Guidelines and benchmarks for Green Large Area Developments
Final report

Prepared for
Ministry of New and Renewable Energy,
Government of India

January 2012
Guidelines and benchmarks for Green Large Area Developments Final report

© Ministry of New and Renewable Energy, Government of India and Association for Development and Research of Sustainable Habitats (ADaRSH)

All rights reserved. No part of this publication may be reproduced in any form or by any means without prior written permission of Ministry of New and Renewable Energy, Government of India and Association for Development and Research of Sustainable Habitats.

For more information

ADaRSH
Darbari Seth Block,
IHC Complex, Lodhi Road,
New Delhi-110003,
India

Tel.+91-011-24682100 or 24682111
Fax: +91-011-24682144 or 24682145
Email: info@grihaindia.org
Web: www.grihaindia.org

Ministry of New and Renewable Energy
Block No. 14, C.G.O. Complex,
Lodhi Road,
New Delhi-110003

Ph:+91-011-24360707 extn. 1011 /1054
Fax: +91-011-24363035
Email: aktripathi@nic.in
Web: www.mnre.gov.in
Table of Content

INTRODUCTION ............................................................................................................................................. 1
  Objective of Study ............................................................................................................................................... 1
  Background and overview ............................................................................................................................... 1
  Large development status in India today ........................................................................................................ 3
  Methodology ...................................................................................................................................................... 4

SUSTAINABILITY GOAL SETTING FOR LARGE DEVELOPMENTS ................................................................... 9
  Goal 1: Carrying Capacity Analysis to arrive at optimum population and green cover ... 9
  Goal 2: Setting target for reduction of carbon footprint............................................................................ 18

SECTION A: SUSTAINABLE SITE ...................................................................................................................... 27
  I. Site Selection: ................................................................................................................................................ 27
    Guideline-1: Select a suitable site to preserve existing natural resources & upgrade environmentally degraded sites. .................................................................................................................. 28
    Site Assessment &Planning:.......................................................................................................................... 31
    Guideline-2: The proposed development should preserve & protect the rare and unique geological and geo-morphological features of the site. ................................................................. 32
    Guideline-3: Encourage soil conservation in the proposed site. ................................................................. 40
    Guideline 4: Surface water preservation ..................................................................................................... 45
    Guideline-4a: Protect and enhance on-site water resources and receiving water quality.46
    Guideline-4b: Maintain surface water features to conserve water and other resources. . 49
    Guideline 5: Conserving existing vegetation .............................................................................................. 50
    Guideline-5a: Control & manage rare plants found on site: ................................................................. 50
    Guideline-5b: Preserve all vegetation designated as special status ........................................................ 50
    Guideline-5c: Use native plants& preserve/ restore plant communities native to the ecoregion .................. 51
    Guideline-5d: Follow the existing vegetation conservation plan as prescribed in MOEF design guideline ............................................................................................................................ 51
    Guideline-6: Conserve Bio-diversity of the proposed site & surrounding. ........................................... 53

SECTION B: SOCIO ECONOMICS .................................................................................................................... 57
  Guideline 7: Measures to be undertaken on site and within site design to bring in equity and social well being ....................................................................................................................................... 57

SECTION C: MOBILITY SYSTEMS ..................................................................................................................... 61
  Guideline 8: Develop a hierarchical road network within the development................................. 61
  Guideline 9: Street networks within large developments should be developed in a manner so as to promote safety, efficiency, community living, environmental and aesthetic quality and cycling and walking ................................................................. 67
  Guideline 10: Encourage walking and cycling within the development........................................ 72
  Guideline 11: Promote use of mass transportation............................................................................... 80
  Guideline 12: Promote use of clean fuels, sustainable road construction practices and use of ICT ................................................................. 84
Guideline 13: Energy Efficient Electrical Systems for Large Development .................................................. 85
Guidance note to ensure low loss in electricity distribution network in large development .......................................................... 103
Cogeneration or Combined heat & power system ................................................................. 106
Cogeneration systems ........................................................................................................ 106
Steam turbine based Cogeneration systems .................................................................. 107
Gas turbine based cogeneration systems ...................................................................... 107
Diesel generators and natural gas fired gen-sets based .............................................. 108
Guideline 14: Energy Efficient Street Lighting ................................................................. 110
Introduction .................................................................................................................... 110
Purpose of the guidelines ............................................................................................... 110
Energy efficient street lighting principles ....................................................................... 110
Energy efficient street lighting opportunities and benefits ............................................ 111
Guidance Note ............................................................................................................... 111
Cut-off luminaire ............................................................................................................. 118
Guideline 15: Efficient Pumping Systems for Large Development ........................................ 126
Guidelines for optimization of pump selection .............................................................. 126
Guidelines for monitoring of pumping system .............................................................. 126
Guideline 16: Energy resource planning including utilisation of renewable energy and smart grids .......................................................... 129
Step 1: Load profiling and categorization ...................................................................... 129
Step 2: Energy resource planning: Renewable and non-renewable .............................. 130
2. Renewable energy resource profiling for technology selection ............................. 130
Step-3: Optimization process for selecting the appropriate RE technology and its system ................................................................................................................................. 134
Step-4: Finalize the load dispatch strategies and automation requirement .................. 134
Step-5: Finalizing the control strategies along with the communication protocol ........ 135
Step-6: Installation of entire RE power system along with its control systems, Data Acquisition System and automation system .......................................................................................... 136
Renewable Energy Applications .................................................................................... 137
Guideline 17: Climate responsive planning for layout in large developments and energy efficiency parameters for specific building typologies .......................................................... 140
Building Form – .............................................................................................................. 141
Solar Shading – ................................................................................................................. 142
Day lighting .................................................................................................................... 147
Guideline 18: Sustainable construction processes, commissioning, monitoring, operation and maintenance .......................................................................................................................... 156
Commissioning, operation and maintenance ................................................................ 158

SECTION D: ENERGY AND ENERGY SYSTEMS ........................................................................... 85

SECTION E: WATER & WASTE WATER MANAGEMENT SYSTEMS .................................... 165
Guideline 19: Sustainable water management .................................................................. 165
Guideline 20: All large development should have provision for adequate quality of water for potable and non-potable applications and to ensure the above, a stringent monitoring plan should be adopted through periodic audits......................................................... 171
Guidance notes .................................................................................................................. 172
Minimum Required Quantities of Minerals in Drinking water and Associated............. 177
Guideline 21: To ensure adequate water monitoring and leak detection plan at the community level in large developments, occasional water audits or preferably regular monitoring through SCADA system is recommended. ........................................ 192
Guidance Notes .................................................................................................................. 192
Steps in a Water Audit........................................................................................................ 194
GUIDELINES ON SUSTAINABLE WASTEWATER MANAGEMENT ............................................. 197
Guideline 22: All large developments should have provision of the Dual Plumbing/Dual Water Distribution System to recycle and reuse the treated waste water. ............. 197
Guidance notes: .................................................................................................................... 198
Guideline 23: Ensure Operation and Maintenance (O & M) of Decentralised Wastewater Systems and Safe disposal of generated sludge in all large development ........ 206
Guidance Notes .................................................................................................................. 207
Guideline 24: Water reuse and recycling (including rainwater harvesting) for Large Development ......................................................................................................................... 209
Guideline 25: Sustainable storm water management......................................................... 210
Guidance notes .................................................................................................................... 212
GUIDELINES ON WATERSHED MANAGEMENT .................................................................. 225
Guideline 26a: Ensure that the rainwater falling on the site (excluding the rainwater being stored) and provided site conditions permit is recharged through adequate measures.......................................................... 225
Guideline 26b: Ensure a Monitoring plan to maintain the level of ground water (pre and post monsoon). .......................................................................................... 225
Guidance notes .................................................................................................................... 226
SECTION F: SOLID WASTE MANAGEMENT ........................................................................ 239
Guideline 27: Organic/Biodegradable and Recyclables waste management ................. 240
Guideline 28: E-waste Management in large development........................................... 247
Guideline 29: Hospital/Health Care Unit waste Management ...................................... 252
Guideline 30: Construction & Demolition (C & D) waste management ....................... 259
Steps for Integrated management of C & D waste............................................................. 261
Stages of Waste Minimization .......................................................................................... 263
List of hazardous wastes present in C & D waste............................................................. 264
SECTION G: RISK MITIGATION/ADAPTION AND CLIMATE CHANGE ...................... 267
Guideline 31: Guideline for planning for climate change adaptation in large developments ............................................................................................................................................... 267
ANNEXURE 1: LITERATURE REVIEW .............................................................................. 277
Introduction......................................................................................................................... 277
Need for a Green Large Development .............................................................................. 278
Existing Rating Systems for large developments ................................................................. 282
Review ................................................................................................................................. 285

ANNEXURE 2: GREEN BUILDING MATERIALS .................................................................. 307

ANNEXURE 3: GLOSSARY AND ABBREVIATION .......................................................... 313
Site selection ......................................................................................................................... 313
Sustainable urban environmental planning ................................................................. 313
Water and wastewater management ............................................................................... 317
Solid waste management ................................................................................................. 318
Risk mitigation/adaptation and climate change ............................................................ 319
Abbreviations .................................................................................................................... 320

ANNEXURE 4: REFERENCE .............................................................................................. 323
List of tables

Table I: Per capita supply in class I and class II cities in various Indian States .................. 12
Table II: Urban green space/forest cover provided in various countries .......................... 14
Table III: Energy consumption for the following activities needs to be estimated: .......... 21
Table IV: Electricity emission factors (Weighted average emission factor of all Indian regional grids for FY 2009-10 in tCO2/MWh) .................................................. 22
Table V: India-specific CO² emission coefficients for road transport ............................. 22
Table VI: CO² emission coefficients for other fuel types ............................................. 23
Table 2.1: Slopes and land uses ................................................................................. 34
Table 3.1: Field determination method of soil texture .................................................... 41
Table 3.2: Soil drainage characteristics for land suitability evaluation ......................... 43
Table 3.3: Erosion hazard ............................................................................................. 45
Table 8.1: Hierarchical road planning for large urban developments ......................... 62
Table 8.2: Key considerations while planning for hierarchical road network ............... 63
Table 8.3: Carriage-way widths ................................................................................... 64
Table 8.4: Recommended design service volumes (PCUs/hr) ........................................ 64
Table 8.5: Key cross-sectional elements- Minimum widths ......................................... 65
Table 10.1: Capacity and width of Footpaths .............................................................. 73
Table 10.2: Capacity and width of cycle tracks ......................................................... 74
Table 10.3: Length of grades of cycle tracks ................................................................ 74
Table 10.4: Other key considerations while planning/designing cycle tracks: .......... 75
Table 11.1: Desirable modal split for Indian cities ....................................................... 82
Table 13.1: Loss percentage in electrical equipment (please give reference) .......... 86
Table 13.2: Large development classification of Voltage Preferences (please see comment of BEE) ................................................................. 88
Table 13.3: Maximum allowable transformers losses for oil cooled transformers ...... 89
Table 13.4: Recommended capacitor rating for direct connection to induction motors (To improve power factor to 0.95 or better) ................................................................. 92

Table 13.5: Multiplying factor for calculating the sizes of capacitor for power factor improvement ............................................................................................................. 94

Table 13.6: I2R Losses per Phase (in Watts) of Various Sizes (in mm2) of Aluminium Cables of 10 m Length in a 3 Phase System (pl see BEE comment) ........................................ 98

Table 13.7: Voltage Ranges in AC Installations .................................................................................................................. 101

Table 13.8: Typical natural gas fired turbine and cogeneration system ................................................................. 107

Table 13.9: Cogeneration based on diesel generators ................................................................................................. 108

Table 13.10: Cogeneration based on natural-gas-fired gensets .................................................................................... 109

Table 14.1: Street classification and carriageway width ............................................................................................. 112

Table 14.2: Recommended illumination levels and uniformity ...................................................................................... 112

Table 14.3: Recommended energy standards for different road types & carriageway widths .......................................................... 113

Table 14.4: Recommended street light arrangement & pole heights ............................................................................. 115

Table 14.5: Recommended lamp type & wattage & luminaire type ............................................................................ 119

Table 14.6: Analysis of optimized street lighting scheme ........................................................................................ 124

Table 16.1: Electricity output from a 1 MW capacity solar PV power plant at some of the locations in India ........................................................................................................ 132

Table 17.1: Recommended minimum WWR for H/S ratios ....................................................................................... 149

Table 17.2: Envelope .................................................................................................................................................. 150

Table 17.3: Other Parameters - Window Wall Ratio (WWR) .................................................................................... 150

Table 17.4: Minimum Visible light transmission (VLT) Requirement ........................................................................ 151

Table 17.5: Heating Ventilation and Air conditioning (HVAC) Indoor Design Condition ..................................... 151

Table 17.6: Outdoor air requirements ....................................................................................................................... 151

Table 17.7: Lighting .................................................................................................................................................. 152

Table 17.8: Envelope parameters .......................................................................................................................... 153

Table 17.9: Indoor Design Condition ....................................................................................................................... 154

Table 17.10: Outdoor air requirements .................................................................................................................... 154
Table 17.11: Lighting..................................................................................................................154
Table 19.1: Efficiency of Irrigation equipment........................................................................167
Table 20.1: CPCB recommended water quality based designated best use categories......173
Table 20.2: CPCB water quality standards—Chemical constituents.....................................174
Table 20.3: Standards for irrigation ..........................................................................................176
Table 20.4: Water treatment methods based on contaminants ..............................................178
Table 20.5: Water quality standards for irrigation.................................................................186
Table 20.6: Recommended Limits for Constituents in Reclaimed water for Irrigation......187
Table 20.7: Recommended water reuse standards .................................................................190
Table 22.1: Assessment of Technology options for sewage/wastewater treatment........203
Table 22.2: Summary of Water Quality Parameters of Concern for Water Reuse ..........204
Table 25.1: Summary of SUDS Components ........................................................................221
Table 26b 1: Region wise recommended rain water harvesting strategies .......................233
Table 26b 2: Region wise recommended rain water harvesting techniques .......................234
Table 29.1: Schedule I of the Bio-Medical Waste Rules.......................................................254
Table 29.2: Schedule II of the Bio-Medical Waste Rules ......................................................255
Table 31.1: Recommended adaptation measures on the basis of climate impact..............272
List of figures

Figure 1: Per capita carbon emissions in a few Indian cities (2007-08) .................................................. 20
Figure : Estimating Business as usual emissions (transport) ................................................................. 24
Figure Estimating emissions for planned development scenario (transport) .................................. 25
Figure 2.1: Lay out roads and lots in steep slope ................................................................................. 35
Figure 2.2: open space and corridors between development cells or lots ......................................... 35
Figure 2.3: Ideal grading ......................................................................................................................... 36
Figure 2.4: Several small retaining walls can be screened ................................................................. 37
Figure 2.5: Terraced retaining walls break up the mass ....................................................................... 38
Figure 2.6: Strategy to retain existing vegetation of steep site .......................................................... 39
Figure 2.7: Plant trees to screen undesirable views and buffer incompatible uses ......................... 39
Figure 3.1: The soil texture triangle ....................................................................................................... 43
Figure 3.2: Schematically representation of soil profiles based on drainage classes ..................... 44
Figure 8.1: Typical cross sections of the roads .................................................................................... 66
Figure 9.1: Comparison of area used for street among five typical patterns ..................................... 68
Figure 9.2: Some vertical and horizontal speed control measures ....................................................... 70
Figure 9.3: Narrowing measure ........................................................................................................... 70
Figure 9.4: Volume control measures .................................................................................................. 71
Figure 11.1: Conceptual representation - Transit oriented design ....................................................... 81
Figure : Dimming of street lighting installation .................................................................................... 121
Figure 17.1: Analysis to calculate shading ......................................................................................... 142
Figure 17.2: Shading devices ............................................................................................................... 143
Figure 17.3: The horizontal shadow angle and vertical shadow angle ............................................. 143
Figure 17.7: Corelation between height and separation, visible light tranmission and window to wall ratio ................................................................. 148
Figure 22.1: Suggested Water Recycling Treatment and Reuse ....................................................... 199
Figure 22.2: Generalized flow sheet of waste water treatment ......................................................... 202
Figure 25.1: SUDS Management train-adapted from www.ciria.org..........................215

Figure 25.2: Pervious Pavements.................................................................................216

Figure 25.3: Green roof (Source: Karen Liu, PhD, from Proceedings of the Green Rooftops for Sustainable Communities Conference, Chicago, 2003, p.279).........................217

Figure 25.4: Infiltration trench .......................................................................................218

Figure 25.5: Infiltration basin.........................................................................................219

Figure 26b 1: Cross section view of recharge well.........................................................227

Figure 26b 2: View of percolation pit.............................................................................228

Figure 26b 3: Cross section view of recharge trench ....................................................228

Figure 26b 4: View of recharge trench..........................................................................229

Figure 26b 5: Use of common recharge well (Source: Centre for Science and Environment) .........................................................................................................................230

Figure : Hierarchy of integrated solid waste management..........................................239

Figure 28.1: Elements of E-waste management system for India..................................249

Figure 28.2: E-Waste trade value chain.........................................................................250

Figure 31.1: Spatial patterns of maximum and minimum temperature over India........268

Figure 31.2: Trends in annual extreme rain fall over India...........................................269
Rapid urbanization and lifestyle changes of people is leading to a huge growth in the real estate sector, leading to rapidly increasing energy and resource demand.

Part of the all round growth is being reflected in increasing numbers of larger developments and campuses coming up in the country. They comprise of large townships, educational and institutional campuses, medical colleges and hospitals and special economic zones. There are about 585 approved SEZs, 8 new campuses of IITs, and 5 new campuses of IISERs coming up in addition to private sector projects. A large development goes beyond building level and several macro issues need to be addressed if they have to be planned in a green and sustainable way; some them being Socioeconomics, hydrogeology & watershed development, urban ecology, comprehensive energy resource planning with effective utilisation of renewable energy resources, minimisation of infrastructure development, sustainable mobility systems, and project & construction management.

The evolving policy landscape in the country is aggressively trying to address holistic development of environment friendly developments. The National Mission on Sustainable Habitats intends to address this by harmonising Energy Conservation Building Code (ECBC) with building bye laws, mainstreaming efficient transportation modes and solid waste management programmes. The National Building Code of India is introducing a section on Sustainable Buildings and the Low Carbon Strategies for Inclusive growth spearheaded by the Planning Commission lays a road map for low carbon growth in the country. The Solar Cities programme of this Ministry is another flagship initiative to mainstream energy efficient solar cities.

The Ministry has been promoting Green Building and GRIHA Rating System through some promotional incentives under which 117 projects have been registered with 4.98 million sq. m built up area. Association for Development and Research of Sustainable Habitats (aDaRSH), an independent registered society for promotion and implementation of GRIHA rating system in the country, has been created to promote this. All Central Government Buildings are to be constructed as green buildings with GRIHA rating. The Ministry is providing financial support for capacity building, awareness, exemption in rating-cum-evaluation fees, promotional incentives for architects, engineers etc. under the scheme.

Complementing these efforts the Ministry of New and Renewable Energy in association with aDaRSH (Association for Research and Development on Sustainable Habitats) and with help of TERI has now formulated “Draft Guidelines and benchmarks for green large area developments such as townships, neighbourhoods, educational and institutional campuses, special economic zones and medical college hospitals” under the guidance of a Technical Advisory Committee (TAC). These guidelines will be useful for developing a campus townships as a “Green Campus/Townships” and should serve as a great learning resource and help the different stakeholders to construct “Green Campus/ Townships”, which has indeed become the need of the hour in our quest for a sustainable urban habitat. We would appreciate your valuable comments and inputs.

(Deepak Gupta)
Developments of Guidelines and Benchmarks for Green Large Area Developments

Technical Advisory Committee (TAC):

1. Dr. Bibek Bandyopadhyay, Advisor (Solar), MNRE- Chairman
2. Ms. Mili Majumdar, Director, TERI
3. Shri Rahul Sharma, ASSOCHAM
4. Shri S.L. Singhal, Export Promotion Council
5. Mr. Jay B. Kshirsagar, Chief Planner, Town and Country Planning Organisation, Representative of M/oUD
6. Representative of Delhi Urban Arts Commission
7. Mr. Girija Shankar, Assistant Energy Economist, Representative from Bureau of Energy Efficiency
8. Mr. Manit Rastogi, Managing Director, Morphogenesis
9. Shri Tanmay Tathagat, Director, Environmental Design Solutions
10. Shri Ashok B. Lall, Sr. Architect, Delhi
11. Shri Anupam Yog, Mirabilis Advisory Services
12. Mr. Sanjay Sinha, Head Infrastructure, Mahindra World City, Jaipur
13. Emaar MGF, Delhi
14. Dr. Ashvini Kumar, Director (ST), Ministry of New and Renewable Energy
15. Dr. Arun K Tripathi, Director (ST), Convener, Ministry of New and Renewable Energy

Special invitees:

1. Shri Brijesh Kumar, Ex CEO, Greater Noida Authority
2. Prof Kuldip Chander, Ex Professor and Head, School of Planning and Architecture
3. Shri Ajit K Gupta, Ex- Advisor, MNRE
Team members

[A] ADaRSH & TERI
1. Akshima T. Ghate
2. Amit Kumar
3. Divya Sharma
4. Gaurav Shorey
5. Hina Zia
6. Mili Majumdar
7. Nitish Poonia
8. Parimita Mohanty
9. Pradeep Kumar
10. Rana Pratap Poddar
11. Richa Tandon
12. Shabana Charania
13. Sonia Rani
14. Sudipta Singh
15. Tarun Garg

1. Dr. B. Bandyopadhyay, Advisor
2. Dr. Arun Kumar Tripathi, Director
3. Mr. Hiren Chandra Borah, Scientist ‘B’
[C] **Experts consulted**

1. Mr. Subhash Deshpande, Director Plumbing IAPMO India
2. Mr. Rajesh Bansal, Addl. Vice President, BSES
3. Mr. John Brent, Armstrong
4. Dr. A. K. Gosain, Professor & Head, Dept. of Civil Engineering, IIT Delhi
5. Professor (Dr.) Souro Joardar, Architect & Urban Planning Expert
6. Ms. Anita Tikoo, Landscape Architect, Vinyas

[D] **Cover credits**

1. Nitish Poonia
2. Soumitree Devadutt

[E] **Report formatting and secretarial assistance**

1. Dharmender Kumar
2. Mahanand Joshi
Introduction

The Ministry of New and Renewable Energy entrusted ADaRSH with the formulation and development of guidelines and benchmarks for Large Developments including educational institute campuses, housing societies and townships, residential campuses, etc.

