits of the tree attract birds and bees. The Terminalia arjuna or Arjuna is another sacred tree, which is also used in Ayurvedic preparations. There are numerous other species known to have medicinal properties, which are used in remedies for diseases and in alternate medical treatments like Ayurveda.

3. India’s Forest and Tree Cover

The Forest types of India vary from the coastal regions in South to the mountain peaks in the North. The climate can be broadly divided into seven or six types and the Forest types are dependant on the climate as shown in Map 1- Forest Map of India[10]. The government of India, has put in place a National Mission for a Green India as part of the country’s National Action Plan for Climate Change with a budget of INR44,000 crore (approx. USD 10 billion) over a period of 10 years. The overarching objective of the Mission is to increase forest and tree cover in 5 million hectare and improve quality of forest cover in another 5 million hectare .[11]

Trees are a major national & urban asset and the benefits that accrue from them are often under appreciated. Developers get permissions for cutting mature trees after rigorous Environmental Impact Assessment on the basis of compensatory plantation but the loss to environmental, economic and community life is seldom evaluated. The community has spent considerable human effort and resources to grow and develop trees. The tree cover on public land has increased while the tree cover on private land has decreased due to intense high density developments.. The example of the Banyan Tree at Royal Gardens of Calcutta, India covering an area of 404 sqm is a case in point for the lone tree as a habitat for varied flora and fauna.



***Map 1[9]: Forest/ Vegetation Types in India (Source**: www.mapsofindia.com)*

3.1 Preserving Urban Tree Cover

India's Initial National Communication on Climate Change (NATCOM) sent to UNFCCC has targeted an increase in forest and tree cover to 25% by 2007 and 33% by 2012 [12]. Some urban civic bodies are investigating the value of their green assets. The Pune Municipal Corporation in India, has appointed a private agency to do a scientific survey of the twenty lakh plus trees spread over 120 sq.m. area[13]. Most of the trees are 40 to 90 cm girth at breast height and aged 20-50 years. The Forest Department has reported that the tree cover in Chandigarh has gone up from 9 sq. km. in 2007 to 11 sq.km. in 2009 while the forest cover has gone up from 26% to 35.7%[14].This was indicated by the pictures taken through the satellites. The increased green cover has resulted in an increase in the animal population. Delhi is sprawled over an area of 1483 square kilometer and has seen an increase in the green cover due to tree plantations taken up and setting up of nine new city forests. The green cover was 268 square kilometer (18.07%) in 2003, 283 square kilometer (19.09%) in 2005, 300 square kilometer (20%) in 2007 and is estimated to be 400 square kilometer (25%) in 2010[15]. The Lutyen's Bungalow Zone (LBZ), a 2800 hectare area housing government offices and bungalows is just 1.88% of the Delhi Metropolitan Area but serves as green lungs to the entire city. The World Monument Fund and

INTACH are proposing a preservation plan for its tree lined avenues, water courses and grand vistas that are threatened by private builders.

3.2 Biodiversity and Indian Forests

The table 1, has been prepared to study the climate types of the various physiographic regions of India and the forest types found therein. The predominant tree species of the forests types are listed below as a reference and recommendation for tree plantation.