Objective of Study

The broad objectives of the study are:

- To study and analyse trends in large campus development guidelines both nationally and internationally.
- To assess the trends in large campus developments in India and analyse our national and local requirements
- Based on the above, to formulate a set of guidelines and benchmarks to be followed by project proponents when developing large campuses.

Background and overview

An increasing number of people in India are migrating to the cities today. In order to accommodate pressures of urbanization, India is undergoing large-scale development in all spheres; particularly in the real estate sector, wherein the energy and resource demand is increasing rapidly. Higher incomes have given rise to higher demand for real-estate development for investment purposes, thereby adding to the stress on the environment. With increasing urbanization and rapid rise in improving individual’s economic levels and consumption pattern in many parts of India, there is an increasing trend to consume more natural resources per capita. This is evident from the aspirational lifestyles and resulting in changing tastes and expenditure patterns of individuals and societies. This is equally witnessed from modern construction needs and changing sky lines of metros and tier 2 and even tier 3 cities. This is constantly putting up tremendous pressure on fragile ecosystem by over extraction of natural resources finally affecting bio diversity of our planet. Increasing demand supply gaps and depleting environmental conditions is increasing awareness on need for environment friendly constructions. To achieve this, it is predominantly important to have to accept major challenge in controlling and judiciously using natural resources to shrink ecological foot print. This is known as carbon foot print, a measure to understand our consumption patterns. The way to achieve this is by holistically planning our growth needs, one of which is construction and combining them with need based economy, but at the same time without compromising on essential comforts, functionality and adaptability of buildings for acceptable levels of suitability. The changing policy landscape in the country
Guidelines and benchmarks for Green Large Area Developments Final report

is aggressively trying to address these concerns in a holistic fashion. The National Mission on Sustainable Habitats intends to address this by harmonising Energy Conservation Building Code (ECBC) with building bye laws, mainstreaming efficient transportation modes and solid waste management programmes. The National Building Code of India is introducing a section on Sustainable Buildings and the Low Carbon Strategies for Inclusive growth spearheaded by the Planning Commission lays a road map for low carbon growth in the country.

Buildings consume significant amount of energy in their construction, operation and maintenance. Globally, about 40% of energy consumption is estimated to be in the building sector. An estimated 42% of the global water consumption and 50% of the global consumption of raw materials is attributed to buildings when taking into account the manufacture of materials, construction, and operation of buildings through their life. In addition, building activities contribute an estimated 50% of the world’s air pollution, 42% of its greenhouse gases, 50% of all water pollution, 48% of all solid wastes and 50% of all CFCs to the environment. India too faces similar challenges in its fast growing construction sector.

The sector has now begun developing large-scale projects that offer multiple product options as a part of a single package. So, for instance, a housing project may offer lifestyle facilities such as on campus club-houses, gymnasium, swimming pools, convenience stores, etc. There are an increasing numbers of such large developments coming up in the country.

They comprise

1. Large (mixed-use) townships,
   - Housing societies
   - Complexes of Housing boards
   - Housing complex by Builders
   - Housing complexes by Urban development organizations
   - Public Sector Undertaking Townships (designs are controlled and complete in all respects)
   - Private developer township,
   - plotted developments with part construction by the developer
2. Educational and institutional campuses,
3. Medical colleges and hospitals and
   - Hospital complexes (eg: AIIMS)
4. Special economic zones.
5. Hotels/ resorts

When a large project is planned and implemented it comprises multiple buildings and other infrastructural facilities, on a single site. Environmental
Performance assessment for such projects can go beyond the environmental design of each building, and calls for assessment of larger environmental issues, and their effects that are brought out by the built environment.

Some of these macro parameters that apply to such developments at various scales are

Environmental Planning,

1. Planning,
2. Landscape Architecture,  
   - Ecology,  
   - Environmental design & Urban Agriculture,  
   - Agronomy,
3. Socioeconomics,  
4. Water resources,  
   - hydrogeology &  
   - watershed development,  
   - Water including recycling and recharging,
5. Mobility systems,  
6. Urban Design,  
   - Architecture,  
   - Structures and construction systems,
7. Risk Mitigation & Climate change,
8. Sustainability & Long-range planning,
9. Project & Construction Management
10. Energy and energy systems  
    - HVAC including co-generation and tri-generation,  
    - Renewable and passive energy,  
    - Power systems including smart grids

Thus, depending on the large development typology as explained above, the applicability of guidelines shall vary. In the wake of addressing the issue of climate change, reducing the dependence on fossil fuels by increasing the share of renewable energy and energy efficiency measures the development of green campuses is imperative today.

**Large development status in India today**

The real estate sector in India is among the best performing financially and invites several thousand crores of investments every year. All major industrial houses in India are now expanding their businesses to include real estate development in their corporate roster. Several first-time developers are venturing in to develop large educational campuses for private universities,
residential townships, commercial centres such as malls and IT Parks, and special economic zones.

Most such projects follow no set guidelines for sustainable design, planning and development and the current set of codes and standards, although comprehensive in their nature are looked upon as mutually exclusive.

It is to address and counter this situation that a comprehensive set of inclusive and integrated guidelines are proposed to address large developments across the country.

**Methodology**

Our methodology falls under the ‘applied research’ category and follows the below-mentioned steps:

1. Formulating the guideline objectives
2. Literature review
3. Developing the objectives
4. Preparing the guideline design
5. Development of Guidelines and benchmarks for Green Large Area Developments

The steps in the methodology have been elucidated below.

**Formulating the guideline objectives**

The general approach to the study involves identification of a possible problem, and then to analyze how best a solution can be formulated to solve the same. Our methodology attempts being aspiration based (trying to address what we are aspiring for, or trying to move towards) rather than problem-solution based (which is inherently unsustainable).

For instance, occupant health is a direct outcome of Indoor Environmental Quality, however, IEQ is also dependent on outdoor environmental quality, which is largely ignored in India, but great impetus is given to it in EU and other developed countries. Outdoor environmental quality is greatly impacted by on-site transport planning, green cover, building-to-building spacing, local GHG / pollutant emission sources, localized sources of odors, etc.

As can be seen in the list below, the subjects covered in similar studies overseas have addressed the following issues:
1. Better land use and planning
2. Preventing and reducing noise and protecting quiet areas
3. Improving urban transport
4. Improving water quality
5. Increasing energy efficiency and use of renewable energy
6. Reducing greenhouse gas emissions
7. Improving outdoor air quality
8. Improving waste management
9. Increasing biodiversity and green space
10. Better local governance

We thus begin by understanding what we want to achieve via this exercise and how each one of the guidelines / benchmarks developed by us shall impact one / several aspects of large developments, such that they end up being sustainable. The following summarizes some of the aspects of this adopted approach:

1. Response to local context – This includes understanding and responding to the following
   - Local natural-resource environment and response to the same – resource mapping and detailed site planning exercises to determine response to site geology, topography, hydrology, flora and fauna, etc.
   - Local socio-economic environment and response to the same – need identification of the project in a given area, will it enhance or degrade the current environmental setting (will it lead to a rapid transition from rural to urban, or natural to build).
   - Local climate conditions and response to the same – what kind of design interventions shall be suitable as a response to the local climate? This shall include landscape design, hydrology, master planning, broad architectural interventions.
   - Local built environment and response to the same –
     - What kind of air-quality exists around the site? What kind of water quality exists there?

2. Urban planning and design concerns – what ideal approach can be adopted to ensure that the site is designed (master planned) in a manner
as to inherently be sustainable for the proposed (immediate) and future constructions.

3. Energy efficiency concerns – What is the ideal approach to energy management in a large sustainable development/project?

- Visual comfort requirements in buildings and outdoors and how large scale design interventions influence the same
- Thermal comfort requirements in buildings and community spaces and how large scale design interventions influence the same, including energy resource planning and Renewable energy integration.
- Benchmarking the energy consumption of the entire development for sustained use.
- Possibility of on-site energy generation for net zero energy including solar, wind and cogeneration / tri-generation
- Transport energy efficiency and kind of mobility systems that can be employed for maximum energy conservation
- Embodied energy at the site level (site clearing, excavation, leveling, etc.) and how that can be minimized.

4. Water efficiency concerns – What is the ideal approach to water resource management in a large sustainable development/project?

- What hydro-geological conditions prevail on site? What kind of intervention would require little or no alteration of the existing conditions, to retain the natural flow of water on site?
- What is the level of the ground water table? Can a strategy be adopted to sustain the prevailing level of the water table over the entire life cycle of the project?
- Benchmarking for sustained water use on site.
- How productively can the waste water be utilized on site? Can the waste water be completely used on site and not need any off-site disposal?

5. Social development – what concerns should be addressed as to ensure the implementation of the millennium development goals in the large project.

**Literature Review**

The next step was to review all the literature on our research problem. This included international documents on the sustainability of large developments, as
well as national documents that pertain to large development projects. (Detailed literature review is attached as Appendix 1)

The literature survey helped us understand the approach adopted by various other countries as well as our own so far with respect to large developments.

**Developing the research objective and formulation of the guidelines**

The research objectives defined helped detail the exact guidelines and what they set out to achieve. These were then be divided into sub-objectives that will work on the specific details within each objective. The objectives eventually translated into formulating the final ‘guidelines’ for large developments.

The guidelines have been elucidated under following heads with two primary goal setting exercise prior to adoption of guidelines;

The goal setting is done for:

1. Carrying capacity based analysis to assess the optimum population the site can hold
2. Targeted carbon footprint of the development

**Guidelines for Green Large Area Developments**

Section A: Sustainable site selection and planning

Section B: Socio-economics

Section C: Mobility systems

Section D: Energy efficiency and renewable energy

Section E: Water and wastewater management

Section F: Solid waste management

Section G: Risk mitigation/adaptation and Climate Change
Sustainability Goal Setting for large developments

Prior to moving on the section on Guidelines for large development, goal setting is very important. The overarching goal of course, remains the achievement of sustainability in every aspect. There are two key activities which a developer of large development needs to take prior to designing for buildings and physical infrastructure. These are:

1. Carrying capacity based analysis to assess the optimum population the site can hold
2. Targeted carbon footprint of the development

Goal 1: Carrying Capacity Analysis to arrive at optimum population and green cover

The intent of this exercise is to do carrying capacity based analysis to assess the optimum population that the site can hold using critical environmental parameters of ‘water availability’ and ‘green cover made available per capita’

Apply the concept of carrying capacity to understand the population that the land can carry for development of large campuses, the basic intent being to retain the quality of urban environment as much as possible while calculating carrying capacity in terms of water and green cover available to the population who would reside in the campus.

The objective of the carrying capacity assessment is to:

1. Arrive at allowable population density
   And /Or
2. FAR

In other words, the objective of carrying capacity is to be assess how much more population a town / city / site in question can hold by densification, redevelopment, infrastructure up gradation singularly or in various combinations with available water and without disturbing the optimum greens.

Once the optimum population is decided it would be compared with the allowable FAR/ population density of the site to see and the variation be noted.

The determining factor for assessment would be;
1. Water- Quantum of municipal supply, other sustainable source of water available.

2. Green Cover- Total per capita green cover available/made available on site

**Introduction:**

300 million people live currently in Indian towns and cities, and within 25 years it is expected that another 300-400 million people will be added to this number (11th five year plan). As per McKinsey (2010) the urban population in India is expected to reach 590 million by the year 2030.

Increasing population coupled with continued urbanization is likely to result in the emergence of about 60-70 cities with population of more than a million by 2030. In the past five years, the Central government has focused a lot on the development of SEZs and new towns. As many as 439 SEZs have been approved in principle, out of which 198 had been notified till 8 March, 2008 (MoUD website as on 8th November, 2010). Apart from these, other new towns like—Dholera in Gujarat, Dighi in Maharashtra, new towns on Manesar-Bawal corridor in Haryana, Indore-Mhow corridor in Madhya Pradesh, and Nasik-Igatpuri corridor in Maharashtra—have been conceived on a grand scale. For example, at 900 sq km, town Dholera is envisioned to be six times bigger than Chandigarh city.

Emergence of these new cities and the growth of the older ones are bringing in complex changes to ecology, natural resources and environment at local, regional and global scales. It is high time we pay heed to our planning practices and guidelines that are followed to plan our cities and make them in such a way that they promote sustainable development with little impact on environment quality. Of particular importance is the availability of water and green areas to ensure quality of life, health and environmental benefits to the population to reside.

Many concepts are available that address this need, to measure the cause and magnitude of changes that rapid urban growth has brought about, carrying capacity concept being one of them.

---

1. 2010. India’s Urban Awakening. McKinsey Global Institute
Carrying Capacity Concept:

Planners define carrying capacity as the ‘ability of a natural and artificial system to absorb population growth or physical development without considerable degradation or damage’ (K.Oh et al, 2005). Carrying capacity is also said to be the ability of natural and manmade systems to support the demands of various uses and subsequently refers to inherent limits in the systems beyond which instability, degradation or irreversible damage occurs (K.Oh et al, 2005). In terms of settlement planning, it is defined as the level of human activities, population growth, land-use, physical development which can be sustained by the urban environment without causing serious degradation and irreversible damage (K.Oh et al, 2005).

The concept has been widely used in calculating carrying capacity of tourism activities in a particular area (Sonak, 2004), regional carrying capacity assessments (Graymore, M.L.M, et al; 2008, 2010), carrying capacity assessment for recreational land use, assessing ecological sustainability of land-uses in semi-arid regions (Kessler, 1994), determination of density using the urban carrying capacity assessment system (Oh, K.; 2005), carrying capacity analysis to function as a basis for determining building permit allocation in the future (Clarke, 2002) etc.

The concept when applied to human carrying capacity for sustainable agricultural land-use is based on the sustainable supply of natural resources and on resilience thresholds of ecosystem. The level of maximum sustained exploitation of natural resources can also be expressed as maximum sustainable agricultural production levels, or sustainable population densities based on such production levels (Kessler, 1994). Of all the use the concept is thus far put to, the usefulness lies in the fact that it allows the comparison of regions with respect to their potential to sustain human populations on the basis of the sustainable supply of natural resources limiting land use.

The concept is easy to use, needs minimum data inputs and is a quick ready tool for assessment of population threshold on the basis of key parameters or

---

Guidelines and benchmarks for Green Large Area Developments Final report

Integration of several critical parameters on which the site’s sustainability would depend.

**Elements for considering Carrying Capacity – Available Water and Green Cover**

**Water**

Even though provision of safe drinking water in urban areas has increased, still in terms of absolute numbers a large population remains unserved. About 10% population still lacks access to safe drinking water in urban areas (26.8% in rural). Moreover, this coverage does not ensure equitable distribution in adequate amount and majority lives with inequitable access. This is evident with high disparity in the per capita water availability amongst various cities as well as within the cities. For instance, while the city of Triuvannamalai gets 584 lpcd (liters per capita per day), Tuticorin gets only 9 lpcd.

The following table gives an account of per capita supply in class I and class II cities in various Indian States:

**Table I: Per capita supply in class I and class II cities in various Indian States**

<table>
<thead>
<tr>
<th>Serial number</th>
<th>State</th>
<th>No of class I cities</th>
<th>Per capita water supply in class I cities</th>
<th>No of class II cities</th>
<th>Per capita water supply in class II cities</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Andaman and Nicobar</td>
<td>1</td>
<td>139.93</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2</td>
<td>Andhra Pradesh</td>
<td>47</td>
<td>109.47</td>
<td>52</td>
<td>78.88</td>
</tr>
<tr>
<td>3</td>
<td>Assam</td>
<td>5</td>
<td>301.66</td>
<td>8</td>
<td>131.84</td>
</tr>
<tr>
<td>4</td>
<td>Bihar</td>
<td>23</td>
<td>218.23</td>
<td>17</td>
<td>120.56</td>
</tr>
<tr>
<td>5</td>
<td>Chandigarh</td>
<td>1</td>
<td>540</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>6</td>
<td>Chhatisgarh</td>
<td>7</td>
<td>174.18</td>
<td>7</td>
<td>90.15</td>
</tr>
<tr>
<td>7</td>
<td>Delhi</td>
<td>1</td>
<td>292.49</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>8</td>
<td>Goa</td>
<td>1</td>
<td>100.06</td>
<td>2</td>
<td>100.03</td>
</tr>
<tr>
<td>9</td>
<td>Gujarat</td>
<td>28</td>
<td>143.15</td>
<td>31</td>
<td>130.45</td>
</tr>
<tr>
<td>10</td>
<td>Haryana</td>
<td>20</td>
<td>142.59</td>
<td>7</td>
<td>91.32</td>
</tr>
<tr>
<td>11</td>
<td>Himachal Pradesh</td>
<td>1</td>
<td>221.3</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>12</td>
<td>Jammu and Kashmir</td>
<td>2</td>
<td>140.01</td>
<td>4</td>
<td>142.21</td>
</tr>
<tr>
<td>13</td>
<td>Jharkhand</td>
<td>14</td>
<td>209.12</td>
<td>10</td>
<td>118.31</td>
</tr>
</tbody>
</table>
### Guidelines and benchmarks for Green Large Area Developments Final report

<table>
<thead>
<tr>
<th>Serial number</th>
<th>State</th>
<th>No of class I cities</th>
<th>Per capita water supply in class I cities</th>
<th>No of class II cities</th>
<th>Per capita water supply in class II cities</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>Karnataka</td>
<td>33</td>
<td>148.19</td>
<td>26</td>
<td>162.05</td>
</tr>
<tr>
<td>15</td>
<td>Kerala</td>
<td>8</td>
<td>190.28</td>
<td>26</td>
<td>97.27</td>
</tr>
<tr>
<td>16</td>
<td>Madhya Pradesh</td>
<td>25</td>
<td>144.6</td>
<td>23</td>
<td>93.77</td>
</tr>
<tr>
<td>17</td>
<td>Maharashtra</td>
<td>50</td>
<td>310.09</td>
<td>34</td>
<td>106.74</td>
</tr>
<tr>
<td>18</td>
<td>Manipur</td>
<td>1</td>
<td>173.81</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>19</td>
<td>Meghalaya</td>
<td>1</td>
<td>140.03</td>
<td>1</td>
<td>172.11</td>
</tr>
<tr>
<td>20</td>
<td>Mizoram</td>
<td>1</td>
<td>140.01</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>21</td>
<td>Nagaland</td>
<td>1</td>
<td>139.98</td>
<td>1</td>
<td>139.98</td>
</tr>
<tr>
<td>22</td>
<td>Orissa</td>
<td>12</td>
<td>247.59</td>
<td>12</td>
<td>108.38</td>
</tr>
<tr>
<td>23</td>
<td>Pndicherry</td>
<td>2</td>
<td>140</td>
<td>1</td>
<td>125.24</td>
</tr>
<tr>
<td>24</td>
<td>Punjab</td>
<td>19</td>
<td>290.24</td>
<td>14</td>
<td>177.31</td>
</tr>
<tr>
<td>25</td>
<td>Rajasthan</td>
<td>24</td>
<td>179.78</td>
<td>21</td>
<td>115.53</td>
</tr>
<tr>
<td>26</td>
<td>TamilNdu</td>
<td>42</td>
<td>79.9</td>
<td>42</td>
<td>70.93</td>
</tr>
<tr>
<td>27</td>
<td>Tripura</td>
<td>1</td>
<td>139.97</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>28</td>
<td>Uttar Pradesh</td>
<td>61</td>
<td>170.12</td>
<td>46</td>
<td>127.77</td>
</tr>
<tr>
<td>29</td>
<td>Uttarakhand</td>
<td>6</td>
<td>177.06</td>
<td>1</td>
<td>163.26</td>
</tr>
<tr>
<td>30</td>
<td>West Bengal</td>
<td>60</td>
<td>187.88</td>
<td>27</td>
<td>112.53</td>
</tr>
</tbody>
</table>

Average

Source: 2009. “Status of water supply, wastewater generation and treatment in class I cities and class II towns in India”, Control of urban population series CUPS/70/2009 - 10, Central Pollution Control Board, Delhi.

In large developments water availability is often a problem. We relate here the amount of water available with the population planned for the development to see whether the water available is sufficient for the planned population. In case of insufficient water availability for planned population, either ground water is used or water has to be brought from far off places at huge costs, both environmental as well as fiscal.

**Green Cover**

Benefits of urban green spaces are many. They not only provide for physical and psychological health, but promote social cohesion, helps in climate change
mitigation and pollution abatement besides helping in conservation of ecosystem and biodiversity. Wherever growing construction activities are rapidly engulfing large agricultural land and destroying green fields in the process a conscious effort is needed to plan and provide for green spaces in large developments to avoid damage to environment as well as to provide benefits of nature.