Table 1: Biodiversity and Indian Forests

S.NO	CLIMATE TYPE	REGION	EXISTING FOREST TYPE	PREDOMINANT TREE SPECIES
1	*ALPINE ZONE*	*HIGH ALTITUDE OF HIMALAYAS*	*Alpine, Dry Temperate with grasslands & Wet Temperate*	*Birch,Douglas- Fir,Giant sequoia, Sitka spruce, Alerce, Kauri, Conifers, Abies, Larix, Oak, Rhododendron, Pine, Cedar, Juniper, Cypress and Redwood*
2	*HUMID SUB TROPICAL*	*NORTHERN INDIA- Indo Gangetic Plain to North East India*	*Tropical Deciduous moist & Tropical Dry Deciduous & Wet Temperate*	*West-Sal forests, Pine forests, Shorea robusta, Terminalia tomentosa, Anogeissus latifolia, Mallotus philippinensis, Olea cuspidata, Bauhinia retusa and Bauhinia variegata. East- Schima wallichii, Castanopsis tribuloides, C. indica, Terminalia crenulata, Terminalia bellerica, Engelhardtia spicata, Betula spp. and Anogeissus*
3	*TROPICAL-DRY & WET*	*Inland Peninsular India*	*Tropical Deciduous moist & Tropical Dry Deciduous*	*Adina cordifolia, Albizzia odoratissima, Albizia procera, Alstonia scholaris, Bombax ceiba, Toona ciliata, Dalbergia latifolia, Grewia tiliaefolia, Holoptelea integrifolia, Hymenodictyon excelsum, Lagerstroemia lanceolata, Lagerstroemia speciosa, Lannea coromandelica, Miliusa velutina, Pterocarpus marsupium, Schleichera oleosa, Spondias pinnata, Radermachera xylocarpa, Tectona grandis, Terminalia bellerica, Terminalia paniculata, Terminalia tomentosa, Vitex altissima, Xylia xylocarpa and Machilus macrantha (1)*
4	*TROPICAL-WET*	*South Western lowlands, Western Ghats, southern Assam, Andaman Nicobar, Lakshwadeep*	*Moist Tropical Evergreen, Semi-evergreen, Wet Temperate*	*canopy trees-Cullenia exarillata, Mesua ferrea, Palaquium ellipticum, Gluta travancorica, and Nageia wallichiana.Others- include Calophyllum austroindicum, Garcinia rubro-echinata, Garcinia travancorica, Diospyros barberi, Memecylon subramanii, Memecylon gracile, Goniothalamus rhyncantherus, and Vernonia travancorica. Pygeum gardneri, Schefflera racemosa, Linociera ramiflora, Syzygium spp., Rhododendron nilgiricum, Mahonia nepalensis, Elaeocarpus recurvatus, Ilex denticulata, Michelia nilagirica, Actinodaphne bourdellonii, and Litsea wightiana*

5	*SEMI-ARID*	*Karnataka, Tamil Nadu, Andhra Pradesh, central Maharashtra, Eastern Rajasthan, Inland Gujarat, Western parts of UP, Haryana, Punjab*	*Tropical Dry Deciduous*	*North- Sal and Teak, Pterocarpus marsupium, Sterospermum suaveolens, Spondias pinnata, Cleistanthus collinus, Acacia lenticularis, Flacourtia indica, Boswellia serrata, Butea monosperma, Sterculia urens, Cochlospermum religiosum and Euphorbia nivulia. Central- Hardwickia binata- Albizia amara, Terminalia alata, T. chebula, T. tomentosa, Acacia catechu, Lagerstroemia parviflora, Aegle marmelos, Syzgium operculatum, Symplocus racemosa, Dlbergia latifolia, Croton oblongifolius, Pterospermum acerifolium, Phoenix robusta and Clematis nutans*
6	*ARID*	*WESTERN INDIA- Rajasthan*	*Tropical Thorn*	*North west- Acacia senegal, A. leucophloea, Prosopis spicigera, Capparis zeylanica, Salvador spp, Carissa spp., Gymnosporia spp., Grewia spp., Gardenia spp. Thar desert- Prosopis cineraria, Anogeissus rotundifolia, Tecomella undulata, Tamarix articulata. Deccan- Balanites roxburghii, Cordia myxa, Capparis spp., Azadirachta indica, Cassia fistula, Diospyros chloroxylon, Carissa carandas and Phoenix sylvestris*

4. Case Study – Public Building Design for North India & Biodiversity

4.1 Design Concept

The North Indian (Uttar Pradesh) climate is Humid Sub Tropical and the Forest type is Tropical Dry Deciduous. The building proposed is designed around a rectangular quadrangle with an orientation to minimize solar heat gain and maximize ventilation. The wind is channelized through jallis (openings in walls) and windows into the building and the cross ventilation is setup because of a large internal courtyard shaded with pergola. The built form is surrounded by open spaces on all four sides. As shown in the Design Concept (Figure 1) the outdoor activities are primarily the extension of indoor spaces such as**:**

- Children's play area adjoining the *balvadi (Crèche)* adjoining the Programme Convergence Cell.
- Open air theatre adjoining the multipurpose hall adjoining the Retail Facility.
- Outdoor display of art and crafts along a water body adjoining Skill development cell.
- Parking adjoining the Information Cell.