We propose optimum green space to be provided per capita. Very few standards exist that could be followed for this. There are some international standards but their applicability in Indian context is yet to be studied and proved. However WHO’s standard of 9 m\(^2\) could be used as they are based on overall health factor.

Various international examples exist where standards and norms for urban green spaces have been fixed. For example in Germany and Japan, a 140 m\(^2\) suburb forest area per capita is proposed to reach a balance of carbon dioxide and oxygen besides meeting the ecological balance. Studies show that developed countries have remained within the limit of 20 m\(^2\) park area per capita. Way back in the year 1943-44, it was suggested for the city of London, that 1.62 hectares of open space be provided per 1000 population (16.2 m\(^2\) per capita). However, great variations exist in the per capita norms and standards around the world which are summarized in the table given below:

**Table II: Urban green space/forest cover provided in various countries**

<table>
<thead>
<tr>
<th>Region/country</th>
<th>Estimated urban green space/forest cover</th>
</tr>
</thead>
<tbody>
<tr>
<td>Europe</td>
<td>18% average woodland cover. 18.5% cover within municipal limits which is about 104 m(^2) per capita.</td>
</tr>
<tr>
<td>France/Paris</td>
<td>80 m(^2) of urban forest per inhabitant in greater Paris region</td>
</tr>
<tr>
<td>The Netherlands</td>
<td>228 m(^2) per capita green space cover</td>
</tr>
<tr>
<td>Australia/Canberra</td>
<td>80 m(^2) per capita crown cover</td>
</tr>
<tr>
<td>USA</td>
<td>32 m(^2) per capita green space cover</td>
</tr>
<tr>
<td>China/Nanjing/Wuhan</td>
<td>44.3 m(^2) per capita in Nanjing and 10.3 m(^2) per capita in Wuhan</td>
</tr>
<tr>
<td>Hong Kong</td>
<td>3 m(^2) per capita green space cover</td>
</tr>
<tr>
<td>Singapore</td>
<td>7.5 m(^2) per capita green space cover</td>
</tr>
</tbody>
</table>
### Guidelines and benchmarks for Green Large Area Developments Final report

<table>
<thead>
<tr>
<th>Region/country</th>
<th>Estimated urban green space/forest cover</th>
</tr>
</thead>
<tbody>
<tr>
<td>India/Delhi</td>
<td>21 m² per capita average tree and forest cover is present</td>
</tr>
<tr>
<td>India/Chandigarh</td>
<td>55 m² per capita average tree and forest cover is present</td>
</tr>
</tbody>
</table>


In India, the UDPFI guidelines propose an overall town level recreational facilities standards as 10 m² to 12 m². They do not, however, propose any standard for green space alone. This includes open space such as specified parks, amusement parks, maidan, multipurpose open space botanical garden and zoological parks and even traffic parks. This also includes sports centre and sports complex at district and sub city centre level respectively. Similarly in Delhi Master Plan, open space at the neighbourhood level is designated to be 4.5 m². The green cover is to be provided at the rate of 15% of the total land, excluding the ridge/regional park in Delhi. This 15% would include formal parks as well as woodlands and incidental greens for balancing the environment. This excludes specialized parks like biodiversity parks, plantation along the roads, drains, riverbanks etc. Similarly, the Master Development Plan of Jaipur proposes to reach a per capita open space of 8.80m² by the year 2025 from the present average of 1.60 m² per capita.

However, in absence of any set standard for Indian cities, and also considering the wide geographical variations and so varying green cover, we propose a minimum standard of 9 m² to be provided by all the developers. This is also considering the fact that all these available norms comply to a city level scale.Large campus, in our case, would be a unit much below a city scale.

**Methodology:**

The methodology to assess the optimum design population is given as follows:

**Carrying Capacity of Available Water: Calculation for water supply**

1. Per capita standard for study area(X)-( Ranging from 70 lpcd to 130 lpcd)(UDPFI guidelines). Developer may use development regulations specific to city or town where the site is located)

2. Total water availability(Y)=Quantum of municipal supply and /or available sustainable local sources of water
3. Assumed 20% loss by leakage*

4. Population that can be supported by this water = Z1 = Y/X (where y is converted in liters)

5. Z1 ≥ population planned for the development

Note 1: It is assumed here that the total municipal supply should cater to the following usage - Domestic, landscape and process (HVAC etc). If the municipal supply cannot suffice all the three usage mentioned, then the developer must be able to show recycled water capacity on site to cover this up. It is not encouraged to use ground water if municipal supply or any other sustainable source is available.

Note 2: Where ground water is the prime source of water, the developer must make an assessment of water table levels and thus the available water on site. Ground water equivalent to allowable per capita lpcd (depending on the standards of the city in question) should only be extracted. Any demand beyond this should be made available through recycle, reuse and recharge facility. Artificial recharge systems would have to be essential elements where ground water is the prime source of water.

**Estimation of Green Cover**

1. Population planned for the site = (X)

2. Total green cover = (Y) *(where, Y = canopy cover made available on site (Tree cover and urban forests). This excludes, paved and non-paved urban parks with grass cover, shrubs, ornamental trees, non-green open spaces like playfields, jogging tracks, roads, paved pathways, and parking space)*

3. Per capita green space made available = Z2 = Y/X sqmts/capita

4. Z2 ≥ 9 m²/capita (WHO standard)

5. The green cover has to be provided for total fixed population for which the large development is designed. The green cover has to be provided on ground. Incase if the available ground space is inadequate, measures such as vertical greens and roof top green shall be provided for, to meet the norms.

*Derived from service level benchmarks for Non Revenue Water of the Ministry of Urban Development, Government of India.*
Interpretation of Assessment made-

1. The population planned within the development should optimally not exceed the population figure estimated depending on the water availability.

2. The green cover provided per capita should be greater than or equal to the WHO standard provided.
Goal 2: Setting target for reduction of carbon footprint

Carbon footprint is defined as the total ‘carbon dioxide equivalent’ (CO2e) emissions released from energy use within a development / city / state / country / sector.

In the context of increasing concerns about climate change impacts of increasing levels of carbon emissions in atmosphere, it has become critical to plan for low-carbon growth of urban areas as they contribute towards a significant share of carbon emissions. Retrofitting exiting urban settlements to reduce their carbon impact is a daunting task for the city planners; however, the new urban developments that are coming up in the country can make a contribution towards achieving the goal of low-carbon growth. To do this, the new developments have to be planned in a manner that they minimize use of fossil fuels to sustain the activities that are planned to come up within their premises. The key interventions that can be taken include:

1. Reducing and optimizing energy use in buildings
2. Reducing and optimizing energy use in provision of services like water pumping, etc.
3. Promoting use of alternative clean fuels like solar energy, wind energy, etc.
4. Reducing use of personalized motorized transport within the development by-
   - Providing adequate and quality infrastructure for walking and cycling
   - Providing mass transport options that run on clean fuels
   - Promoting use of clean fuels in personal vehicles by providing adequate supporting infrastructure for use of clean fuels

The sections on building energy use, mobility planning, etc. discussed later in detailed guidelines give guidance on planning the above-discussed interventions.
Why promote low carbon growth?

- Increasing carbon emissions due to developmental pressures
- Impact in terms of climate change, a global concern

Low carbon growth gives-

- Direct carbon reduction benefits, and
- Co-benefits like improved local environmental quality, health, safety, etc.

New urban developments should promote low carbon growth i.e. minimize

Large developments should set goals for reducing carbon emissions. A carbon footprint reduction target should be set by either:

1. Setting a baseline emission scenario on business as usual (BAU) and fixing a reduction target as against the BAU (e.g. 30% reduction in per capita carbon emissions as compared to the BAU), or

2. Considering the national/similar population size city’s per capita carbon footprint and fixing a reduction target in reference to these values (e.g. per capita carbon footprint would not exceed national/identified city’s average, per capita carbon footprint would be half of national/identified city’s average, etc.)

Once, a carbon footprint reduction target has been set, the developer in discussion with all the consultants shall aspire to design the large development to achieve the targeted carbon footprint. While designing/planning the development to achieve these goals, it is recommended that the developers/consultants measure the reduction in carbon savings that will be achieved as compared to a conventional approach. This implies measuring carbon footprint of the planned developments.
Framework to measure carbon footprint

The per capita carbon estimate for India in 2008 was 1.18 tonnes, nearly one-fourth of the corresponding global average of 4.38 tonnes. Per capita carbon footprint estimates for various Indian cities in 2007-08 as given in a study done by ICLEI can also be referred to depending on the similarity of the large development (in terms of population size, economic structure, etc.) to the listed cities (Figure I).

![Figure I: Per capita carbon emissions in a few Indian cities (2007-08)](image)

1. Estimate the total energy consumption within the development (when it will be fully operational). It should be noted that energy consumption that is in control of developer should only be included in the energy consumption estimate.
### Table III: Energy consumption for the following activities needs to be estimated:

<table>
<thead>
<tr>
<th>Activity</th>
<th>Total Energy consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building operations (buildings that are being developed by builder)</td>
<td>Electricity – from grid</td>
</tr>
<tr>
<td></td>
<td>Electricity – from off-grid sources (diesel/ kerosene generators, solar/wind energy, etc.)</td>
</tr>
<tr>
<td>Provision of services</td>
<td>Electricity – from grid</td>
</tr>
<tr>
<td></td>
<td>Electricity – from off-grid sources (diesel/ kerosene generators, solar/wind energy, etc.)</td>
</tr>
<tr>
<td></td>
<td>Other sources – LPG, natural gas, diesel, etc.</td>
</tr>
<tr>
<td>Transportation within the development</td>
<td>Petrol</td>
</tr>
<tr>
<td></td>
<td>Diesel</td>
</tr>
<tr>
<td></td>
<td>CNG</td>
</tr>
<tr>
<td></td>
<td>Auto-LPG</td>
</tr>
<tr>
<td></td>
<td>Electricity – from grid/ off-grid sources</td>
</tr>
<tr>
<td></td>
<td>Others</td>
</tr>
<tr>
<td>Electricity generation (if electricity is being generated on-site)</td>
<td>Fossil fuel consumption for electricity generation</td>
</tr>
</tbody>
</table>

2. Estimate the carbon emissions from energy use

In order to estimate the carbon emissions from energy use, the total energy consumption figures obtained in the previous step need to be multiplied by respective emission factors and the derived carbon emissions then need to be summed up. Tables below give values for India-specific emission factors.

\[
CF = \sum_{i} E_i \times EF_i
\]

where,
Guidelines and benchmarks for Green Large Area Developments Final report

CF = Carbon Footprint (tonnes CO2e)

E = Energy consumption (GJ)

i = Energy type (electricity, petrol, diesel, CNG, etc.)

EF = Emission factor specific to fuel type ‘i’ (tonnes CO2e/GJ)

Table IV: Electricity emission factors (Weighted average emission factor of all Indian regional grids for FY 2009-10 in tCO2/MWh)

<table>
<thead>
<tr>
<th>Region</th>
<th>Emission Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>NEWNE</td>
<td>0.82</td>
</tr>
<tr>
<td>South</td>
<td>0.75</td>
</tr>
<tr>
<td>India</td>
<td>0.81</td>
</tr>
</tbody>
</table>

Source: Central Electricity Authority, 2011

Table V: India-specific CO2 emission coefficients for road transport

<table>
<thead>
<tr>
<th>Categories</th>
<th>CO2/TJ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gasoline</td>
<td></td>
</tr>
<tr>
<td>2W/ 3W</td>
<td>43.9 ± 7.3</td>
</tr>
<tr>
<td>Car/ Taxi</td>
<td>61.5 ± 4.0</td>
</tr>
<tr>
<td>Diesel Oil</td>
<td></td>
</tr>
<tr>
<td>MCV/HCV</td>
<td>71.4 ± 0.55</td>
</tr>
<tr>
<td>LCV</td>
<td>71.4 ± 0.5</td>
</tr>
</tbody>
</table>

Source: NATCOM, India
Table VI: CO₂ emission coefficients for other fuel types

<table>
<thead>
<tr>
<th>Fuel type</th>
<th>Unit</th>
<th>CO₂ emission factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>LPG</td>
<td>kg/TJ</td>
<td>63100</td>
</tr>
<tr>
<td>Motor Gasoline</td>
<td>kg/TJ</td>
<td>69300</td>
</tr>
<tr>
<td>Kerosene</td>
<td>kg/TJ</td>
<td>71900</td>
</tr>
<tr>
<td>Gas/Diesel oil</td>
<td>kg/TJ</td>
<td>74100</td>
</tr>
<tr>
<td>Natural gas/ CNG</td>
<td>kg/TJ</td>
<td>56100</td>
</tr>
</tbody>
</table>

Source: IPCC, 2006

The carbon emissions estimated based on the total energy consumption of the development (when it is fully operational) will indicate the impact that the development has in terms of carbon released. If the developer has proposed design elements/measures that will reduce the carbon impact of the settlement, the carbon savings due to same should be highlighted by the developer in order to indicate his/her commitment to low carbon growth.
Figure: Estimating Business as usual emissions (transport)

1. Total planned population
2. Per capita motorized trip rate
3. Total no. of motorized trips

- Modal distribution of trips (Trips by private, public modes, etc.)
- Apply mode share factor

- Motorized trips by private vehicles & public transport by resident population
- Trip length
- Carbon emission factor

- Carbon emissions from transport
Figure Estimating emissions for planned development scenario (transport)

Per capita motorized trip rate (all modes)

<table>
<thead>
<tr>
<th>City Category</th>
<th>2007</th>
<th>2011</th>
<th>2021</th>
<th>2031</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-10 lakes</td>
<td>0.5</td>
<td>0.5</td>
<td>0.4</td>
<td>0.7</td>
</tr>
<tr>
<td>5-10 lakes</td>
<td>0.4</td>
<td>0.4</td>
<td>0.5</td>
<td>0.6</td>
</tr>
<tr>
<td>10-20 lakes</td>
<td>0.5</td>
<td>0.5</td>
<td>0.6</td>
<td>0.8</td>
</tr>
<tr>
<td>20-40 lakes</td>
<td>0.6</td>
<td>0.7</td>
<td>0.8</td>
<td>0.9</td>
</tr>
<tr>
<td>40-80 lakes</td>
<td>0.7</td>
<td>0.8</td>
<td>0.9</td>
<td>1.0</td>
</tr>
<tr>
<td>80+ lakes</td>
<td>0.8</td>
<td>0.9</td>
<td>1.0</td>
<td>1.2</td>
</tr>
<tr>
<td></td>
<td>1.1</td>
<td>1.1</td>
<td>1.3</td>
<td>1.4</td>
</tr>
</tbody>
</table>

Motorized mode share (targeted)

Modal share targeted for the development
E.g. Higher share of public transport as compared to the BAU

Modal distribution of trips (Trips by private, public modes, etc.)
Apply mode share factor

Motorized trips by private vehicles & public transport by resident population (targeted)
X
Trip length
X
Carbon emission factor

Carbon emissions from transport
Section A: Sustainable Site

Sustainable site is the first step to ensure sustainability of any urban development. In India all the large developments undergo the process of EIA (Environmental Impact Assessment) clearance to facilitate integration of environmental concerns in project development. But for a variety of reason (either due to lack of awareness, capacity or clear legislative framework) the urban environmental concerns are tend to be neglected in large developments in India.

A detailed design guideline/ mitigation measures that can support the site planners/ engineers/ architect and developer to design and execute a sustainable site that will have least adverse impact on the nature/ eco-system of urban fringe has been suggested.

Two major issues that need to be considered to achieve a sustainable site are as follows:

1. Site Selection
2. Site assessment & planning
   a. Topography/slopes
   b. Soil
   c. Water
   d. Bio-diversity/Urban Ecology

I. Site Selection:

The increased developmental pressure on agricultural lands on the immediate surroundings of urban centers has aggregated the problem of degradation of natural environment. The rapid urbanization pays insufficient attention to the conservation of natural ecosystem and as a result ecologically valuable lands are getting converted in to urban spaces in a fast rate. Therefore site selection has a significant impact on the environment in large scale urban developments. This is the first step to control this rapid environmental degradation and ensure sustainability in the large scale project development.
Guideline-1: Select a suitable site to preserve existing natural resources & upgrade environmentally degraded sites.

The increased developmental pressure on agricultural lands on the immediate surroundings of urban centers has aggregated the problem of degradation of natural environment. The rapid urbanization pays insufficient attention to the conservation of natural ecosystem and as a result ecologically valuable lands are getting converted in to urban spaces at a fast rate. Therefore site selection has a significant impact on the environment in large scale urban developments. This is the first step to control this rapid environmental degradation and ensure sustainability in the large scale project development.

Some specific parameters to consider when selecting a site include:

1. Limit development of sites designated as most productive agricultural land by ICAR (Indian Council of Agricultural Research).
2. Avoid development within the 100 year flood plain zone or significant watershed area.
3. Avoid development of areas that contain wetlands including isolated wetlands/ coastal wetlands.
4. Avoid development in the close vicinity of any significant natural or manmade heritage area.
5. Avoid development of sites designated as densely vegetated forest land by FSI (Forest Survey of India) or Indian Council of Forestry Research and Education (ICFRE).
6. Avoid development on land that is designated for threatened or endangered species and their habitats by BSI (Botanical Survey of India) or ZSI (Zoological Survey of India) or WII (Wildlife Institute of India) etc.
7. Encourage selection of environmentally degraded or contaminated land.
8. Encourage sites within existing communities and already developed places.
9. Ensure the project comply with statutory laws and regulatory codes and should follow the development plan or master plan of local government.
Guidance Note:

1. Study the master plan/zonal development plan of the area where the site for large development is proposed. A good look at a Google-earth image/Bhuvan image should be able to assist you in giving valuable insights as to the neighbouring developments around your site, as also the site’s ecological context. Based on this, try and assess if the site conforms to the surrounding land-use patterns, and does not require excessive alteration of the natural or built environment to cater to your site. This way, needless encroachment of arable land or the like can be avoided.

2. Try and avoid projects/strategies where drastically different functions/activities are proposed in areas of a certain predetermined function. For instance, proposing a commercial development (especially one including eateries and restaurants) in a residential zone shall require upgradation of the transportation corridors, sewage and sanitation systems, water supply pipelines, etc. This shall have to be done at the cost of the government/tax-payers and shall also cause nuisance to the residents of that locality. Avoiding such an approach can ensure that the requirements for such disruption are minimized or completely avoided.

3. The project should comply with the provisions of
   - Eco-sensitive zone regulations,
   - Coastal zone regulations,
   - Heritage areas (identified in the master plan or issued separately as specific guidelines),
   - Water body zones (in such zones, no construction is permitted in the water-spread and buffer belt of 30 m minimum around the FTL),
   - Various hazard prone area regulations (Earthquake Prone Areas, Cyclone Prone Areas, Flood Prone Areas, Land Slide Prone Areas, Planning in hill areas etc.) and others if the site falls under any such area

4. Sites for new townships should conduct an analysis of the cultural and historical conditions, the urban context considerations, availability of water and other critical infrastructures like electricity, roads with adequate width and capacity and environmental considerations including ecosystems and bio-diversity.
5. Sites for new developments should be carefully assessed in context of the wider environment, particularly in relation to the habitats dwelling on-site or in adjacent sites. This shall ensure biodiversity protection in the long run along with preservation and protection of -

- Carbon sinks
- Natural micro-climate control mechanisms (tree cover, decreased summer temperatures, etc.)
- Natural control systems for protection against diseases and epidemics
- Agricultural land and food security

6. In addition to the criteria listed above, the proposed project location should meet the standards prescribed by the CPCB (Central Pollution Control Board) and IS (Indian standards) for the following environment parameters.

- Ambient air, water and noise quality standards
- Natural disaster prone areas
- Ecologically sensitive areas

7. The proposed site should be in conformity with the specifically designated use on the ‘development plan’ of the area. This shall help control the level of expenditure required to add infrastructure to spaces that lack it, or to alter areas that are of a particular usage, to another usage. In places where the use of premises is not specifically designated on the development plan, it should be in conformity with the land-use zones in which they fall (as specified by the ‘master plan’).

8. “Resource and needs” assessment of the project should be done at the pre-design stage. Issues which need to be identified at the pre-design and site selection stage are -

- Connectivity to infrastructure and public transport network
- Power requirements and power source
- Water requirements and water source
- Waste management on the site
9. Urban infrastructure and facilities, public transport, infrastructure for power, water supply to meet the estimated requirements, and sewage system network should be made available nearby or should be made available with minimum negative impact on the environment.

- The existing drainage pattern of the proposed site should be surveyed, and the proposed drainage pattern should not alter the existing drainage pattern. It should comply with the existing drainage plan of the place.

- It is desirable to integrate the existing utility and infrastructure, and identify whether additional infrastructure needs to be planned for the proposed project.

10. Efforts should be made to reuse negative urban spaces or industrial sites and environmentally degraded sites, if possible, to reduce the pressure on undeveloped land.

- If possible and justified in terms of sustainable design goals, a site selected should offer the possibility of urban redevelopment (where development is constrained due to environmental pollution or increasing urban pressure) or it should use existing urban infrastructure confirming the desired density goals.

- This, to some extent, will help reduce the perennial pressures on the undeveloped land.

  - Layout and form of the project must conform to the landscape of the area without unduly affecting the scenic features of that place.

  - The impact of proposed future development on the infrastructure should be considered while selecting the site.

**Site Assessment & Planning:**

Natural resource mapping is an integral part of any sustainable large development; it determines the detail layout for the appropriate distribution of land uses in the proposed land. In an overall planning process natural resource mapping occurs after the selection of site and after strategic master planning is taken place as per the project need. The purpose of natural resource mapping is to protect & preserve the most sensitive part of the nature existing in the site and guide entire development (residential, commercial, institutional, industrial or recreational etc.) in such a way that it creates less impact on the environment holistically.
The first stage of the natural resource mapping is to assess the relative importance of the factors/indicators that make up the natural environment. The major natural resources that are relatively important and found in most of the site are topography, soil, water & bio-diversity. Though we know that every site is different and it is the responsibility of the site planner to decide which natural resource need to be preserved or protected.

**Guideline-2: The proposed development should preserve & protect the rare and unique geological and geo-morphological features of the site.**

**Topography:**

The first information that is essential for any site development is the shape of the land surface on which the site is located. It is necessary to understand why the land is the shape it is. Details about the shape of the surface and its slopes also need to be recorded, so that it can be worked out where it is likely to be relatively cheap or expensive to place structures. There natural shape of the land surface (ridge or depression) has always a deep relation with its ecosystem. Therefore it is always recommended that the site developers & planners should always try to retain the natural shape of the site as maximum as possible through various design interventions. Recommendations are:

1. Flat slopes are most suitable for any kind of urban development.
2. Development should be restricted over surface features such as rock faces, steep slopes and screes, which result from geological or geo-morphological processes and should be incorporated wherever possible into the planned development of a site to add to its special sense of place. If at all at any case development has to take place on steep slopes following design strategies need to be followed.
   - Retain existing vegetation on steep slope.
   - Sedimentation & erosion control/ prevention plan.
   - Use open space development, varied lot size & configuration.
   - Roads & lot layouts should complement the site topography.
   - Develop design & engineering strategies to minimize cut & fill of slopes.
   - Phasing in land clearing & construction activity.
   - Employ restoration practices
Guidance Note:

Hillside and steep slope development presents a number of health, safety, and environmental challenges for communities. Hillside or steep slope alteration can lead to increased erosion, landslides, and sedimentation. Development on steep slopes can present greater fire hazards. It is more difficult to control fires on sloped land, in part because it is more difficult to access. Septic systems on steep slopes are highly unreliable due to the slope and shallow soils. Hilltop development presents additional expenses and difficulties in extending and maintaining infrastructure (roads, sewer, water systems, and power lines). Engineering and constructing sewer and water systems are especially difficult. Conversely, protecting hillsides and steep slopes preserves the natural scenic beauty of the native landscape, adds value to property, and provides educational and recreational opportunities. Therefore as per Ian McHarg theory the flat slopes are most suitable for any kind of large developments in terms of optimum utilization of resources and minimum impact on the environment. Therefore it is recommended that the proposed large developments should avoid developments on steep slopes (> 30%). If at certain unavoidable circumstances the development has to be proposed on hilly terrine or steep slopes then the development should strictly follow the developmental guidelines of the local government (“comprehensive plan” or “local landuse regulation”) for the protection of steep slope. Some planning or design strategies are listed below for sustainable construction on hillside or steep slopes. This guideline addresses how to minimize the impact of the development on the natural environment of the site and how to make urban development more compatible with the hillside environment.

Slopes and land uses:

It is difficult to generalize about the suitability of slope environment for landuse. But given information on the physical character of the site and the proposed landuse, useful recommendations can be made on the suitability of residential, commercial or industrial construction techniques, in an effort to minimize deterioration of slopes and streams. Different angles of slope have different implications for development. Table x gives some rough guidance on the link between angle of slope and development potential. Such information can be used to decide which angles of slope are important in relation to a particular landuse planning problem.
Table 2.1: Slopes and land uses

<table>
<thead>
<tr>
<th>Type of land use</th>
<th>Permitted angle of slope</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Maximum</td>
</tr>
<tr>
<td>Streets and drives</td>
<td>8%</td>
</tr>
<tr>
<td></td>
<td>1%</td>
</tr>
<tr>
<td>Parking areas</td>
<td>5%</td>
</tr>
<tr>
<td></td>
<td>1%</td>
</tr>
<tr>
<td>Main footpaths -- bitumen</td>
<td>8%</td>
</tr>
<tr>
<td></td>
<td>5%</td>
</tr>
<tr>
<td>Main ramp on footpath ---short</td>
<td>14%</td>
</tr>
<tr>
<td>Entrance areas</td>
<td>4%</td>
</tr>
<tr>
<td></td>
<td>1%</td>
</tr>
<tr>
<td>Minor footpaths</td>
<td>14%</td>
</tr>
<tr>
<td></td>
<td>5%</td>
</tr>
<tr>
<td>Terraces ---paved</td>
<td>2%</td>
</tr>
<tr>
<td></td>
<td>1%</td>
</tr>
<tr>
<td>Lawns</td>
<td>5%</td>
</tr>
<tr>
<td></td>
<td>1%</td>
</tr>
<tr>
<td>Mown grass banks</td>
<td>33%</td>
</tr>
<tr>
<td></td>
<td>--</td>
</tr>
<tr>
<td>Planted slopes</td>
<td>50%</td>
</tr>
<tr>
<td></td>
<td>--</td>
</tr>
</tbody>
</table>

If the project area is to be used for buildings, the angle of slope can have severe repercussions on building costs. It costs money to flatten sites or to terrace them for development. Earth shifting can do considerable environmental damage, often to areas much larger than that covered by a building, so a slope analysis that is produced to ensure the minimal area of disturbance is, therefore, a vital piece of information for the landuse planning process.

Roads and Lot Layout

Straight lines and rectilinear shapes generally do not complement natural hillsides. Lay out roads and lots in a pattern that offers a variety of sizes and configurations that complement the topography and features of the site. Use flag or panhandle lots only where they can minimize cut and fill and can provide access to developable areas not readily accessible by public roads. Panhandle* accesses shall meet the requirements of the City for servicing and fire protection.

* Panhandle is an informal geographic term for an elongated arm-like protrusion of a geo-political entity.
Trails and Open Space
Retain open space and corridors between development cells or lots to provide continuous habitat linkages within the site as well as with neighboring sites. Use trails or linear systems to link parts of the hillside community which are not otherwise linked by roads due to topographic constraints. An open space, streetscape and trail system should be developed to provide pedestrian access within the hillside area and to/from key destinations in other parts of the community (e.g., schools, commercial or town centers, parks, other trails, etc). Avoid extensive slope grading to accommodate parks. Establish “pocket” parks for respite where natural terrain permits, or very minor grading is needed, which could serve as a local amenity as well as protect more of the slope. Incorporate significant features such as rock outcrops, streams, cliffs, and stands of trees into the open space/trail system.

Grading
In preparation of a grading plan that indicates clear feasibility for roads and building envelope without massive manipulation of the site, the following must be considered:
Avoid grading or alteration of key topographic features (e.g. knolls, ridgelines, bedrock outcrops, cliffs, ravines, etc).

Avoid a manufactured appearance for graded slopes. Avoid sharp cuts and long or wide slopes with a uniform grade.

Establish contours and gradients that resemble the naturally occurring terrain. Round out slope transitions and blend transitions between lots or adjacent to undisturbed areas.

Refrain from grading large flat terraces on hillside sites in order to expand developable area or to develop housing or other uses characteristic of flat or gently-sloped sites. Developing smaller terraces (eg, for building pads, lawn areas, patios, stepped retaining walls, etc) is acceptable.

Cut and Fill

In designing and developing the site, minimize the total amount of cut and/or fill and its environmental and visual impact by:

1. Where the volume of cut exceeds the volume of fill material for a proposed development, do not dispose of it on site in the form of unnecessary filling, berming or side-casting. Where necessary, dispose of excess material at appropriate off-site locations.

2. Re-vegetate exposed slopes as quickly as possible to prevent erosion and slope stability problems.
Earthworks

In preparing an erosion plan the following must be considered:

1. Avoid potentially hazardous or unstable areas of the site.
2. Do not clear more trees and vegetation than is needed to install services for any given phase of the development.
3. Do not create deep scars or expose large areas of highly visible sub-soil and parent material of the site.
4. Avoid side-casting of material along undeveloped road frontages.
5. Avoid the excavations and the placement of fill that result in terrain forms that are not characteristic of the natural topography.

![Figure 2.4: Several small retaining walls can be screened](image)

Retaining Walls

Use retaining walls where they can reduce disturbing the slope to provide useable construction sites.

1. Retaining walls should respect the natural character of the site and not be dominating or fortress-like.
2. Retaining wall height should generally be limited to 3.0 metres for roads and site works, 1.2 metres for front yards, and 2.4 metres for rear and side yards. Higher walls may be appropriate where they are articulated, have a surface texture/pattern, or where sufficient landscaping is provided at its base.
3. Employ a system of smaller stepped retaining walls over the use of a large uniform wall. The height and depth of the wall steps should be consistent with the natural terrain or with the slope above and below the walls. For stepped retaining wall systems, landscape the intermediate terraces.
4. If the retaining wall is related to the structural integrity of the building, it will be necessary to address the retaining wall through the building permit process.

![Terraced retaining walls break up the mass](image)

Figure 2.5: Terraced retaining walls break up the mass

**Other mitigation measures:**

Use the environmental inventory & assessment to identify environmentally sensitive areas and features to be protected and to determine measures to avoid, minimize or mitigate environmental impact of the proposed development and development activities. Particular attention need to be paid to sedimentation & erosion control plan during and after site development and construction.

1. Existing vegetation on steep slopes is important to the ecological and aesthetic values of the site, as well as to the maintenance of slope stability, drainage and erosion prevention.

2. Use open space development, and varied lot size and configuration, to retain tree stands and other vegetation communities to preserve environmental value (e.g., habitat, biodiversity, heritage trees, etc), maintain soil stability, provide a buffer between development cells, and define neighbourhood character.

3. Make strategic use of existing vegetation to retain the site’s natural character and to break up views of building facades, roadways (eg, cut and fill slopes), and other site works.
4. Phase land clearing to minimize the area exposed to soil loss and erosion at any one time. Phasing may be service related (e.g., clear initially only enough to install roads and main service lines), or spatially related (i.e., clearing only one portion of the parcel at a time, completing development and re-vegetation to control erosion before starting the next portion).

5. Restore disturbed areas of the site that are not part of a roadway or formal yard landscaping, to a natural condition as soon as possible after disturbance.

6. Employ restoration practices specifically tailored to address the type and degree of disturbance and the specific conditions of the site.

7. Replace trees in a manner that helps to restore the natural character of the hillside site. Specifically, plant trees to screen undesirable views and buffer incompatible uses. Arrange trees in natural groupings or clusters rather than in lines or formal arrangements.
Guideline-3: Encourage soil conservation in the proposed site.

Soils can vary greatly even over relatively small areas and therefore the investigation of conditions even on a small site is worthwhile. Soils derive from rocks and those rocks are known as the parent material. It is movement of water through soil that governs the development of soil. Without the original involvement of water and air, soils cannot occur and without them soils cannot act as a growing medium. As the weathering process continues, the special characteristics of the soil develop and gradually change as plants and men interact with the soil.

The concept of land capability is important for urban development as it implies that if a soil is not cultivated beyond its capability then soil erosion can be avoided and soil fertility and structure maintained so that yields do not drop. In a world where the food distribution system frequently cannot cope with localized shortages, particularly when they occur in developing countries it is important to maintain whatever land capability already exists for agriculture and to enhance that where possible.

1. Very fertile/ highly productive soils of the site should be conserved for future use.
2. Care and measures should be taken to store & preserve topsoil.
3. Minimize soil disturbance in design & construction.
4. Create a soil management plan.
5. Effective plan for soil erosion & sedimentation control.

- On the proposed site the net imperviousness of the site should not exceed the imperviousness factor as prescribed by the National Building Code 2005; Part 9 (Plumbing services) Section 5.5.11.2.1.
- Preserving existing vegetation or revegetating disturbed soils is one of the most effective ways to control soil erosion.
- Soil erosion control plan (such as - temporary seeding, Earth dikes & contour trenching, mulching, geotextiles, silt fence, sedimentation trap, top soil laying, permanent planting, drainage swales, sedimentation tank, timing of construction etc.) as prescribed in detail design guideline by GRIHA (Green Rating for Integrated Habitat Assessment).
- Design strategies to control wind erosion (vegetation, sheltered zone on the leeward side, wind breaks at regular interval etc.) as prescribed in soil conservation guideline by MoEF.
6. Avoid the build-up of toxic soils through inappropriate disposal of non-biodegradable wastes.

7. Biodegradable waste should be composted and recycled to improve the soil.

**Guidance note:**

Soil is transitional between the air, water & life of the surface on one hand and rock of the sub-surface on the other. Accordingly it is composed of gaseous, water, organic and rock constituents. Variation to these constituents imparts to soils a set of physical characteristics which influence & influenced by surface phenomena, including landuse. In the context of landuse& environment following aspects of soil should be highlighted.

1. **Soil Fertility:** Influenced by its structure, drainage & organic content
2. **Soil Bearing Capacity:** the ability to support weight (overburden) such as buildings, road and vehicles.
3. **Soil Erodibility:** the susceptibility to erosion and failure in sloping terrain (Soil erosion)

**Soil Fertility:**

Soil fertility is normally taken to be the capacity of a soil to produce a desired crop consistently. Soil fertility is influenced by the availability of nutrients from the soil which in turn is influenced by its **structure, drainage and organic matter content**. It is which of these factors that is at the minimum level of availability to the plants that ultimately determines the way in which plants react to an individual soil. Man frequently intervenes through adding water or chemicals, so changing the soil structure and its composition. Soils can be defined, therefore, as having a natural inherent capacity for fertility and an actual fertility which results from the soil being manipulated by man.

**Soil Texture:**

Texture is the composition of fine soil particles (2 mm diameter) consisting of sand, silt and clay. Soil texture could be assessed manually in the field (Table 4), but preferably determined quantitatively based on texture laboratory analysis and classified according to Figure 2.

**Table 3.1:** Field determination method of soil texture

<table>
<thead>
<tr>
<th>No.</th>
<th>Texture class</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Sand (S)</td>
<td>Very coarse, can not form clods or balls, and no stickiness.</td>
</tr>
<tr>
<td>No.</td>
<td>Texture class</td>
<td>Description</td>
</tr>
<tr>
<td>-----</td>
<td>-----------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>2</td>
<td>Loamy sand (LS)</td>
<td>Very coarse, can form balls/clods but easily collapse.</td>
</tr>
<tr>
<td>3</td>
<td>Sandy loam (SL)</td>
<td>Somewhat coarse, can form balls that can easily collapse, have some stickiness.</td>
</tr>
<tr>
<td>4</td>
<td>Loam (L)</td>
<td>Not coarse and not slippery, can form balls; can be rolled with shiny surface and somewhat sticky.</td>
</tr>
<tr>
<td>5</td>
<td>Silt loam (SiL)</td>
<td>Slippery, can form strong clods/balls, can be rolled with shiny surface, and rather sticky.</td>
</tr>
<tr>
<td>6</td>
<td>Silt (Si)</td>
<td>Very slippery, can be rolled with shiny surface, and rather sticky.</td>
</tr>
<tr>
<td>7</td>
<td>Clay loam (CL)</td>
<td>Some rough/coarse materials; recognized, can form a rather firm balls, can be rolled but easily broken, somewhat sticky.</td>
</tr>
<tr>
<td>8</td>
<td>Sandy clay loam (SCL)</td>
<td>The coarse materials can be easily recognized can form a rather firm balls, can be rolled but easily broken, sticky.</td>
</tr>
<tr>
<td>9</td>
<td>Silty clay loam (SiCL)</td>
<td>Slippery, can form firm balls, can easily form shiny rolls, and sticky</td>
</tr>
<tr>
<td>10</td>
<td>Sandy clay (SC)</td>
<td>Slippery but rather coarse, can easily form shiny rolls but can not easily bent, and sticky.</td>
</tr>
<tr>
<td>11</td>
<td>Silty clay (SiC)</td>
<td>Slippery, can form balls, can easily be rolled, and sticky.</td>
</tr>
<tr>
<td>12</td>
<td>Clay (C)</td>
<td>Heavily sticky, can form very rounded and good balls, hard when dry, sticky when wet.</td>
</tr>
</tbody>
</table>
Soil drainage indicates the speed of water infiltration or the soil condition describing the duration and level of water saturation and inundation. In general, plants require good drainage soils to facilitate oxygen availability. The drainage classes are given in Table 3. The most preferred classes by most plants are classes 3 and 4. Classes 1 and 2 have a very low water holding capacity, while classes 5, 6, and 7 are often saturated and oxygen deficient and thus are unsuitable for most plants, but lowland rice is suitable in this kind of soil.

**Table 3.2: Soil drainage characteristics for land suitability evaluation**

<table>
<thead>
<tr>
<th>No</th>
<th>Drainage class</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Excessively drained</td>
<td>The soil has a very high hydraulic conductivity and low water holding capacity, and thus required irrigation for annual crops. The soil color is homogenous without mottles or gley (reduced) layer.</td>
</tr>
<tr>
<td>2</td>
<td>Somewhat excessively drained</td>
<td>The soil has a high hydraulic conductivity and low water holding capacity.</td>
</tr>
<tr>
<td>3</td>
<td>Well drained</td>
<td>The soil has a moderate hydraulic conductivity and moderate water holding capacity, moist, but not wet near the surface. The soil color is homogenous without iron and manganese concretion and no gley (reduced) layer at up to 100 cm soil depth.</td>
</tr>
<tr>
<td>No</td>
<td>Drainage class</td>
<td>Characteristics</td>
</tr>
<tr>
<td>----</td>
<td>------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>4</td>
<td>Moderately well drained</td>
<td>The hydraulic conductivity is moderate to somewhat low, low water holding capacity (available water pores), and the soil may sometimes be wet near the surface. The soil color is homogenous without iron and manganese concretion and no gley (reduced) layer at up to 50 cm soil depth.</td>
</tr>
<tr>
<td>5</td>
<td>Somewhat poorly drained</td>
<td>The hydraulic conductivity is somewhat low and the water holding capacity (available water pores) is low to very low, the soil sometimes flooded. This soil color is homogenous without iron and manganese concretion and no gley (reduced) layer at up to 25 cm soil depth.</td>
</tr>
<tr>
<td>6</td>
<td>Poorly drained</td>
<td>The soil hydraulic conductivity is low and the water holding capacity (available water pores) is low, the surface is flooded for extended length of time to the surface. This soil is suitable for lowland rice and selected other crops. The soil has some iron and Manganese concretion up to the surface layer.</td>
</tr>
<tr>
<td>7</td>
<td>Very poorly drained</td>
<td>The soil hydraulic conductivity is very low, and the water available pores are very low. The soil is permanently wet and inundated for extended length of time. This soil is suitable for lowland rice and selected other crops. The soil has some iron and manganese concretion up to the surface layer.</td>
</tr>
</tbody>
</table>

Figure 3.2: Schematically representation of soil profiles based on drainage classes

**Soil Bearing Capacity:**

Bearing capacity can be a serious consideration in problems which involve loading the soil surface. Near all soils settle under the weight of surface structure, but in most cases the amount of subsidence is negligible with little
influence on the structures themselves. In certain locales, however, soils of low-bearing capacity have presented some of the most critical land use problems. Usually clayey in composition, weakly consolidated and water saturated, these soils deform under the pressure of surface weight. Loss of water, compaction and actual plastic movement reduce the volume of soil resulting in subsidence of surface.

**Soil Erodibility/ Soil Erosion:**

When land is under construction, soil erosion can be significant – often many times greater than on land used for agriculture. The resulting sediment damages surface water resources, obstructs roads and degrades wildlife habitat. Once developed, the land has more roofs, roads, parking lots and compacted turf. Impervious surfaces like these send more runoff across landscapes, and consequently, the risk of flooding is increased. Urban runoff impairs water quality in streams, lakes and wetlands by delivering sediment, nutrients, hydrocarbons and other pollutants. Ground water recharge is also reduced by impervious surfaces.

The erosion hazard is based on the signs of sheet, rill, and gully erosion. Another approach is by estimating the average annual eroded surface layer, relative to the un-eroded soils as shown by the thickness of the “A-horizon”. The “A-horizon” is characterized by dark color because of high organic matter content. The level of erosion hazard is presented in table 3.3.

**Table 3.3: Erosion hazard**

<table>
<thead>
<tr>
<th>Class</th>
<th>Surface soil loss cm/yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very low (sr)</td>
<td>&lt;0.15</td>
</tr>
<tr>
<td>Low (r)</td>
<td>0.15 – 09</td>
</tr>
<tr>
<td>Moderate (s)</td>
<td>0.9 – 1.8</td>
</tr>
<tr>
<td>High (b)</td>
<td>1.8 – 4.8</td>
</tr>
<tr>
<td>Very high (sb)</td>
<td>&gt; 4.8</td>
</tr>
</tbody>
</table>

**Guideline 4: Surface water preservation**

Surface water channels distribute the rain and allow some of the water to return directly to the sea. They are also involved in transporting water to the recharge areas that fill the aquifers. The need to conserve them, through controlling the type of development that happens in recharge areas and in any areas from which water drains into recharge areas, has an important
impact on site planning. This section only looks at water running over or held on the surface and what this means for site planning; it does not consider water in general. It indicates the detailed information which the site planner needs on water — the quantity and quality and flow characteristics of water in streams and rivers, the danger of flooding, and the usefulness as drinking water or as a recreational resource.

The streams that drain the land link together to form drainage basins. Each drainage basin is surrounded by a watershed. The watershed and its associated river/stream basins can also be useful concepts when site plans are being produced which cover substantial areas.