The beautiful *Jharokhas*, terraces and semi- covered spaces not only provide to mitigate the harsh climatic conditions but also give a sense of space and enclosure. The balcony is a very important architectural element necessary to provide shade to the windows as well as the building surface. The use of pergolas on the Roof Top ,appropriately insulate the terrace and prevent heat gain in the building apart from providing shady spaces surrounded by Landscaped terrace. The building having three storeys structure, stepping externally on each floor provide shading to the surface and windows. The Elevations and Section of the building are placed at Figure 3.

Table 2: Area Statement

1	*Plot area*	*9147.00 square metre*
2	*Ground coverage*	*2283.98 square metre = 24.97%*
3	*Total built up area* *Ground floor=2284.98 square metre* *First floor =2401.89 square metre* *Second floor=1666.63 square metre*	*6352.50 square metre*
4	*Floor area ratio achieved*	*69.45%*

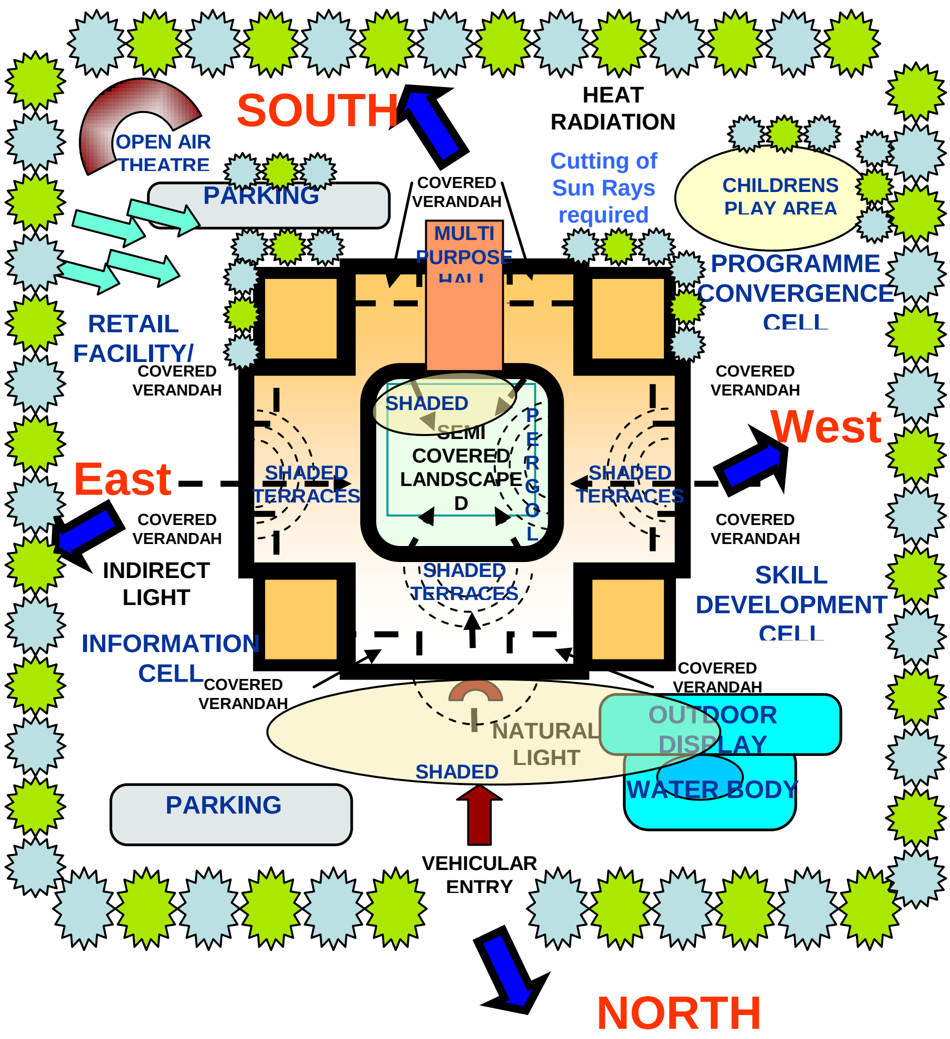


Figure 1: Design Concept