The location of the ponds, lakes, wells and wetlands (including bogs and marshland) that are within the project area and in the site context area need to be recorded (both natural and man-made water features). Detailed information needs to be gathered on their water quality, wildlife value, recreational value, permanence and also on the condition of their edges. The latter is often crucial to their conservation value. Throughout the world some of the most interesting and scarce wildlife habitats are associated with water. So recording the location of wet areas, near as well as within the project site, may help later with the development of a plan for nature conservation within the site. It will also help in making decisions about which areas should be drained and which retained as water bodies. There are many possible ways of treating still water and wetland, ranging from drainage to conservation. The site planner should assess the range of possibilities.

**Guideline-4a: Protect and enhance on-site water resources and receiving water quality.**

Prevent and minimize generation, mobilization and transport of common storm water pollutants and watershed specific pollutants of concern to receiving waters, including surface water and ground water and combined sewers or storm water systems.

Improved water quality supports recreational opportunities and fisheries resources. Water treated on site can also lead to reduced expenditures for infrastructure and energy associated with public and private stormwater treatment. When a receiving water body does not meet water quality standards (e.g., total maximum daily loads), municipalities incur an additional cost and liability.

**Design Strategies:**

- Implement strategies to reduce the volume of storm-water runoff, such as:
- Reduce impervious cover
- Disconnect impervious cover
- Provide depression storage in the landscape
- Convey storm-water in swales to promote infiltration
- Use bio-filtration to provide vegetated and soil filtering
- Evapotranspire (e.g., use engineered soils and vegetation on green roofs or in biofiltration areas/landscaping to maximize evapotranspiration potential)
- Infiltrate stormwater (infiltration basins and trenches, permeable pavement, etc.)

- Materials used in building, hardscape, and landscape materials that can be a source of pollutants in stormwater include:
  - Copper and zinc roofs, roof gutters and downspouts, and siding
  - Galvanized materials (fences, guardrails, signposts)
  - Treated lumber
  - Parking lot coal tar sealants
  - Fertilizers
  - Pesticides

- Plan for and implement maintenance activities designed to reduce the exposure of pollutants to stormwater, such as:
  - Minimizing exposure to rainfall of stored materials that could contribute pollutants
  - Developing and implementing a spill response plan
  - Avoiding non-stormwater discharges (e.g; wash water)
  - Minimizing the use of salt for deicing
  - Avoiding routine maintenance of construction equipment on site to reduce pollutant loadings of oils, grease, hydraulic fluids, etc.
  - Avoiding fueling of vehicles on site to the maximum extent practicable.
Ideally, a variety of treatment practices will be implemented in series (a treatment train) to provide multiple pollutant removal processes (runoff reduction through evapotranspiration and infiltration, sedimentation, filtration, adsorption, biological degradation/uptake) to reduce the concentrations of pollutants in stormwater and to provide redundancy in the system. Soil and vegetation-based controls are preferred due to their ability to reduce runoff through evapotranspiration, maintain infiltration rates, and regenerate adsorption capacity. Stormwater treatment systems that have been demonstrated to achieve the 25 milligrams/liter TSS discharge concentration include:

- Water quality wet ponds
- Constructed stormwater wetlands
- Bioretention
- Biofiltration (e.g., raingardens)
- Vegetated buffer strips
- Sand filters
- Bioswales (as the initial BMP in a treatment train configuration)

BMPs that are not considered sufficiently effective individually to qualify for this credit include many below grade vaults and hydrodynamic separators, inlet inserts, and dry extended detention basins, although these could be used in combination with the proven BMPs listed above in a treatment train.
Guideline-4b: Maintain surface water features to conserve water and other resources.

Design and maintain water features created in the landscape with minimal or no make-up water from potable sources or other natural surface or subsurface water resources.

Using non-potable water sources, such as gray water, reclaimed water, and rainwater in water features reduces water waste and conserves potable water for higher-priority uses, such as drinking water. This practice simultaneously reduces the infrastructure, energy expenditure, and costs associated with pumping, cleaning, and processing municipal water.

Design Strategies:

1. Design water features that match or mimic water in the natural environment. Avoid water features that are incompatible with the local ecological context (e.g., a lake in a desert).

2. Estimate volumes of rainwater or other non-potable sources available on site for use in water features, and design water features that that are integrated with the site so as to utilize this water on site, and not require additional water from potable water sources.

3. Collect and reuse non-potable water from sources such as rainwater from rooftops, graywater, reclaimed water or stormwater basins.

4. Design and maintain water features as natural ecosystems, with water source(s), plants, and other aquatic organisms appropriate for local conditions.

5. Water quality can be enhanced in created water features with biologically-based water treatment including certain beneficial bacteria, enzymes, mineral, and oxygen-based additives, especially during initial establishment.

6. Natural swimming pools or other water features intended for human contact may require additional treatment methods such as ozonation or thermal treatment.
Guideline 5: Conserving existing vegetation

The existing vegetation of any place conveys a wealth of information about environmental condition. Until recently, though little use appears to have been made of this information source in land use and environmental planning. As a functional element of the environment the plant cover serves to stabilize slopes, retard erosion, conserve water quality & quantity, maintain local micro-climates, filter the atmosphere, decrease noise and provide habitat for wildlife. Vegetation can be utilized, not only as a primary determinant in judging ecological sensitivity but also as an indicator to environmental constraints that have influenced previous land use. Thus the task generating environmental information for land use planning must embrace a detail analysis of vegetation both as a developed resource and an integral element of the natural & cultural landscape.

Guideline-5a: Control & manage rare plants found on site:

Develop and implement an active management plan for the control and subsequent management of known rare plants found on site to limit damage to local ecosystem services.

Design strategies:
Contact local and regional governmental agencies, consultants, and educational facilities as resources for the most appropriate and effective management techniques for rare species identified on site.

Guideline-5b: Preserve all vegetation designated as special status

Identify and preserve all vegetation designated as special status by local, state, or Central Government.

Mature trees and other plants are significant community resources because of their cultural, aesthetic, or historic relevance. Special status vegetation may be deemed important because they are associated with a significant historic event or place, are located in a place that provides critical functions (such as soil stability along a stream), or are species that are relatively rare in an area.

Design strategies:
Design the site to minimize harm to special status trees and other plants. Consult with local experts qualified in plant health and safety to determine special protection measures.
Guideline-5c: Use native plants & preserve/ restore plant communities native to the ecoregion.

1. Plant appropriate vegetation that is native to the ecoregion of the site.

2. Preserve plant communities native to the ecoregion of the site to contribute to regional diversity of flora and provide habitat for native wildlife.

3. Restore appropriate plants and plant communities native to the ecoregion of the site to contribute to regional diversity of flora and provide habitat for native wildlife.

Native plants can provide habitat for native wildlife, including important pollinator species (e.g., insects, birds, and bats) that are necessary for plant reproduction, including cultivation of crops. Up to 80 percent of the world’s food plant species are dependent on pollination by animals.56 Wildlife habitat also supports recreational and ecotourism activities, such as fishing and birdwatching, and opportunities for environmental education.

Design strategies:

Native plants can be used for both formal and naturalistic designs. On sites with existing native vegetation, design the site to preserve native plants where possible. On previously developed sites, contact local and regional governmental agencies, consultants, educational facilities, and native plant societies as resources for the selection of native plants appropriate for the site.

Guideline-5d: Follow the existing vegetation conservation plan as prescribed in MOEF design guideline.

Refer annexure-1 for extracts of MOEF design guideline.

Guidance note:

Plant classification schemes are often a source of much confusion and discouragement in plant sciences. Thus, it seems appropriate to identify the major classification schemes which are suitable for purpose of land use environmental planning. The floristic plant classification system is the schemes most widely used today among botanists, agronomists, ecologists, and other plant scientists. This is the schemes which uses the latin or latinized words for plant names – for instance, pinus strobus for white pine–and the group plants into classes, orders, family, genera, and species.

Several ecological oriented schemes have been devised, though no one is currently predominant. The classification are based on similarity of habitat
and differ markedly from the floristic system in as much strikingly dissimilar looking plants and genetically unrelated plants often occupy the same habitat. These scheme is based on moisture and classifies plants into 3 major categories:

1. Hydrophytes - water loving plants
2. Xerophytes - drought tolerant plants
3. Mesophytes - which is intermediate

A third set of classification schemes is based in the structure of the total assemblage of plants on a closed forest, open forest, parkland, tundra and grassland are example of common structural classes.

The structural schemes, augmented by the ecological and floristic schemes appears to be suitable reference framework for conveying plant-cover information for land use and environmental planning purpose in addition to identification of forest, shrub, grassland structures, an indication of secondary structural features and salient floristic characteristics is usually valuable also. An example of a four level classification is –

1. Level one is based on vegetative structure and includes height, percentage of area coverage canopy, and life-forms.
2. Level two calls for identification of dominant plants. This may involve only one tree type in some areas, whereas in other areas it may involves as many as four or five types of plants.
3. Level three calls for an indication of density and the trunk sizes of trees and shrubs. This may be based on firsthand field measurement, through visual estimates may be adequate for most planning purpose.
4. Level four is intended to provide information on the site on which the vegetation is found. Familiar terms such as flood plain, upland, vacant farm land, or residential area can be used to describe the physical setting.

Greater specificity may be gained by indicating the habitats of certain plants within the sites for example, riverbank or slope face or the use associated with the site such as recreation of highway right-of-way.

It is necessary to add that the use of this classification scheme or a variant of it must be adjusted to the nature of the planning problem and the quality and abundance of available information sources.
Guideline-6: Conserve Bio-diversity of the proposed site & surrounding.

1. Continuous transformation of bio-diversity rich land in to large scale urban space have been creating a tremendous pressure on environment, such as:
   - Habitat loss
   - Fragmentation & degradation
   - Invasive alien species
   - Over exploitation of species
   - Genetic resources to satisfy the needs of growing population
   - Global climate change etc.
   - These pressures lead to erosion of resource base for food, medicines and livelihoods, pollute environment, increase health risks and affect livelihoods of communities challenged by poverty.

2. There is a relationship between biodiversity loss and the emergence and spread of new and more virulent disease organisms including SARS, Ebola, malaria, and the HIV pandemic, that have resulted from human impacts on habitats and wildlife.

3. Water availability is directly linked to the conservation of biodiversity in integrated ecosystems and larger landscapes for watershed management.

Emerging Issue:

4. 10-30% of the mammal, bird and amphibian species threatened with extinction, due to rapid urban development. (Reported by the Millennium Ecosystem Assessment, released in March 2005 )

5. Many species at threat of extinction are (Recorded by the International Union for Conservation of Nature (IUCN)) –
   - 1 out of 8 birds
   - 1 out of 4 mammals
   - 1 out of 4 conifers
   - 1 out of 3 amphibians
   - 6 out of 7 marine turtles
6. 75% of genetic diversity of agricultural crops has been lost.

7. 75% of the world’s fisheries are fully or over exploited.

8. 1/3rd of reef-building corals around the world are threatened with extinction.

9. Up to 70% of the world’s known species risk extinction if the global temperatures rise by more than 3.5°C.

10. Total forestland shrunk by 94 million hectares (232 million acres) in the last decade and now covers only about 30% of all land.

**Over 350 million people suffer from severe water scarcity.**

**Design Strategies:**

1. Avoid urban development on land that are ecologically sensitive/rich in bio-diversity/protected habitat.

2. Avoid construction activity during critical timing of existing/surrounding bio-diversity, such as nesting, fawning, breeding period.


5. Controlled and regulated access during construction and operation.

6. Landscape and urban planning (e.g. design of expressway landscaping to complement natural ecology for extensions of habitats).

7. Nature engineering solutions (Wildlife bridges, tunnels, fences and ‘ecoducts’).

8. Alternative choices (wind power as opposed to thermal power).


10. Removal and storage of top soil for restoration of wetland and terrestrial habitats.

11. Collection of seeds to ensure a supply of locally adapted native plants (useful practice in restoration of mined out areas) etc.

12. Enhancing existing degraded habitats and creating additional habitats to mitigate the loss of those removed by the project.
13. Creating new habitat on alternative sites (re-vegetation of vacant lands, landfills, exposed rocks).

14. Alternative substitutes for enhancing habitat use and value (e.g. artificial nests for improving habitat use)

15. Upgrade legal status of habitats of equivalent or better biodiversity values for improving protection to offset losses due to land take elsewhere.

16. Provision of financial resources for ‘creative’ management (naturalization of managed areas)

The conventional practice of site development has least respect for the factors of natural environment (topography, soil, water, flora & fauna) and leads towards environmental degradation. In natural resource assessment the site developers have to assess each and every resource in detail and conscious attempt is made to leave the most sensitive land under each category and restrict the infrastructural development on that part of land where the impact on the ecosystem is relatively lesser and the development on the less sensitive area should follow the above mentioned design guidelines. Natural resource mapping if properly carried out will lead to richer and more stimulating environment. Improving the quality of life in cities does not imply an inherent increase in the quantity of publicly looked after land, nor of associated costs to the community of supporting such land. It implies the reverse in many ways. If the whole townscape becomes richer in terms of the variety of environmental experiences it supports, then the present level of open space will in many cases suffice.
Section B: Socio economics

Guideline 7: Measures to be undertaken on site and within site design to bring in equity and social well being

Introduction:
Equity and social well-being is a prerequisite for a harmonious society where people of all class can co-exist besides helping each other in their various functions. The labour class, the informal sector, the low-income group for example are the backbone of any development and rightfully deserve equal opportunity for a better quality of life. On the other hand, a mixed development where all classes of people are accommodated fosters community feeling and brotherhood amongst the residents.

Benefits of the guideline
Fosters planning to accommodate all sections of society
Promotes social cohesion and harmony
Provides equal opportunity to employment and growth

Guidance Note:

Planning/Design stage

1. The design elements should provide for creating public facilities for all: This would include creating such spaces that help build an egalitarian society. These facilities could be:
   - Easy access to public transport,
   - Facilities and infrastructure for differently abled,
   - Areas for parking of bicycles, sidewalks for pedestrians and cycle paths,
   - Public open spaces
   - Provision of drinking water faucets, benches in shady areas and public toilets

2. Health and education: Facilities for health and education that are accessible to all sections of society

3. Housing for all sections of society: A provision of certain % of housing should be provided for low income category
4. **Recreation and culture**: Facilities for recreation and culture like community halls, auditoriums, museums etc.

5. **Cleanliness**: Zero littering development, provisions of dustbins, proper waste management system that leads gradually to zero waste campus, enforcement of no littering policy

6. Room for informal market like vegetable vendors. Innovativeness in accommodating informal sector within site in a way that they support the requirement of the development is desirable. This would also mean providing them with proper space and infrastructure such that proper hygiene and cleanliness is maintained. For example, planning for waste collection and disposal system for the vegetable vendors, ‘chai valas’, small food kiosks/snack parlour etc; planning for proper drainage system and water supply system to the these establishments so that while washing and cleaning, proper hygiene and cleanliness is maintained. In addition, it is seen that in the lack of planned spaces for informal sector, they tend to build ad-hoc structures as per their capacity, which becomes a cause of nuisance especially during monsoon season. Proper paved spaces with storm water drainage system be planned for the informal sector to avoid all these problems.

7. Shelter for guards with basic facilities like toilet

**During Construction**

1. No forced labor, child labor shall occur on site

2. Workers shall be free of discrimination of any kind, whether in employment or opportunity, with respect to gender, wages working conditions, and social benefits.

3. Workers’ wages and working conditions shall respect all applicable laws and international conventions, as well as all relevant collective agreements. Where a government-regulated minimum wage is in place, this shall be observed.

4. Conditions of occupational safety (ILO) and health for workers shall follow internationally recognized standards,
   - Decent living facility of construction workers – provision of basic toilet facility, water and shelter (rain proof).
   - Basic doctor facilities for construction workers.
   - Crèche for children of construction workers.
• Area to dispose of human and other waste – water that is left from their washing activities what happens to it

Post Construction/Operational stage

1. Ensuring community participation for planning and maintaining facilities on site (RWA system).

2. Ensuring overall community safety and special provisions for safety for children, women, elders
Guideline 8: Develop a hierarchical road network within the development

Road network for large urban developments should follow a functional hierarchy with adequate provision of roads for different purposes like through traffic and access to property. Road planning should go hand-in-hand with built-area planning in order to ensure that both complement each other and help achieve the overall objectives of sustainable site planning.

Benefits of the guideline
Hierarchical road networks segregate roads based on their function and capacity. They offer different levels of mobility, safety and environmental quality and can be instrumental in efficient interaction between roads and abutting land uses. Well-planned hierarchical and integrated road networks for large developments are hence critical for achieving the goal of sustainable development for such developments.

Guiding notes:
1. What is road hierarchy?

Roadways serve a variety of functions, including but not limited to the provision of direct access to properties, pedestrian and bicycle paths, bus routes and catering for through traffic that is not related to immediate land uses. Many roads serve more than one function and to varying degrees, but it is clear that the mixing of incompatible functions can lead to problems.

A road hierarchy is a means of defining each roadway in terms of its function such that appropriate objectives for that roadway can be set and appropriate design criteria can be implemented. These objectives and design criteria are aimed at achieving an efficient road system whereby conflicts between the roadway and the adjacent land use are minimized and the appropriate level of interaction between the roadway and land use is permitted. The road hierarchy can then form the basis of ongoing planning and system management aimed at reducing the mixing of incompatible functions.
Guidance note:

Hierarchical road planning

Hierarchical road planning should be done according to the prescribed road classifications and design standards for urban roads in India. The Indian Roads Congress (IRC) codes - IRC: 86-1983 and IRC: 69-1977 should be strictly adhered to in this respect. Table 8.1 gives guidelines for hierarchical road planning for large urban developments.

<table>
<thead>
<tr>
<th>Road hierarchy</th>
<th>Functions</th>
<th>Recommended ROW (meters)*</th>
<th>Design speed**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arterial roads</td>
<td>For through traffic on continuous routes</td>
<td>50-60</td>
<td>80 kmph</td>
</tr>
<tr>
<td>Sub-arterial roads</td>
<td>For through traffic on continuous routes but offering somewhat lower level of traffic mobility than the arterial roads</td>
<td>30-40</td>
<td>60 kmph</td>
</tr>
<tr>
<td>Collector road</td>
<td>For collecting and distributing traffic from and to local streets/roads and for providing access to arterial roads</td>
<td>20-30</td>
<td>50 kmph</td>
</tr>
<tr>
<td>Local road</td>
<td>For access to residences, business or other abutting property</td>
<td>10-20</td>
<td>30 kmph</td>
</tr>
</tbody>
</table>


Note:

*Alterations to the recommended standards can be made after due consideration of factors like:

---

- present and expected traffic
- land use pattern
- likely future development
- predominant mode of travel on the corridor

**Change in design speeds should not be sudden but in stages (10 kmph)**

Table 8.2: Key considerations while planning for hierarchical road network

<table>
<thead>
<tr>
<th>Road hierarchy</th>
<th>Key considerations in road planning and design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arterial roads</td>
<td>- Continuity is important</td>
</tr>
<tr>
<td></td>
<td>- Spacing – 1.5 km in highly developed central business districts (CBD) and 8 km in sparsely developed urban fringes</td>
</tr>
<tr>
<td></td>
<td>- Minimum roadway intersection spacing – 0.5 km</td>
</tr>
<tr>
<td></td>
<td>- Preferably a divided carriage way should be provided</td>
</tr>
<tr>
<td></td>
<td>- No frontage access should be provided</td>
</tr>
<tr>
<td></td>
<td>- Parking loading and unloading activities should be restricted/regulated</td>
</tr>
<tr>
<td></td>
<td>- Pedestrian crossings should be preferably allowed at intersections only</td>
</tr>
<tr>
<td>Sub-arterial roads</td>
<td>- Continuity is important</td>
</tr>
<tr>
<td></td>
<td>- Spacing – 0.5 km in highly developed central business districts (CBD) and 3-5 km in sparsely developed urban fringes</td>
</tr>
<tr>
<td></td>
<td>- Minimum roadway intersection spacing – 0.3 km</td>
</tr>
<tr>
<td></td>
<td>- Frontage access can be provided</td>
</tr>
<tr>
<td>Collector road</td>
<td>- Full access can be allowed</td>
</tr>
<tr>
<td></td>
<td>- Parking can be restricted during peak hours</td>
</tr>
<tr>
<td></td>
<td>- Minimum roadway intersection spacing – 0.15 km</td>
</tr>
<tr>
<td>Local road</td>
<td>- Provide access to abutting property</td>
</tr>
<tr>
<td></td>
<td>- Have low traffic volumes</td>
</tr>
<tr>
<td></td>
<td>- Trip generation and termination points</td>
</tr>
<tr>
<td></td>
<td>- Street character depends on predominant use of adjoining land</td>
</tr>
<tr>
<td></td>
<td>- Unrestricted parking and pedestrian movement can be provided</td>
</tr>
</tbody>
</table>

Cross-section design

The recommended ROWs given in table 8.3 should be adopted for road design. The cross-section on these ROWs however may vary based on hierarchy, design speed and volume and composition of traffic expected on these roads. The other factors that may influence cross-section designs include provision for parking lane, bus bays, loading/unloading bays/access points, volume of pedestrians and cyclists, width of drains, location of utility lines, etc. (IRC, 2006). The cross-section design should take into consideration all design standards and site factors. Some key standards for cross-sectional elements are discussed below.

Table 8.3: Carriage-way widths

<table>
<thead>
<tr>
<th>Description</th>
<th>Width (meters)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single lane without kerbs</td>
<td>3.50</td>
</tr>
<tr>
<td>2-lane without kerbs</td>
<td>7.00</td>
</tr>
<tr>
<td>2-lane with kerbs</td>
<td>7.50</td>
</tr>
<tr>
<td>3-lanes with or without kerbs</td>
<td>10.5/11.0</td>
</tr>
<tr>
<td>4-lane with or without kerbs</td>
<td>14.0</td>
</tr>
<tr>
<td>6-lane with or without kerbs</td>
<td>21.0</td>
</tr>
</tbody>
</table>

Source: IRC: 86-1983

Table 8.4: Recommended design service volumes (PCUs/hr)

<table>
<thead>
<tr>
<th>S.No</th>
<th>Type of carriageway</th>
<th>Arterial*</th>
<th>Sub-arterial**</th>
<th>Collector ***</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2-Lane (One-Way)</td>
<td>2400</td>
<td>1900</td>
<td>1400</td>
</tr>
<tr>
<td>2</td>
<td>2-Lane (Two-Way)</td>
<td>1500</td>
<td>1200</td>
<td>900</td>
</tr>
<tr>
<td>3</td>
<td>3-Lane (One-Way)</td>
<td>3600</td>
<td>2900</td>
<td>2200</td>
</tr>
<tr>
<td>4</td>
<td>4-Lane Undivided (Two-Way)</td>
<td>3000</td>
<td>2400</td>
<td>1800</td>
</tr>
<tr>
<td>S.No</td>
<td>Type of carriageway</td>
<td>Total Design Service Volumes for Different Categories of Urban Roads</td>
<td></td>
<td></td>
</tr>
<tr>
<td>------</td>
<td>-------------------------------------</td>
<td>---------------------------------------------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>4-Lane divided (Two-Way)</td>
<td>3600 2900 -</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>6-Lane Undivided (Two Way)</td>
<td>4800 3800 -</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>6-Lane Divided (Two-Way)</td>
<td>5400 4300 -</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>8-Lane Divided (Two-Way)</td>
<td>7200 - -</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Roads with no frontage access, no standing vehicles, very little cross traffic

** Roads with frontage access but no standing vehicle and high capacity intersections

*** Roads with free frontage access, parked vehicles and heavy cross traffic

Source: IRC: 106-1990

**Table 8.5: Key cross-sectional elements - Minimum widths**

<table>
<thead>
<tr>
<th>Cross-sectional elements</th>
<th>Minimum width</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carriage-way</td>
<td>3.5</td>
</tr>
<tr>
<td>Footpath</td>
<td>1.5</td>
</tr>
<tr>
<td>Cycle track</td>
<td>2.0</td>
</tr>
<tr>
<td>Median</td>
<td>1.2, (Desirable width – 5m)</td>
</tr>
<tr>
<td>Verge</td>
<td>1.0</td>
</tr>
<tr>
<td>Parking lane</td>
<td>3 m, (for parallel parking)*</td>
</tr>
</tbody>
</table>

* Can be reduced to 2.5 m where available space is less

Figure 8.1: Typical cross sections of the roads
Guideline 9: Street networks within large developments should be developed in a manner so as to promote safety, efficiency, community living, environmental and aesthetic quality and cycling and walking.

Street network planning for large developments should focus on:

- Promoting efficient movement of motorized road traffic
- Offering convenience to cyclists and pedestrians in terms of connectivity and safety
- Achieving efficient provision of utilities and services
- Enabling social interaction and exchange so as to enhance the culture of community living
- Enhancing aesthetic and environmental quality of the neighbourhoods
- Promoting equitable accessibility
- Reducing requirements for land

Benefits of the guideline

Different patterns of street networks offer distinct advantages and disadvantages with respect to the points listed above. While loops and cul-de-sacs are recognized for promoting safe pedestrian movements along with promoting community interaction and efficiency, grid patterns offer ease of orientation and connectivity. These street systems also have different land requirements (figure). The choice for street patterns should take into account such costs and benefits while making a choice for a specific street pattern.

Specifically, air quality and noise levels
Guidance note

Street networks specifically in residential neighbourhoods should promote slow speeds, preferably below 30 kmph, low motorized traffic volumes and least levels of noise. Such street networks combined with facilities like pleasant landscaping, street furniture, street lighting and community amenities can help promote cycling and walking in these neighbourhoods which in turn can lead to higher level of community interaction and security.

Promoting slow speeds

Measures to control the speed of vehicles include:\(^{11}\):

1. Vertical measures, which rely on forces of vertical rise acceleration to discourage speeding
   - Speed humps
   - Speed tables
   - Raised crosswalks
   - Raised intersections
   - Textured pavement

2. Horizontal measures, which rely on forces of lateral shift acceleration to discourage speeding
   - Roundabouts;
   - Neighborhood traffic circles;
   - Chicanes, lateral shifts, and chokers;

---

\(^{11}\) Janaagraha and Chennai City Connect, 2009
• Curb extensions; and,
• Center island narrowings.

3. Narrowing measures, which rely on a psychoperceptive sense of enclosure to discourage speeding

**Promoting low motorized traffic volumes**

Volume control measures can be adopted to reduce the level of motorized traffic in residential areas. The primary aim of these measures is to discourage or eliminate through traffic. Design of street patterns is critical to accomplish such objectives. Some of the volume control interventions could be:

1. Full street closures;
2. Half street closures;
3. Median barriers; and
4. Forced turn islands12.

---

12 Ibid
Figure 9.2: Some vertical and horizontal speed control measures
Source: Janaagraha and Chennai City Connect, 2009

Figure 9.3: Narrowing measure
Source: Janaagraha and Chennai City Connect, 2009
Figure 9.4: Volume control measures
Source: Janaagraha and Chennai City Connect, 2009

(For further information on volume and speed control measures, following handbook could be consulted: Revamp your neighbourhood handbook, Compiled by Janaagraha and Chennai City Connect, 2009. In addition, IRC codes could be reoffered)
**Guideline 10: Encourage walking and cycling within the development**

Walking can serve short trips of 1-2 km length and cycling can serve longer trips. The circulation network in large developments should be planned in a manner so as to promote walking and cycling for trips within the development. These modes need to be planned in an integrated manner after assessing the overall mobility needs within the development. The basic aim in planning facilities for these modes should be to minimize their conflict with motorized traffic; convenience of cyclists and pedestrians should be given the highest importance. Walking and cycling within large developments can be promoted by:

- Providing dedicated infrastructure for pedestrians and cyclists;
- Providing supporting facilities and ensuring secure and comfortable environment for walking and cycling; and
- Planning basic facilities/amenities at walking/cycling distance.

**Benefits of the guideline:**

Walking and cycling offer the most environment friendly ways to move. They are useful in promoting healthy living and can be instrumental in achieving higher levels of social interaction provided the facilities to promote use of walking and cycling are well-planned and safe.

**Providing dedicated infrastructure for pedestrians and cyclists**

As far as possible, dedicated infrastructure should be provided for pedestrians and cyclists. This infrastructure includes footpaths and cycle tracks along roads and walkways/cycle tracks through open spaces/green belts etc. The aim should be to:

1. **Provide footpaths on all roads (i.e. ensure 100% walkability along roads)**
   Preferably footpaths should be provided on both sides of the roads. They should be segregated from the motorized traffic on carriageway by creating level difference, so as to prevent mixing of non-motorized and motorized traffics. The height of the footpaths, however, should not discourage the pedestrians from using it. As per IRC: 103-1988, ‘height of the kerb at the edge should not exceed the height of non-mountable kerbs’ i.e. 325 mm.

   The footpaths should be designed to cater to the expected pedestrian traffic. The minimum width of a footpath should be 1.5 m. The table below gives the norms for required widths of footpaths for different levels of pedestrian traffic.
Table 10.1: Capacity and width of Footpaths

<table>
<thead>
<tr>
<th>Number of persons per hour</th>
<th>Required width of footpath (mts)</th>
</tr>
</thead>
<tbody>
<tr>
<td>All in one direction</td>
<td>In both directions</td>
</tr>
<tr>
<td>1200</td>
<td>800</td>
</tr>
<tr>
<td>2400</td>
<td>1600</td>
</tr>
<tr>
<td>3600</td>
<td>2400</td>
</tr>
<tr>
<td>4800</td>
<td>3200</td>
</tr>
<tr>
<td>6000</td>
<td>4000</td>
</tr>
</tbody>
</table>


Note:
- For sidewalks in shopping areas, width should be increased by 1 m (treated as ‘dead width’).
- Footpaths adjoining shopping frontages should be at least 3.5 m; a minimum of 4.5 is desirable adjoining longer shopping frontages.
- For footpaths adjacent to buildings and fences, dead width of 0.5 m should be taken.
- For areas of heavy pedestrian activity (such as bus stops, railway stations and recreational areas, the width of sidewalks should be appropriately increased to account for accumulation of pedestrians.
- Environmental and safety considerations should be taken into account in addition to capacity requirements while planning pedestrian facilities in residential, shopping and office areas.
- At points of congestion, footpaths may be wider.
- Width required to lay underground services should also be taken in account while deciding the width of footpath.
- Wherever possible, it is desirable to have a verge (minimum 1 m wide) between footpath and carriageway.
- On slopes and ramps, the capacity should be suitably reduced.
- Footpaths should have a well maintained surface with a crossfall within the range of 2.5 to 3%.

2. Provide cycle tracks on all roads with heavy motorized activity

**Cycle track**

‘A cycle track is a way or a part of a roadway designed and constructed for the use of pedal bicycles, and over which a right-of-way exists.’
As per IRC: 11-1962 and IRC: 86-1983, separate cycle tracks should be provided when the peak hour cycle traffic is 400 or more on routes with a motor vehicles traffic of 100-200 vehicles per hour. When the vehicle traffic is more than 200 vehicles/hour, separate cycle tracks are justified even if cycle traffic is only 100 cycle per hour. However, it is recommended that the new developments that are being planned should provide dedicated cycle tracks/lanes segregated from the carriageway and footpaths by verge and level difference, respectively on all main roads designed for a speed above 30 kmph (collector and arterial roads) irrespective of the expected vehicle and cycle traffic. This is recommended primarily to encourage cycling by residents on these roads. Preferably the tracks should be provided on both sides of the roads and should meet carriageway level at intersections by well-designed ramps. The minimum width of a cycle track should be 2 mts. Cycle track widths for different levels of cycle traffic are indicated in the table below.

Table 10.2: Capacity and width of cycle tracks

<table>
<thead>
<tr>
<th>Width of cycle track</th>
<th>Capacity in number of cycles / hour</th>
<th>One-way traffic</th>
<th>Two-way traffic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two lanes (3 m)</td>
<td>250 to 600</td>
<td>50 to 250</td>
<td></td>
</tr>
<tr>
<td>Three lanes (4 m)</td>
<td>Over 600</td>
<td>250 to 600</td>
<td></td>
</tr>
<tr>
<td>Four lanes (5 m)</td>
<td>---</td>
<td>Over 600</td>
<td></td>
</tr>
</tbody>
</table>

Sources: IRC: 86-1983

Table 10.3: Length of grades of cycle tracks

<table>
<thead>
<tr>
<th>Gradient</th>
<th>Maximum Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 in X</td>
<td>(Y)</td>
</tr>
<tr>
<td>1 in 30</td>
<td>(295)</td>
</tr>
<tr>
<td>1 in 35</td>
<td>(410)</td>
</tr>
</tbody>
</table>

Minimum width of verge – 1 mt. If land available is inadequate, then the width of the verge can be reduced to 0.5 mt. If overtaking is to be provided, the width should be made 3 mts. Each additional lane where required should be 1 mt wide.
### Gradient and Maximum Length

<table>
<thead>
<tr>
<th>Gradient</th>
<th>Maximum Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 in 40</td>
<td>(500)</td>
</tr>
<tr>
<td>1 in 45</td>
<td>(656)</td>
</tr>
<tr>
<td>1 in 50</td>
<td>(820)</td>
</tr>
<tr>
<td>1 in 55</td>
<td>(984)</td>
</tr>
<tr>
<td>1 in 60</td>
<td>(1,181)</td>
</tr>
<tr>
<td>1 in 65</td>
<td>(1,394)</td>
</tr>
<tr>
<td>1 in 70</td>
<td>1,640)</td>
</tr>
</tbody>
</table>

Source IRC: 11-1962

Note: gradient steeper than 1 in 30 should be avoided. Only in exception cases, gradients of 1 in 20 and 1 in 25 may be allowed for lengths not exceeding 20 mts and 50 mts respectively (Source IRC: 11-1962).

Table 10.4: Other key considerations while planning/designing cycle tracks:

- **Sight distance** – Clear view of not less than 25 mts; If gradient of 1 in 40 or more, then a clear view of not less than 60 mts.

- **Vertical clearance** – Minimum head-room provided should be 2.25 mts (preferable – 2.5 mts).

- **Horizontal clearance** – At underpasses and similar other situations, a side clearance of 25 cms should be allowed on each side. Minimum width for an underpass for a two-lane cycle track should be 2.5 mts.

- **Location** – Preferably, cycle tracks should be located beyond hedges, tree line or footpath (clearance of minimum 0.5 m from hedges and 1 m from trees/ditches).

In shopping areas, however, footpath should be nearest to the shop frontage.

3. **Provide pedestrian/cycle pathways through open spaces**

   In addition to footpaths and cycle tracks along roads, pedestrian/cycle pathways should be provided through open/green spaces within the development. An inter-connected network should be developed in order to reduce distances for walking and cycling and ensure continuity of the network. Pedestrian pathways/cycle tracks through open/green spaces will encourage walking and cycling by residents. The design of these pedestrian pathways/cycle tracks should follow the IRC norms as discussed above.
4. Ensure continuity, safety and universal accessibility of the entire pedestrian and cycle network

Continuity and universal accessibility of pedestrian/cycle network is vital in terms of encouraging residents to use these modes and for ensuring their safety. Continuity of the network can be ensured by planning an interconnected network with adequate design elements to address points of level change and crossings. To ensure universal accessibility, the following reference standards, regulations and codes can be used:

- Indian Disability Act 1995
- National Building Code
- Guidelines and space standards for barrier free built environment for disabled and elderly persons – 1998, C.P.W.D., Ministry of Urban Affairs and Employment, India

In addition to the above listed Indian standards and codes, the following international codes can be also be used:

- American for Disabilities Act (ADA)
- ADA Accessibility Guidelines for Buildings and Facilities(ADAAG), 1998
- International Building Code

One of the most critical parameters while planning/designing pedestrian/cycle facilities is to ensure safe interface of pedestrians/cyclists with motorized traffic. It is difficult to avoid points of interface between pedestrian/cyclists and motorized traffic; it is therefore important to design these points appropriately to ensure safety of all. There are several measures that can be applied to ensure safe crossings; these may include:

- Well-designed intersections/crossings (follow IRC codes like 103-1988, 65-1976, etc.)
- Grade separation at crossings i.e. providing subways and over bridges (follow IRC codes like 103-1988, 11-1962, 86-1983, etc.)
- Well-designed signals at intersections and mid-block crossings (prioritization to pedestrians/cyclists, pedestrian pushbutton signals) (follow IRC codes like 93-1985, 103-1988, etc.)
- Using speed control measures (follow IRC 99-1988)
- Installing proper signages and road markings (follow IRC 35-1970, etc.)
Providing supporting facilities and creating secure and comfortable environment for walking and cycling

In order to make walking and cycling an attractive mode of transportation, it is important to provide supporting facilities for pedestrians and cyclists in addition to providing dedicated infrastructure for their movement. Following can be done to create a comfortable environment for walking and cycling:

1. Landscaping along NMT network (providing shade)
2. Providing amenities like drinking water/rest rooms
3. Providing sitting furniture
4. Designating areas for cycle parking where storage facilities and charging points (for e-bikes) can be provided
5. Installing street lighting, information signages
6. Providing facilities like cycle renting
7. Promoting vibrant road spaces by providing planned spaces for hawkers along streets (this will ensure security of pedestrians and cyclists)

Planning basic facilities/amenities at walking/cycling distance

The way land use is distributed has a long term impact on the character of a development; it also shapes the lifestyle of its residents. Compact, walkable and cyclable developments characterized by diverse land uses are illustrative of sustainable and low carbon communities. Accessibility can be used as a tool to ensure compactness, walkability and diverseness of a development, thus making it sustainable in the long run.

Basic amenities are an indispensable part of urban life. People living in any given area have certain basic requirements of life which need to be fulfilled, like their daily share of groceries, medicines, food products, ATMs, dry cleaners, recreational centers, etc. Also, due to the social\textsuperscript{15} (gathering, outdoor relaxation), economic\textsuperscript{16} (increase in property value) and environmental\textsuperscript{2} (cooling urban heat islands, environment education) impacts of green space, the provision of same has become as vital as other basic amenities. Hence, green space here is considered an integral part of spatial planning just like basic amenities.

\textsuperscript{15}Accessible Natural Greenspace Standard (ANGSt)
Many sustainability and smart growth guidelines/literature identify 400m as the most comfortable distance to walk\textsuperscript{17,18,19}. Usually, 5 minute distance is also a threshold distance up to which walking dominates the choice of using a personal vehicle. Apart from this, the Assessable Natural Green Space Standards (ANGSt) prescribes a minimum distance of 300m for location of green space. Also, the normal walking speed of a person is about 3-4km/hr. This means that a person can cover around 300m distance in 5 minutes.

Thus, in order to promote walking and accessibility to green space, the least distance prescribed by different literatures i.e. 300m is taken as a benchmark. Whereas, for other amenities, the most prescribed, i.e. 400m is taken as a benchmark.

How is it beneficial?

- **Increase accessibility**- By distributing the land uses in a way that basic amenities and green space are at a walkable distance increase the comfort and convenience of the residents of the development.
- **Promote diverse mix of land uses**- This also encourages a diverse mix of uses to be located within a geographic area which helps in elevating the sense of community in that area.
- **Encourage walking**- Having the majority of places that one needs to access everyday available at a walking distance also inherently encourages the habit of walking leading to a healthy lifestyle.
- **Reduce per capita VMT** (Vehicle Miles Traveled) - Most of the uses are located at walking distance which reduces the probability of the residents to use their personal vehicle, hence reducing per capita VMT and GHG emissions (primarily CO\textsubscript{2}).
- **Shared use of infrastructure**- In case of infill development, ensuring accessibility limits the requirement of setting up new infrastructure and hence limits the use of resources.

The development should hence be planned in a manner so as to ensure accessibility to ‘public green spaces\textsuperscript{20}’ and ‘basic civic amenities’ by walking and cycling.


\textsuperscript{18}Gruen, Victor, the Heart of Our Cities. The Urban Crisis: Diagnosis and Cure. Simon and Schuster 1964, New York, p. 250.

\textsuperscript{19}Walking Distance Research, Fairfax Government, TOD Committee (http://www.fairfaxcounty.gov/planning/tod_docs/walking_distance_abstracts.pdf) accessed on 25th March 2011.

\textsuperscript{20}For the purpose of this guideline, public green space means parks, gardens, botanical gardens, zoological parks, traffic islands, having a minimum area of 2 ha. (Assessable Natural Green Space Standards (ANGSt) and UDPFI standards were referred for required area of green space and the minimum is adopted)
1. Distribute the land uses in a new development in such a way that all the public green spaces are within a distance of 300m (5 min walking distance) from each residential unit/non-residential building entrance.

2. Distribute the land uses in a new development in such a way that the basic civic amenities are within a distance of 400m from each residential unit/non-residential building entrance.

3. Encourage sharing of already existing amenities/infrastructure surrounding the development site by locating the new development in a way that the centre of the new development is at a distance of 400m from existing green space and basic civic amenities. (Applicable to small/infill developments)
**Guidance Note: Basic amenities**

For the purpose of identifying basic civic amenities that are to be provided for various sizes of development and the population it caters to, the following table derived from UDPFI guidelines may be used.

<table>
<thead>
<tr>
<th>Facilities/Population</th>
<th>For every 2500</th>
<th>For every 5000</th>
<th>For every 7500</th>
<th>For every 15000-20000</th>
<th>For every 50000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nursery School</td>
<td>yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary School</td>
<td>yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Senior Secondary School</td>
<td></td>
<td>yes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clinic</td>
<td></td>
<td></td>
<td>yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nursing Home</td>
<td></td>
<td></td>
<td></td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>Community Hall</td>
<td></td>
<td>yes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Community Hall with Library</td>
<td></td>
<td></td>
<td></td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>Milk Distribution Booth</td>
<td></td>
<td>yes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LPG Godown</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>yes</td>
</tr>
<tr>
<td>Police Post</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>yes</td>
</tr>
<tr>
<td>Cluster Centre</td>
<td>yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sector Centre</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>Community Centre</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>yes</td>
</tr>
</tbody>
</table>

In addition to amenities listed above, following amenities should be provided within walking/cycling distance: grocery, pharmacy, internet/fax/computer/cellphone recharge access, stationary, vegetables, ATM/bank, service providers, plumbing, electricians, etc.
Guideline 11: Promote use of mass transportation

As discussed in the previous guideline, people can be expected to walk up to a distance of 300 m to 500 m, beyond which they prefer to use other modes like cycle, two-wheeler, car, bus, etc. to move. On an average, cycles can support trip lengths of maximum 5-6 km; beyond which people prefer motorized modes for faster movement. Large developments should try to capture these longer trips within the development by mass transport modes. This implies that the developments should have well-planned mass transport systems from the beginning. The mass transport network should also be used to promote a transit oriented growth within the development, i.e. high density development planned around transit nodes so as to maximize the usage of transit system and discourage the use of personal vehicles (figure).

![Conceptual representation - Transit oriented design](image)

**Figure 11.1: Conceptual representation - Transit oriented design**

Source – Victoria Public transport guidelines (2008)

Mass transport based movement should be promoted both within and outside the development.