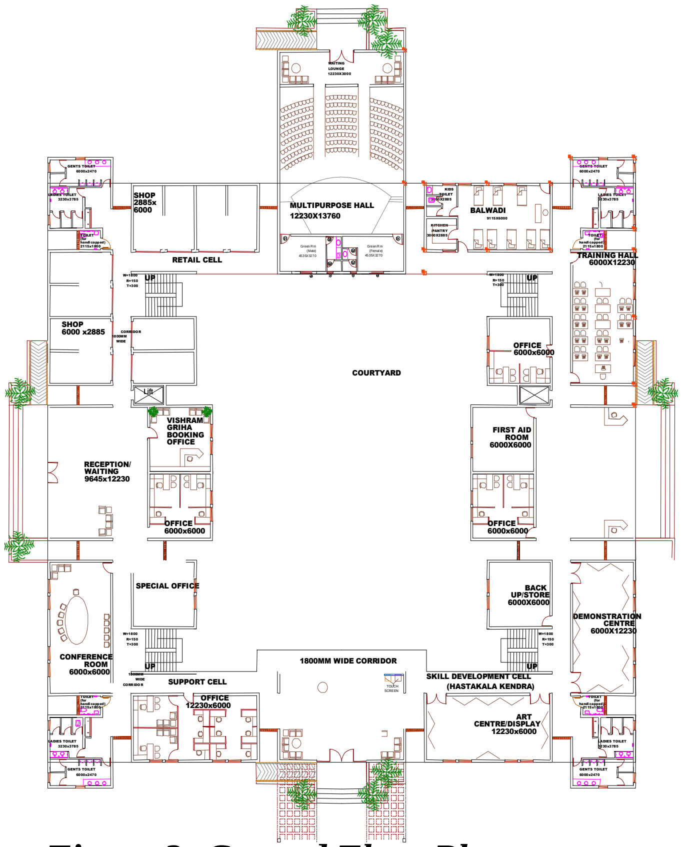


Figure 2: Ground Floor Plan

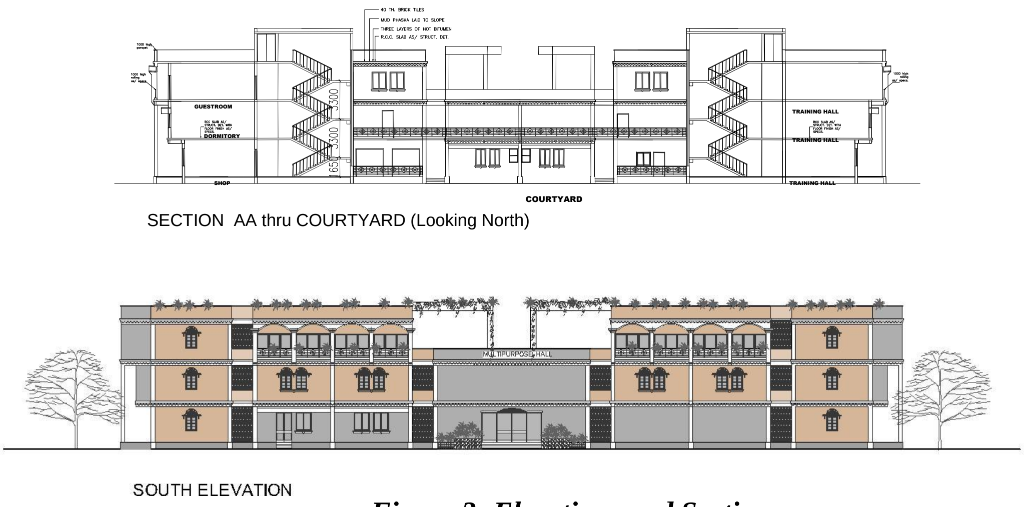


Figure 3: Elevations and Section

4.1.1 Landscape Design

The Landscape is designed for the various outdoor activities complementing the building design. Boundary tree plantation reduces the radiation on vertical surface of the building and also shade the paving and open spaces. Tall columnar trees planted in the set back in the West. Climbers and shrubs in earthen pots on terraces and balconies are proposed for shading the building. Xerophytic native plant species used to adequately reduce irrigation water requirement. Terrace garden and landscaping on the roof top mitigate the solar heat gain and provide comfortable indoor environment. Pergola/ Trellis for shading car parks and paved surfaces provided. The Hard surfaces reduced to 50% by use of Grass concrete pavers around the building. Renewable Solar energy used for outdoor lighting. An outdoor pool with fountains is proposed to improve the micro climate by cooling the air.

4.1.1.1 Plantation Design

The tree species proposed to be planted are native trees valued for their medicinal and aesthetic properties. The number of evergreen trees proposed is 57 out of a total of 95 trees. The remaining are fruit trees and indigenous ornamental trees valued for the aesthetic appeal. The list of the trees along with the common names and numbers are given in the Table 3.

Total carbon dioxide sequestered by these trees @ 12 kg/Year per tree for 20 Years will be 95*12*20=22800 kg of CO_2, or 50276 Pounds of CO_2 or 70910 Kwh (Energy provided by Coal in releasing this amount of CO_2) or 255 GJ. This is 1% of the total EEV of the building calculated in Table 5.

- 1000 KwH=709 Pound CO_2 [16]
- 1 Pound= 0.4535 kg
- 1 KwH=3.6 MJ.

Table 3: Tree List for the Building landscape

S.No.	*Scientific name*	*Common name*	*Numbers*
1.	*Anthocephalus cadamba*	*Kadamba*	*4*
2.	*Bauhinia purpurea*	*Kachnar*	*7*
3.	*Cassia fistula*	*Amaltas*	*9*
4.	*Citrus lemon*	*Lemon*	*4*
5.	*Emblica officinalis*	*Amla*	*4*
6.	*Eriobotrya japonica*	*Loquat*	*1*
7.	*Eugenia jambolana*	*Jamun*	*11*
8.	*Ficus virens (Ficus infectoria)*	*Pilkhan*	*8*
9.	*Lagerstroemia indica*	*Crape myrtle*	*9*
10.	*Mangifera indica*	*Mango*	*2*
11.	*Mimusops elengi*	*Maulsari*	*5*
12.	*Plumeria alba*	*Temple tree*	*7*
13.	*Psidium guajava*	*Guava*	*3*
14.	*Terminalia arjuna*	*Arjun*	*17*
15.	*Saraca asoca*	*Sita ashoka*	*4*
		TOTAL	*95*

4.1.2 Cost Abstract

The cost of the project was calculated based on the CPWD (Central Public Works Department, GOI) Delhi Schedule of Rates 2007 and Cost index up to year 2010 is given in Table 4. To ensure that the embodied energy of the materials used is reduced to the minimum the specifications included fly ash bricks and locally available stones. The table 4 shows the calculation for the total cost based on the bill of quantities.

Table 4: Cost of works for the building

S NO	ITEM	UNIT	COST (Rs)	QUANTITY	AMOUNT (Rs)*
1	Building	Each	98,190,410	1	98,190,410
2	Open Air Theatre	LS	500,000	1	500,000
3	Play Area	LS	500,000	1	500,000
4	Rain Water Recharge Pit	Nos	1,235,170	1	1,235,170
5	Site Levelling	LS	6,285,437	1	6,285,437
6	Boundary Wall	RMT	3,614	387	1,396,984
7	Cement Concrete Roads	SQM	1,354	1180	1,598,032
8	Interlocking Paving Tiles	SQM	985	1150	1,132,407
9	SURFACE DRAINS 40*40 Cm	RMT	1,401	200	280,151
10	Landscaping-Horticulture	SQM	319	3676	1,172,139
11	Water Supply Lines	RMT	596	200	119,277
12	Electric Street Light Poles	Poles	16,050	7	112,351
13	Solar Street Light Poles	Poles	50,250	7	351,750
14	Sewer Lines	RMT	1,185	200	237,066
15	Dustbin	Nos	5,000	10	50,000
16	Sullage Water Recycling Plant	Nos	210,000	1	210,000
17	Connection Charges - Water/Sewer	LS	50,000	1	50,000
18	Connection Charges Electricity	LS	50,000	1	50,000
	TOTAL				**113,471,173**
	Charges for DPR Preparation	1.75%			**1,985,746**
	Project Management Charges	5.25%			**5,957,237**
	Total				**121,414,155**
	Grand Total				**121,414,155**

**All `/ Rs means INR which is roughly means 50 INR equivalent to I USD.*

The Basic Building Materials used in the construction and the quantity of the Cement, Steel and Bricks required for the building under study are given in Table 5. These three materials contribute the major share of the embodied energy value in the construction industry. The grand total quantities are given at **A** in Table 5. The conversion to the energy equivalents for each is given at **B** and the total EEV (embodied energy value)[17] for each of the cement, bricks and steel is given at **C**. The aggregate EEV of these materials may be taken as the EEV for the construction of this building given at D. By dividing the total EEV by the total built up area we arrive at the EEV per square metre given at E in table 5.