**Within the development:**

- Mass transport system should be developed within developments that are expected to have longer trip lengths (above 5 km)
- The system should be made to run on clean fuels
Connectivity with public transport nodes outside the development

- Feeder services should be provided for residents to reach nearest public transport nodes
- Feeder services should be made to run on clean fuels

The mass transport system planned for the development should be adequate and efficient to serve the planned needs of the development. Following parameters should be considered while planning the mass transport system:

- Ensuring adequate availability (including spatial coverage),
- Ensuring accessibility of transit stations,
- Offering Customer convenience - reliability of services, presence of information systems, safety and security while traveling, comfort and cleanliness, time and cost of travel, and
- Planning efficient operations and management of transit services

Translating some of the above parameters into specific goals, the following should be targeted for mass transit planning (TERI, 2010):

- Number of buses per 1000 people: 0.5 to 1.2 per 1000 population
- Desired modal share of mass transportation – refer table below

Table 11.1: Desirable modal split for Indian cities

<table>
<thead>
<tr>
<th>City population (in millions)</th>
<th>Mass Transport</th>
<th>Bicycle</th>
<th>Other modes</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1-0.5</td>
<td>30-40</td>
<td>30-40</td>
<td>25-35</td>
</tr>
<tr>
<td>0.5-1.0</td>
<td>40-50</td>
<td>25-35</td>
<td>20-30</td>
</tr>
<tr>
<td>1.0-2.0</td>
<td>50-60</td>
<td>20-30</td>
<td>15-25</td>
</tr>
<tr>
<td>2.0-5.0</td>
<td>60-70</td>
<td>15-25</td>
<td>10-20</td>
</tr>
<tr>
<td>5.0+</td>
<td>70-85</td>
<td>15-20</td>
<td>10-15</td>
</tr>
</tbody>
</table>

- **Percentage of population in an area/zone having access to public transport services within 500 metres of walking distance:** The higher is the percentage of population, the better it would be. Anything above 80%-85% is considered to be good accessibility.

- **Customer convenience – Following should be targeted:**
  - Facilities for the physically challenged on public transport vehicles and stations
  - Well-maintained clean buses and bus stand premises
  - Easy-to-understand and quick access to information regarding bus schedules, routes, delays, and so on for public transport services
  - Online information on movement of buses
  - Eighty per cent of all services running at a headway of not more than 15 minutes during weekday peak periods
  - Reduced waiting time in peak hours between 5–7 minutes
  - Provision of services (main and feeder) so that all households in the development are within a maximum of 30 minutes of travel time by public transport from the regular trip generating points like schools, hospitals, employment centres, colleges, and shopping areas

- **Efficient operations and management**
  - Minimize operational cost and breakdown rate
  - Maximize fuel efficiency
  - Optimize fleet utilization

The Ministry of Urban Development has recently come up with toolkits for developing mass transit systems; the same should be adopted while planning/designing mass transit systems for large developments. The Ministry has also developed Service Level Benchmarks (SLBs) for urban transport sector. These benchmarks should be referred to if specific service level goals for mobility within development need to be set.
Guideline 12: Promote use of clean fuels, sustainable road construction practices and use of ICT

The developers should target:

- Promoting use of clean fuels
  Adequate infrastructure and alternative fuel availability needs to be planned beforehand in order to ensure use of clean fuels by private vehicles and mass transit systems.

- Promoting use of waste/recycled materials in construction of roads
  Use of plastic wastes, industrial waste products, and waste materials from demolished road/building construction sites should be considered in road construction. Central Pollution Control Board’s (CPCB) guidelines on use of plastics in road construction can be followed.

- Promoting use of information and communication technologies (ICT)
  *In mass transport:*
  Promote use of Passenger Information Systems (Mobile and fixed information devices, driver information systems); Intelligent Public Transport Management Systems (Automatic Vehicle Location System, Electronic Display Systems) in provision of mass transit systems.

  *In traffic management systems:*
  Promote Intelligent Transportation Systems (ITS) to manage traffic operations.

21http://cpcb.nic.in/oldwebsite/Plastic20Waste/Re-use_of_plastic_waste_in_road_construction.html
SECTION D: ENERGY and ENERGY SYSTEMS

Guideline 13: Energy Efficient Electrical Systems for Large Development

Large developments which are having multiple users of electricity, needs a distribution network to distribute electricity among different types of users. During electricity distribution, parts of electricity get lost in distribution network. This is unavoidable due to inherent nature of network, but by proper designing, same can be reduced. This loss of electricity in distribution network is called as technical loss and each and every component in network contributes for technical loss. The main objective of the proposed guidelines is to help designing of distribution network and selection of equipment to optimize this technical loss. (optimization tools such as ETAP may be used in this effort)

Electrical systems

Electrical System in a large development comprises of the infrastructure that brings in electrical supply. The main infrastructures are Electrical Substation, transformers, distribution systems, circuit breakers, Electrical meters, capacitors, captive power etc.

The main aim of having an efficient electrical system in a large development is to have energy efficient delivery systems thereby the losses in the electrical infrastructure is kept to minimum. Also the installed electrical system should have suitable safety mechanism for providing reliable power supply.

Electrical system design

A typical electrical distribution facility in a large development will generally include the following:

- Power distribution systems for equipment, including indoor sub-station, transformers, building distribution, process control systems, building electrical service systems and protection systems
- Power outlet system for movable equipment, material-handling systems, transportation system
- Auxiliary systems like air-conditioning & refrigeration, compressed air system, lighting, fire fighting / detection/alarm systems, communication and computer based equipment.
- D G sets / co-generation equipment/ UPS/Inverter
Any system planning should include certain basic considerations as given below that will support the overall flexible design and efficient operation of the electrical system:

- Safety of life and property including equipment.
- Reliability of system input supply and tolerance limit of interruptions
- Flexibility of plant distribution system
- Location of the plant sub-station and its deployment
- Simplicity /flexibility of operation and maintenance
- Overall cost including running cost
- Providing quality service
- Technical parameters and specifications of materials to follow standards in construction, installation, protection, operation and maintenance
- Adherence to laid down procedures with accountability

Table 1 indicates possible loss as percentage of full load for few electrical equipment

**Table 13.1: Loss percentage in electrical equipment (please give reference)**

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Equipment</th>
<th>% loss of max load</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>A C Motors</strong></td>
<td></td>
</tr>
<tr>
<td>i.</td>
<td>750 Watts - 7.5 kW</td>
<td>14 - 35</td>
</tr>
<tr>
<td></td>
<td>7.5 kW - 150 kW</td>
<td>6 - 12</td>
</tr>
<tr>
<td></td>
<td>150 kW - 1000 kW</td>
<td>4 - 7</td>
</tr>
<tr>
<td></td>
<td>Above 1000 kW</td>
<td>2.3 - 4.5</td>
</tr>
<tr>
<td>ii.</td>
<td>Transformers</td>
<td>0.4 - 1.9</td>
</tr>
<tr>
<td>iii.</td>
<td>Cables</td>
<td>1 - 4</td>
</tr>
</tbody>
</table>
### Table

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Equipment</th>
<th>% loss of max load</th>
</tr>
</thead>
<tbody>
<tr>
<td>iv.</td>
<td>Switch gear</td>
<td></td>
</tr>
<tr>
<td></td>
<td>L.T.</td>
<td>0.13 - 0.34</td>
</tr>
<tr>
<td></td>
<td>Medium voltage up to 11 kV</td>
<td>0.005 - 0.02</td>
</tr>
</tbody>
</table>

### Electrical load optimization

The following steps should be taken into consideration for initial planning and sanction of the electrical design.

1. **Estimation of load details such as:**
   - load in kW and demand in kVA
   - diversity factor
   - load characteristics
   - future expansion

   This includes peak load, load fluctuations under various operating conditions, nature of load, PF and its variation, calculated daily, monthly and annual load factor, and anticipated seasonal variation, effect of large motor starting.

2. **Anticipation of the present demand over a period of time, peak load, maximum demand and demand, diversity and load factors.**

3. **Forecasting and planning of future load demand (expansion plans).**

4. **Determination of the voltage level required for the different applications.**

   Power is supplied through a transmission and distribution (T&D) network. This can be provided using either high voltage & low current or vice versa. The selection of the voltage level is determined by current national and international standards, safety regulations and, of course, the economic considerations. Large consumers can reduce energy losses by drawing power at a high voltage level and distribute it inside their premises at required load centres using their own step-down transformers to match the voltage level to the equipment.
5. Identification of voltage application required in the large development and voltage drops at all levels and at critical points. A campus classification, based on load and preferred incoming voltage, is given in Table 2.

**Table 13.2**: Large development classification of Voltage Preferences (please see comment of BEE)

<table>
<thead>
<tr>
<th>Large Development</th>
<th>Preferred Incoming Voltage Level</th>
<th>Voltage Class as per I.E. Rule</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 MW and above</td>
<td>220 kV</td>
<td>Extra</td>
</tr>
<tr>
<td>Between (10 - 50 MW)</td>
<td>132 - 66 kV</td>
<td>High</td>
</tr>
<tr>
<td>Between (1 to 10 MW)</td>
<td>33 - 11 kV</td>
<td>High</td>
</tr>
<tr>
<td>Up to 50 kW</td>
<td>3ϕ, 440 Volts</td>
<td>Medium/Low</td>
</tr>
</tbody>
</table>


2. Station house-service unit requirement (parallel, standby or emergency operation).

3. Preliminary layout drawing including provisions for future expansion.

4. Detailed single line diagrams, covering all loads/supplies, including main and distribution transformers, switch gear, primary and secondary cabling, protection, insulation level co-ordination, motor starter panels, distribution panels, Automatic power factor correction panels and capacitor banks.

**Transformer Rating and Selection**

Most of the transformers used in electrical power systems are three-phase transformers. They can be characterized by the vector group and the type of cooling. The vector group (e.g. star connection, delta connection) depends on the internal connection of windings of the high voltage and low voltage side.

Cooling of the transformer is performed by air or a liquid, e.g. oil cooled or dry type with a natural or forced flow. The heat is drawn off using cooling ribs at the surface of the tank.

In most cases the power losses can only be ascertained through the test certificate issued by the manufacturer or by carrying out field measurements.

Distribution transformers of the proper ratings and design must be selected to satisfy the minimum acceptable efficiency at 50% and full load rating as recommended in ECBC for dry type and oil cooled transformers. In addition,
the transformer must be selected such that it minimizes the total of its initial
cost in addition to the present value of the cost of its total lost energy while
serving its estimated loads during its respective life span.

The transformer losses for oil cooled transformer for 11 kV and 33 kV as
recommended in CBC are given in table 3.

When new transformer is procured the 50% load and full load losses of the
transformer should be in accordance with the figures as given in table below.

**Table 13.3: Maximum allowable transformers losses for oil cooled transformers**

<table>
<thead>
<tr>
<th>Rating kVA</th>
<th>Max. losses at 50% loading kW</th>
<th>Max. losses at 100% loading kW</th>
<th>Total losses at 50% loading kW</th>
<th>Total losses at 100% loading kW</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Up to 11 kV</td>
<td>Up to 33kV</td>
<td></td>
<td></td>
</tr>
<tr>
<td>100</td>
<td>0.5</td>
<td>1.8</td>
<td>0.6</td>
<td>1.8</td>
</tr>
<tr>
<td>160</td>
<td>0.8</td>
<td>2.2</td>
<td>0.8</td>
<td>2.6</td>
</tr>
<tr>
<td>200</td>
<td>0.9</td>
<td>2.7</td>
<td>0.9</td>
<td>3.0</td>
</tr>
<tr>
<td>250</td>
<td>1.1</td>
<td>3.3</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>315</td>
<td>1.1</td>
<td>3.6</td>
<td>1.3</td>
<td>4.3</td>
</tr>
<tr>
<td>400</td>
<td>1.5</td>
<td>4.6</td>
<td>1.5</td>
<td>5.1</td>
</tr>
<tr>
<td>500</td>
<td>1.6</td>
<td>5.5</td>
<td>2.0</td>
<td>6.5</td>
</tr>
<tr>
<td>630</td>
<td>2.0</td>
<td>6.6</td>
<td>2.3</td>
<td>7.6</td>
</tr>
<tr>
<td>1000</td>
<td>3.0</td>
<td>9.8</td>
<td>3.5</td>
<td>11.4</td>
</tr>
<tr>
<td>1250</td>
<td>3.6</td>
<td>12.0</td>
<td>4.0</td>
<td>13.3</td>
</tr>
<tr>
<td>1600</td>
<td>4.5</td>
<td>15.0</td>
<td>4.9</td>
<td>16.0</td>
</tr>
<tr>
<td>2000</td>
<td>5.4</td>
<td>18.4</td>
<td>5.7</td>
<td>18.5</td>
</tr>
<tr>
<td>2500</td>
<td>6.5</td>
<td>22.5</td>
<td>7.1</td>
<td>23.0</td>
</tr>
</tbody>
</table>

At the time of installation of a new transformer the size is decided based on
the expected loading on the transformer. Normally maximum efficiency; of
the distribution transformer is designed at the loading in the range of 50 to
65% of its full load capacity. If the average load is 80% or more of the rated
power, a bigger transformer or a second transformer should be considered
because the short-circuit losses become a large portion of the total losses.
Capacity and Number of Transformers

The main factors which should be taken into account when determining the number and capacity of transformers are given below.

The number of transformers depends upon the operating duty of the substation or large development. The load curve may show that the installation of two transformers instead of one is more economically attractive. This is usually the case when the load capacity factor is low (less than or equal to 0.5). In this case disconnecting devices are necessary to connect and disconnect the power transformers to ensure economical operation.

Where possible the installation of either one transformer or two transformers connected through a common circuit breaker should be contemplated. If the reliability of supply necessitates the installation of more than one transformer should be sought. When designing substations, redundancy features (Reserve facility) should be taken care of as follows:

The campus should be supplied from two independent sources, where continuity of supply is required. The capacity of the transformers should be so selected that if one of the transformers fails, the remaining transformer shall ensure supply to the equipments without undue overload.

In selecting transformer capacity, it should be ensured for economical operation so that when one of the transformers is out of service, the load on the transformer in operation as far as temperature is concerned shall not affect its service life.

It is always a good practice to provide / or install transformers of one step higher in capacity. For example: If two transformers each rated for 1000 kVA are installed their foundations and structures should be so designed as to make possible the installation of two transformers of 1250kVA each without much material modifications.

Electrical Motors

The electric motors consume a significant amount of electricity in the large development installations. Because of its simplicity and robustness the three-phase squirrel-cage induction motor is the prime mover of the large development. The electric motor manufacturers are seeking methods for improving the motor efficiencies, which resulted in a new generation of electric motors that are known as energy efficient motors.

Improvements in motor efficiency can be achieved without compromising motor performance within the limits of existing design and manufacturing technology.
Any improvement in motor efficiency must result from reducing the Watts losses. In terms of the existing state of electric motor technology, reduction in watts losses can be achieved in various ways. The technical features and benefits of Energy Efficient motors are listed below:

High efficiency motors (ECBC user guide tables 8.3, 8.4, 8.5, 8.6 can be referred for efficiency of Energy Efficient motors as per IS : 12615 2004) are usually manufactured from materials, which incur lower energy losses compared with standard motors. More care is taken with the design and geometry of the motor construction. The high efficiency motors have been improved in four areas:

- Longer core lengths of low loss steel laminations to reduce flux densities and iron losses
- Maximum utilization of the slots and generous conductor sizes in the stator and rotor to reduce copper losses
- Careful selection of slot numbers and tooth/slot geometry to reduce stray losses
- Less heat is produced by a more efficient motor so the cooling fan size is reduced. This leads to lower wind age losses and therefore less waste power.

The advantages of usage of high efficiency motors are as follows:

- Optimum use of energy as operating losses are lower
- Reduced magnetic loss resulting in cooler applications
- Low life cycle cost
- Robust design to take care of wider supply variations (10%) and ambient temperature up to 80°C
- Efficiency figures remain constant up to 75% of the rated output and drop maximum by 1% at 50% rated output

**Power factor**

Power factor (PF) improvement allows the use of smaller transformers, switchgear and cables, etc. as well as reducing power losses and voltage drop in an installation. A high power factor allows the optimization of the components of an installation. Overrating of certain equipment can be avoided, but to achieve the best results the correction should be effected as
close to the individual equipment as possible. Losses in cables are proportional to square of the current and Power factor improvement reduced the T & D losses. By improving the power factor of a load supplied from a transformer, the current through the transformer will be reduced thereby allowing more loads to be added. In practice, it may be less expensive to improve the power factor, than to replace the transformer by a larger unit. Some distribution companies provides incentive in tariff for high PF and penalty for low PF.

**Power factor improvement by installing capacitors**

Power factor improvement by installing capacitors is the widely followed method. Capacitors can be significant energy savers, if they are properly applied. A capacitor bank is also a load albeit with very low loss (0.2-0.4 W/kVAR). So it should be disconnected when VAr support is not required. Automated Power Factor Correction (APFC) panel can be used for automatic switching on and off of the capacitors. If a fuse blows on a large capacitor, an unbalanced voltage results in which increases system and motor losses. Therefore, the fuse integrity of capacitor banks should be closely monitored. A high harmonic content in the power supply has been known to cause either capacitor failure or unplanned operation of protective devices. Hence use of latest semi conductor devices with appropriate technology can prove beneficiary in the long run.

Capacitors should be installed across the terminals of motors. However, the capacitor value should not exceed the no load kVAR value of the motor. Table 4 gives the approximate value of capacitors that need to be connected for different rating of the motors.

**Table 13.4: Recommended capacitor rating for direct connection to induction motors (To improve power factor to 0.95 or better)**

<table>
<thead>
<tr>
<th>Motor H.P</th>
<th>Capacitor rating in KVAR when motor speed is</th>
<th>Motor H.P.</th>
<th>Capacitor rating in KVAR when motor speed is</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3000 r.p.m</td>
<td>1500 r.p.m</td>
<td>1000 r.p.m</td>
</tr>
<tr>
<td>2.5</td>
<td>1</td>
<td>1</td>
<td>1.5</td>
</tr>
<tr>
<td>5</td>
<td>2</td>
<td>2</td>
<td>2.5</td>
</tr>
<tr>
<td>7.5</td>
<td>2.5</td>
<td>3</td>
<td>3.5</td>
</tr>
<tr>
<td>Motor</td>
<td>Capacitor rating in KVar when motor speed is</td>
<td>Motor</td>
<td>Capacitor rating in KVar when motor speed is</td>
</tr>
<tr>
<td>-------</td>
<td>---------------------------------------------</td>
<td>-------</td>
<td>---------------------------------------------</td>
</tr>
<tr>
<td>10</td>
<td>3</td>
<td>4</td>
<td>4.5</td>
</tr>
<tr>
<td>12.5</td>
<td>3.5</td>
<td>4.5</td>
<td>5</td>
</tr>
<tr>
<td>15</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>17.5</td>
<td>4.5</td>
<td>5.5</td>
<td>6.5</td>
</tr>
<tr>
<td>20</td>
<td>5</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>22.5</td>
<td>5.5</td>
<td>6.5</td>
<td>8</td>
</tr>
<tr>
<td>25</td>
<td>6</td>
<td>7</td>
<td>9</td>
</tr>
<tr>
<td>27.5</td>
<td>6.5</td>
<td>7.5</td>
<td>9.5</td>
</tr>
<tr>
<td>30</td>
<td>7</td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td>32.5</td>
<td>7.5</td>
<td>8.5</td>
<td>11</td>
</tr>
<tr>
<td>35</td>
<td>8</td>
<td>9</td>
<td>11.5</td>
</tr>
<tr>
<td>37.5</td>
<td>8.5</td>
<td>9.5</td>
<td>12</td>
</tr>
<tr>
<td>40</td>
<td>9</td>
<td>10</td>
<td>13</td>
</tr>
<tr>
<td>42.5</td>
<td>9.5</td>
<td>11</td>
<td>14</td>
</tr>
<tr>
<td>45</td>
<td>10</td>
<td>11.5</td>
<td>14.5</td>
</tr>
<tr>
<td>47.5</td>
<td>10.5</td>
<td>12</td>
<td>15</td>
</tr>
<tr>
<td>50</td>
<td>11</td>
<td>12.5</td>
<td>16</td>
</tr>
<tr>
<td>55</td>
<td>12</td>
<td>13.5</td>
<td>17</td>
</tr>
<tr>
<td>60</td>
<td>13</td>
<td>14.5</td>
<td>18</td>
</tr>
<tr>
<td>65</td>
<td>14</td>
<td>15.5</td>
<td>19</td>
</tr>
<tr>
<td>70</td>
<td>15</td>
<td>16.5</td>
<td>20</td>
</tr>
</tbody>
</table>
Motor | Capacitor rating in kVAR when motor speed is | Motor | Capacitor rating in kVAR when motor speed is
--- | --- | --- | ---
5 | 225 | 44 | 47 | 50 | 52 | 65 | 72
75 | 16 | 17 | 21 | 23 | 29 | 32 | 49 | 51 | 64 | 72
80 | 17 | 19 | 22 | 24 | 30 | 34 | 42 | 45 | 47 | 50 | 52 | 65 | 73
85 | 18 | 20 | 23 | 25 | 31 | 35 | 44 | 46 | 48 | 51 | 53 | 65 | 74
90 | 19 | 21 | 24 | 26 | 33 | 37 | 46 | 48 | 51 | 53 | 66 | 75
95 | 20 | 22 | 25 | 27 | 34 | 38 | 47 | 49 | 52 | 54 | 67 | 75
100 | 21 | 23 | 26 | 28 | 35 | 40 | 49 | 50 | 53 | 55 | 68 | 76

Note: The recommended capacitor rating given in the above table is only for guidance purpose. (The capacitor rating should correspond approximately to the apparent power of the motor on no-load).