	Table 5:Calculation of EEV of Basic Building Materials								
				Quintel		*Nos*		*Kg*	
S no	*Item*	*Unit*	Quantity	*Cement /Unit*	*Total Cement*	*Bricks/ Units*	*Total Bricks*	*Steel/ Units*	*Total Steel*
1	Building	Each	1	15,905	15,905	1,196,077	1,196,077	295,391	295,391
2	Open Air Theatre	LS	1						
3	Play Area	LS	1						
4	Rain Water Recharge Pit	Nos	1	161.0	161.0	2,500.0	2,500.0	2,800.0	2,800.0
5	Site Leveling	LS	1		-		-		-
6	Boundary Wall	RMT	387	0.9	345.4	411.1	158,906.0		-
7	Cement Concrete Roads	SQM	1180	0.6	755.2		-		-
8	Description	SQM	1150	0.4	514.1		-		-
9	Surface Drains 40*40 Cm	RMT	200	0.6	116.1	92.0	18,400.0		-
10	Description	SQM	3676	0.1	248.9	54.2	199,111.6		-
11	Water Supply Lines	RMT	200		-		-		-
12	Electric Street Light Poles	Poles	7		-		-		-
13	Solar Street Light Poles	Poles	7		-		-		-
14	Sewer Lines	RMT	200	1.7	336.8	322.6	64,515.0		-
15	Description	Nos	10	0.2	2.2		-		-
16	Sullage Water Recycling Plant	Nos	1		-		-		-
A	Grand Total Quantity				18,384		1,639,510		298,191.6
B	EEV in MJ/Unit				670.0		2.3		32.0
C	Total EEV of Basic Building Materials			12,317,742		3,803,663		9,542,130	
D	Total EEV in MJ							25,663,536.4	
E	Total EEV MJ/Sqm							**4,062.8**	
	Total Embodied Energy Value / sqm of the Project is same as of Cost Effective Housing.								
	The total EEV of the building is 25663.536 GJ.								

4.1.3 Case study of effect of Landscape Design on water demand of habitat:

The roof top rain water harvesting is done for ground water acquifer recharge. To reduce the consumption of water low flow faucets and plumbing fixtures have been used. The total area of the building site is 9147 sqm, the green area is 3676 sqm. Since rainfall is 660mm, the rain water collected annually is 2310.95 Cum. With the sullage water treatment and utilization of rain water, the total water demand is reduced by 29.56 %. This demand can be further reduced, if we reduce the grassed area and increase the Tree Cover. However the effect of microclimate due to transpiration and shading provided by tree cover could not be quantified due to lack of available data.

The rain water harvesting potential for the building is calculated in Table 6 & 7 totalling 350.14 cum. The building has been designed to cater to a population of 635 @10 square metre per person. The water demand, sullage and waste generation are accordingly calculated in Table8 and 9. From the calculations it is seen that the water requirement of the lawn areas of the landscape (table 8) is very high. However, the plant species factor should be included for estimating irrigation water requirements because the proposed plantation plan provides for various species of ground covers and shrubs also. Since 95 trees are proposed to be planted the irrigation water demand may be reduced from the 10 litres per square metre as specified in the table to 6 litres per square metre. However, in the present case landscape water demand has been assumed @ 10 litres per square metre. The trees require water only for a year after plantation and thenceforth, survive on rain water/ground water. The tree canopy provides shade for undergrowth, reduces evapo-transpiration, so irrigation water required for shrubs and ground cover is reduced. Hence, the landscape water requirement shall be reduced by 40% through plantation design.

Table 6: Calculation of Rain water harvesting potential

Site Area (Sqm)	Green Area (Sqm)	Hard Area (Sqm)	Annual RainFall (m)	Rainfall in 3 Months	Runoff	Total Volume (Cum)	Annual Rain Water Collected(cum)
9147	3676	5471	0.66	80%	0.8	2310.95	
Total Rain Water Collected							**2310.95**

Table 7	*Design of Rain Water Harvesting Tank*						
	Maximum Rainfall of 80mm/Hour				**Design For RainWater Harvesting Tanks**		
Site Area (Sqm)	Green Area (Sqm)	Net Area (Sqm)	RainFall (m)	Max Rainfall	Runoff	Total Volume (Cum)	Design Volume of Rain Water Harvesting Pit
9147	3676	5471	0.08	100%	0.8	350.14	
Total							**350.14**

Table 8	*Water Demand*						
Population	Water Demand @45Lpcd	Green Area (Sqm)	Green area Daily water (Litres)	Total Volume (Litre)	Total volume (Cum)	Annual Volume (Cum)	Annual Water Demand
635	28575	5471	54710	83285	83.285	30399	
Total							**30399.025**

Table 9	*Sullage Generated*						
Population	Water Demand (in litres) @45Lpcd	Ratio of Sullage Generated	Sullage Treated	Total Volume (Litre)	Total volume (Cum)	Annual Volume (Cum)	Annual Sullage generated
635	28575	0.8	0.8	18288	18.288	6675.12	
Total							**6675.12**

The measures being adopted to reduce water consumption on the demand side and augment water on the supply side by recycling waste water shall result in about 29% water saving as given in table 10. The calculations for the capacity of rain water harvesting tank and the sewage treatment plant are given in table 11.

Table 10: Annual Water Demand Reduction		
Demand	30399	Cum
Rainwater Collected/Recharged	2311	Cum
Sullage Recycled	6675	Cum
Net Water Requirement	21413	Cum
% reduction	29.56%	

Table 11: Rain Water Harvesting Tank and Sewage Treatment Plant

Rainwater Harvesting Tank			Depth(Metre)	Area(sqm)
Capacity	350.14	Cum	4	87.54
Sullage water Treatment Plant				
Capacity	18.288	Cum	3	6.096

5. Conclusions

Any kind of Urban Project to be undertaken in small and medium towns, mega industrial or infrastructure projects or mega cities needs a holistic approach in terms of balancing the resources. It is recommended that infrastructure as well the ecosystem support, available in the vicinity of protected and reserve forests should be the criteria for proposing urban growth centres. Within urban spaces, the urban parks and forests should be leveraged to become a biodiversity bank, a repository of native flora and fauna and a carbon sink.

For sustainable habitats, it is not only important that geographical area under green cover should be increased, but the climate and forest type should also be considered. The quality of trees should be monitored as the carbon sequestration of each type of trees is dependent on its maturity, girth and species of tree and forest health. Providing terrace gardens on the roof tops, shrubs and climbers in planter boxes on the façade and shading of all paved surfaces and roads shall mitigate the urban heat island effect. In this paper parameters like thermal heat islands, soil erosion, and micro climate have not been quantified due to limitation of this study. However an attempt has been done to analyze the urban habitat of the proposed building with the plantation of trees and carbon sequestration by the proposed trees. It has been attempted to calculate the relation between CO_2 consumed during construction of any building and neutralized by planting trees around the building. In the present case the 95 trees planted on site sequester about 1 % of EEV during life time of building.

The water demand of the green areas has been calculated at the rate for the grassed areas, which require more water than areas under tree cover. To develop a sustainable landscape design, it is inadvertently necessary to minimize lawn areas to the absolute functional minimum required and plant native and xeriscape (native and consuming less water) species of trees, shrubs and ground cover. A case study done by the authors is taken up for analysis of tree based green development versus lawn based green development.

The scope of this paper has been limited to a micro-level project case study. However, further research may be conducted at the country level based on the seven/six climatic zones and species of trees therein. Further urban land development models could be worked out to achieve an optimal balance between Urban Development and Biodiversity.

*In the current paper data from foreign source has been taken in absence of authentic Indian data, but the procedure is same for any data.

**These are the personal views of the researchers; Hudco may or may not subscribe to the same.

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