Another chart for calculating the capacitors required for improving the Power factor is given in table 5.

**Table 13.5: Multiplying factor for calculating the sizes of capacitor for power factor improvement**

<table>
<thead>
<tr>
<th>Power factor of load before applying capacitors</th>
<th>Size of capacitors in kVAR per kW of load for raising the power factor to</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.45</td>
<td>1.230</td>
</tr>
<tr>
<td>0.46</td>
<td>1.179</td>
</tr>
<tr>
<td>0.47</td>
<td>1.130</td>
</tr>
<tr>
<td>0.48</td>
<td>1.076</td>
</tr>
<tr>
<td>0.49</td>
<td>1.030</td>
</tr>
<tr>
<td>0.50</td>
<td>0.982</td>
</tr>
<tr>
<td>0.51</td>
<td>0.936</td>
</tr>
<tr>
<td>0.52</td>
<td>0.894</td>
</tr>
<tr>
<td>0.53</td>
<td>0.850</td>
</tr>
<tr>
<td>0.54</td>
<td>0.809</td>
</tr>
</tbody>
</table>
### Guidelines and benchmarks for Green Large Area Developments Final report

<table>
<thead>
<tr>
<th>Power factor of load before</th>
<th>Size of capacitors in kVAR per kW of load for raising the power factor to</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.55</td>
<td>0.769  0.899  1.035  1.063  1.090  1.124  1.156  1.190  1.228  1.268  1.316  1.377  1.519</td>
</tr>
<tr>
<td>0.56</td>
<td>0.730  0.860  0.996  1.024  1.051  1.085  1.117  1.151  1.189  1.229  1.277  1.338  1.480</td>
</tr>
<tr>
<td>0.57</td>
<td>0.692  0.822  0.958  0.986  1.013  1.047  1.079  1.113  1.151  1.191  1.239  1.300  1.442</td>
</tr>
<tr>
<td>0.58</td>
<td>0.655  0.785  0.921  0.949  0.976  1.010  1.042  1.076  1.114  1.154  1.202  1.263  1.405</td>
</tr>
<tr>
<td>0.59</td>
<td>0.618  0.748  0.884  0.912  0.939  0.973  1.005  1.039  1.077  1.117  1.165  1.226  1.368</td>
</tr>
<tr>
<td>0.60</td>
<td>0.584  0.714  0.849  0.878  0.905  0.939  0.971  1.005  1.043  1.083  1.131  1.192  1.334</td>
</tr>
<tr>
<td>0.61</td>
<td>0.549  0.679  0.815  0.843  0.870  0.904  0.936  0.970  1.008  1.048  1.096  1.157  1.299</td>
</tr>
<tr>
<td>0.62</td>
<td>0.515  0.645  0.781  0.809  0.836  0.870  0.902  0.936  0.974  1.014  1.062  1.123  1.265</td>
</tr>
<tr>
<td>0.63</td>
<td>0.483  0.613  0.749  0.777  0.804  0.838  0.870  0.904  0.942  0.982  1.030  1.091  1.233</td>
</tr>
<tr>
<td>0.64</td>
<td>0.450  0.580  0.716  0.744  0.771  0.805  0.837  0.871  0.909  0.949  0.997  1.058  1.200</td>
</tr>
<tr>
<td>0.65</td>
<td>0.419  0.549  0.685  0.713  0.740  0.774  0.806  0.840  0.878  0.918  0.966  1.027  1.169</td>
</tr>
<tr>
<td>0.66</td>
<td>0.388  0.518  0.654  0.682  0.709  0.743  0.775  0.809  0.847  0.887  0.935  0.996  1.138</td>
</tr>
<tr>
<td>0.67</td>
<td>0.358  0.488  0.624  0.652  0.679  0.713  0.745  0.779  0.817  0.857  0.905  0.966  1.108</td>
</tr>
<tr>
<td>0.68</td>
<td>0.329  0.459  0.595  0.623  0.650  0.684  0.716  0.750  0.788  0.828  0.876  0.937  1.079</td>
</tr>
<tr>
<td>0.69</td>
<td>0.299  0.429  0.565  0.593  0.620  0.654  0.686  0.720  0.758  0.798  0.840  0.907  1.049</td>
</tr>
<tr>
<td>0.70</td>
<td>0.270  0.400  0.536  0.564  0.591  0.625  0.657  0.691  0.729  0.769  0.811  0.878  1.020</td>
</tr>
<tr>
<td>0.71</td>
<td>0.242  0.372  0.508  0.536  0.563  0.597  0.629  0.663  0.701  0.741  0.783  0.850  0.992</td>
</tr>
<tr>
<td>0.72</td>
<td>0.213  0.343  0.479  0.507  0.534  0.568  0.600  0.634  0.672  0.712  0.754  0.821  0.963</td>
</tr>
<tr>
<td>0.73</td>
<td>0.186  0.316  0.452  0.480  0.507  0.541  0.573  0.607  0.645  0.685  0.727  0.794  0.936</td>
</tr>
<tr>
<td>0.74</td>
<td>0.159  0.289  0.425  0.453  0.480  0.514  0.546  0.580  0.618  0.658  0.700  0.767  0.909</td>
</tr>
<tr>
<td>0.75</td>
<td>0.132  0.262  0.398  0.426  0.453  0.487  0.519  0.553  0.591  0.631  0.673  0.740  0.882</td>
</tr>
<tr>
<td>0.76</td>
<td>0.105  0.235  0.371  0.399  0.426  0.460  0.492  0.526  0.564  0.604  0.652  0.713  0.855</td>
</tr>
<tr>
<td>0.77</td>
<td>0.079  0.209  0.345  0.373  0.400  0.434  0.466  0.500  0.538  0.578  0.620  0.687  0.829</td>
</tr>
</tbody>
</table>
### Power factor of load before

<table>
<thead>
<tr>
<th>Power factor of load before</th>
<th>Size of capacitors in kVAR per kW of load for raising the power factor to</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.78</td>
<td>0.053 0.183 0.319 0.347 0.374 0.408 0.440 0.474 0.512 0.552 0.594 0.661 0.803</td>
</tr>
<tr>
<td>0.79</td>
<td>0.026 0.156 0.292 0.320 0.347 0.381 0.413 0.447 0.485 0.525 0.567 0.634 0.776</td>
</tr>
<tr>
<td>0.80</td>
<td>-     0.130 0.266 0.294 0.321 0.355 0.387 0.421 0.459 0.499 0.541 0.608 0.750</td>
</tr>
<tr>
<td>0.81</td>
<td>-     0.104 0.240 0.268 0.295 0.329 0.361 0.395 0.433 0.473 0.515 0.582 0.724</td>
</tr>
<tr>
<td>0.82</td>
<td>-     0.078 0.214 0.242 0.269 0.303 0.335 0.369 0.407 0.447 0.489 0.556 0.698</td>
</tr>
<tr>
<td>0.83</td>
<td>-     0.052 0.188 0.216 0.243 0.277 0.309 0.343 0.381 0.421 0.463 0.530 0.672</td>
</tr>
<tr>
<td>0.84</td>
<td>-     0.026 0.162 0.190 0.217 0.251 0.283 0.317 0.355 0.395 0.437 0.504 0.645</td>
</tr>
<tr>
<td>0.85</td>
<td>-     -     0.136 0.164 0.191 0.225 0.257 0.291 0.329 0.369 0.417 0.478 0.620</td>
</tr>
<tr>
<td>0.86</td>
<td>-     -     0.109 0.140 0.167 0.198 0.230 0.264 0.301 0.343 0.390 0.450 0.593</td>
</tr>
<tr>
<td>0.87</td>
<td>-     -     0.083 0.114 0.141 0.172 0.204 0.238 0.275 0.317 0.364 0.424 0.567</td>
</tr>
<tr>
<td>0.88</td>
<td>-     -     0.054 0.085 0.112 0.143 0.175 0.209 0.246 0.288 0.335 0.395 0.538</td>
</tr>
<tr>
<td>0.89</td>
<td>-     -     0.028 0.059 0.083 0.117 0.149 0.183 0.230 0.262 0.309 0.369 0.512</td>
</tr>
<tr>
<td>0.90</td>
<td>-     -     -     0.031 0.058 0.089 0.121 0.155 0.192 0.234 0.281 0.341 0.484</td>
</tr>
<tr>
<td>0.91</td>
<td>-     -     -     -     0.027 0.058 0.090 0.124 0.161 0.203 0.250 0.310 0.453</td>
</tr>
<tr>
<td>0.92</td>
<td>-     -     -     -     -     0.031 0.063 0.097 0.134 0.176 0.223 0.283 0.426</td>
</tr>
<tr>
<td>0.93</td>
<td>-     -     -     -     -     -     0.032 0.066 0.103 0.145 0.192 0.252 0.395</td>
</tr>
<tr>
<td>0.94</td>
<td>-     -     -     -     -     -     -     0.034 0.071 0.113 0.160 0.220 0.365</td>
</tr>
<tr>
<td>0.95</td>
<td>-     -     -     -     -     -     -     -     0.037 0.079 0.126 0.186 0.329</td>
</tr>
<tr>
<td>0.96</td>
<td>-     -     -     -     -     -     -     -     -     0.042 0.089 0.149 0.292</td>
</tr>
<tr>
<td>0.97</td>
<td>-     -     -     -     -     -     -     -     -     -     0.047 0.107 0.250</td>
</tr>
<tr>
<td>0.98</td>
<td>-     -     -     -     -     -     -     -     -     -     -     0.060 0.203</td>
</tr>
<tr>
<td>0.99</td>
<td>-     -     -     -     -     -     -     -     -     -     -     -     0.143</td>
</tr>
</tbody>
</table>

**Example:** Given 100 kW load to be improved from 0.77 to 0.95 Power Factor.
Factor from table is 0.500.
\[ \text{Capacitor required (kVAr)} = 100 \times 0.500 = 50 \text{ kVAr} \]

**Check Metering and monitoring**

Energy accounting, monitoring and control are integral part of the energy conservation management which is required to operate and maintain an electrical network at efficiently.

**a. Energy Accounting**

Metering of the energy consumed by an establishment is necessary so that:

- Energy consumed by equipment can be analysed in detail and corrective methods can be opted for improving equipment performances

- The consumption of active energy in the individual major equipment, systems, sections, and plant can be monitored and variation in energy consumption in relation to electrical demand can be analysed.

- The above analysis helps in bench-marking to arrive at optimum specific energy consumption and reduce network irregularities

- The production of reactive energy by the compensating units of the system may be monitored and corrective steps can be adopted

- It helps in identifying the optimum usage of demand allocation, thereby improving the load factor

- Any consumers supplied via the campus substation may be charged accordingly.

- Energy accounting for the corresponding sections (i.e. individual profit centre concept) can be initiated towards input cost analysis.

- Energy accounting shall help in correlating the daily, fortnightly, monthly, or annual energy consumption index with indication of deviation from the benchmark or the set target.

**b. Monitoring and Control**

It is always the best practice to install energy meters, hour meters (time totalisers) on major equipment/systems (HVAC system, lighting, Pumping system, street lighting etc.,) consuming significant amount of energy. This shall help in accounting energy consumption on ahourly basis, daily basis, month-wise and yearly basis. Co-relation of these consumption patterns with the load demand shall lead to identify energy saving opportunities.
The summation of all sub-meter energy consumption should be compared with the summation of main LT panel energy meter (check meter for grid energy meter) and the energy meters of the DG sets. Energy accounting error of about 3-4% (accounting for cable and equipment losses) between the summed values of sub-metering, main plant check meter and DG set energy meter to that of grid energy meters is reasonable. Enormous percentage error in the readings recorded needs to be viewed seriously.

**Losses in distribution system**

The distribution losses in the system are mainly on account of the losses in the cables and bus bars. The parameters that affect the cable losses are mainly cable resistance, power factor and voltage levels.

**Losses**

In-plant cable losses are in the range of 1% to 4%. Table 6 gives cable loss for various sizes of aluminium conductors.

**Table 13.6:** I2R Losses per Phase (in Watts) of Various Sizes (in mm²) of Aluminium Cables of 10 m Length in a 3 Phase System (pl see BEE comment)

<table>
<thead>
<tr>
<th>Size (mm²)</th>
<th>25</th>
<th>35</th>
<th>50</th>
<th>70</th>
<th>95</th>
<th>120</th>
<th>150</th>
<th>185</th>
<th>240</th>
<th>300</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amps</td>
<td>15</td>
<td>2.7</td>
<td>1.95</td>
<td>1.4</td>
<td>0.99</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>10.8</td>
<td>7.8</td>
<td>5.8</td>
<td>4.0</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>45</td>
<td>24.8</td>
<td>17.6</td>
<td>13.0</td>
<td>9.0</td>
<td>6.5</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>60</td>
<td>43.2</td>
<td>31.2</td>
<td>23.1</td>
<td>15.9</td>
<td>11.5</td>
<td>9.1</td>
<td>7.4</td>
<td>5.9</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>75</td>
<td>-</td>
<td>48.8</td>
<td>36.1</td>
<td>24.9</td>
<td>18.0</td>
<td>14.2</td>
<td>11.6</td>
<td>9.2</td>
<td>7.0</td>
</tr>
<tr>
<td></td>
<td>90</td>
<td>-</td>
<td>-</td>
<td>51.9</td>
<td>35.9</td>
<td>25.9</td>
<td>20.5</td>
<td>16.7</td>
<td>13.3</td>
<td>10.1</td>
</tr>
<tr>
<td></td>
<td>105</td>
<td>-</td>
<td>-</td>
<td>70.7</td>
<td>48.8</td>
<td>35.3</td>
<td>27.9</td>
<td>22.7</td>
<td>18.1</td>
<td>13.8</td>
</tr>
<tr>
<td></td>
<td>120</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>63.8</td>
<td>46.1</td>
<td>36.4</td>
<td>29.7</td>
<td>23.6</td>
<td>18.0</td>
</tr>
<tr>
<td></td>
<td>135</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>80.7</td>
<td>58.3</td>
<td>46.1</td>
<td>37.5</td>
<td>29.9</td>
<td>22.8</td>
</tr>
<tr>
<td></td>
<td>150</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>70.0</td>
<td>56.9</td>
<td>46.4</td>
<td>36.9</td>
<td>28.1</td>
</tr>
<tr>
<td></td>
<td>165</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>87.1</td>
<td>68.9</td>
<td>56.1</td>
<td>44.6</td>
</tr>
</tbody>
</table>
Loss Reduction

Power losses in lines depend upon the resistance of the lines and the current carried. The resistance of lines may be considered constant. Then it follows that the only way to reduce the loss of power is to reduce the current. The current may be reduced by using as many reserve lines as possible. Dual lines should be connected in parallel for a more economical and reliable operation.

Cable laying should be done strictly in accordance with carefully and systematically planned schedule. Drawing of this should be available at site and should be preserved at sub-stations. All cable ends should be suitably labelled to facilitate easy identification. In all control cables adequate number of spare cores should be included. For cables, IS:1255-1958, IS:962-1965, IS 1554 PI & PII, IS 7098 PI & PII and IS:3043-1966 standards shall be used for sizing and laying.

Power back up systems

A. DG Sets

With the rampant power shortage, poor power quality, disturbances, as seen in the present SEB grid power distribution, large developments are put to tremendous difficulties resulting in great discomfort to the users and breakdown of the services, etc., These has lead to the need for captive power generation.
Applications in large development have several advantages in going for Captive Generating sets. Captive power generation offers the following advantages:

1. Continuous availability of power, free from utility power breakdown and grid disturbances, etc., leading to better comfort, less interruptions in essential services etc.,

2. Good power system control obtained when operated in parallel with the utility supply system

3. Possibility of heat and electrical energy generation (Cogeneration) resulting in energy conservation and reduced energy cost,

4. Excess electrical energy generation can be supplied to the utility grid and earning income/ wheeling charges.

**Selection of Captive Generation Equipment**

Based on the energy requirements, availability of fuels, availability and reliability of grid power at the plant location, large developments should take up a detailed and careful study to decide the type of generating equipment, its rating and other specifications. Different modes of operating the Captive generation units are defined based on IEEE standard 446.

Following modes of operation may be considered:

**Standby Power supply Mode (Emergency Power Supply)**

- Captive power generation set utilised in this mode shall meet the large development part load or total load requirement during the failure of utility power supply (Grid supply system).

**Peak Loading Mode (Peak Lopping/Peak Shaving):**

- The captive power generation units are chosen to come into operation during peak load periods to supplement the utility supply (Grid supply) to limit the peak demand drawn from utility and thereby saving the electricity cost paid towards maximum peak demand.

**Base Load Mode (Primary Supply Mode):**

- This mode of operation is required in locations where there is no utility power supply or the utility supply is highly unreliable with frequent outages. A part or whole of the plant load is supplied on a continuous basis in this mode of operation. This mode of operation can also be termed as Total Energy mode. Large developments where the requirement of heat and cooling water supply, apart from electricity may opt for this mode of operation in the initial design stages.
The diesel generating sets are predominately used for captive power generation. The specific energy generation (SEGR) defined as a ratio of total energy generated to the oil consumed of the DG sets varies with size and loading on the DG sets. A SEGR of 4 kWh/litre is considered to be an efficient design for DG sets of more than 100 kVA.

**B. UPS/ Inverters**

An uninterruptible power supply, also uninterruptible power source, UPS or battery back-up, is an electrical apparatus that provides emergency power to a load when the input power source, typically the utility mains, fails. A UPS differs from an auxiliary or emergency power system or standby generator and it provides instantaneous or near-instantaneous protection from input power interruptions by means of one or more attached batteries and associated electronic circuitry. The on-battery runtime of most uninterruptible power sources is relatively short—5–15 minutes being typical for smaller units—but sufficient to allow time to bring an auxiliary power source on line, or to properly shut down the protected equipment.

While not limited to protecting any particular type of equipment, a UPS is typically used to protect computers, data centres, telecommunication equipment or other electrical equipment where an unexpected power disruption could cause injuries, fatalities, serious business disruption and/or data loss. UPS units range in size from units designed to protect a single computer without a video monitor (around 200 VA rating) to large units powering entire data centres, or servers in buildings in large developments.

The efficiency level of the inverters should vary from 92 - 95 % based on the capacity.

**Power Quality**

**A. Voltage Range, and Tolerance**

The voltage ranges in which the AC installations can be classified as per IS: 12360 - 1988, according to their normal voltage for earthed and not effectively earthed systems. These values along with the tolerances on declared voltages are given below in table.

**Table 13.7: Voltage Ranges in AC Installations**

<table>
<thead>
<tr>
<th>Ranges</th>
<th>Line-to-Line rms. Values</th>
<th>Standard Nominal A.C. System Voltages</th>
<th>Tolerance on Declared Voltage</th>
<th>Voltage adopted for the system</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>50 V ≤ u ≤ 1000 V</td>
<td>Three phase - 415</td>
<td>± 6 %</td>
<td>Distribution</td>
</tr>
<tr>
<td>II A</td>
<td>1 kV &lt; u ≤ 52 kV</td>
<td>3.3, 6.6, 11, 33 kV</td>
<td>+ 6 % &amp; - 9%</td>
<td>Sub-transmission</td>
</tr>
<tr>
<td>II B</td>
<td>52 kV &lt; u ≤ 300 kV</td>
<td>66, 132, 220 kV</td>
<td>± 12.5 %</td>
<td>Transmission</td>
</tr>
</tbody>
</table>
The primary sub-transmission voltage is 33 kV (in a few states, it is 66 kV). The 33 kV network is extended from 220 / 132 / 33 kV substations. The secondary sub-transmission voltage is standardised at 11 kV. The low-tension voltage is either 415 V or 240 V, supplied to consumers.

**B. Phase Voltage Imbalance in a Three Phase System**

Most utilities adopt a three-phase, four-wire, grounded-star primary distribution system, so that single-phase distribution transformers can be connected directly to supply lines to cater to single-phase loads, such as residences and street lights. Variations in single-phase load distribution cause the currents in the three-phase system to vary, producing different voltage drops and causing the phase voltage to become unbalanced.

Phase to phase voltage imbalances by even 2.5 % of the nominal voltage can reduce motor efficiency up to 10 %. This causes excessive heating due to the high negative sequence current. Imbalance of more than 5 % should therefore not be permitted.

Perfect balance can never be maintained since loads continuously change. Blown fuses on three phase capacitor banks also unbalance the load and cause phase voltage imbalance.

Proper balancing of single-phase loads on the three phases on both branch circuits and feeders is necessary to keep the load and corresponding phase-voltage imbalance within reasonable.

**C. Effects of Phase Voltage Imbalance**

Unequal loads on individual phases, negative and zero phase sequence components cause overheating of transformers, cables, conductors and motors thus increasing the losses and motor malfunction. The limit of negative phase sequence as per IEC34-1 is 2% of the voltage.

When unbalanced phase voltages are applied to three phase motors, additional negative sequence currents circulate in the motor, increasing heat losses in the rotor. The most severe condition occurs when one phase is open and the motor runs on single-phase power.
In general, single-phase loads should not be connected to three phase circuits supplying equipment sensitive to phase-voltage imbalance. A separate circuit should be used to supply such equipment.

**Guidance note to ensure low loss in electricity distribution network in large development**

**Transformers**
- The no load or copper loss depends upon design, core material and rating of transformer. Higher the rating, higher will be the no load loss therefore it is recommended that correct rating of transformer shall be selected.
- Stand By transformer without load also consumes energy. It is better to share the load on two transformers rather than putting load on one transformer while keeping other as stand by.
- Core material plays very important role, low loss transformers shall always be preferred.
- Losses are more, if transformer temperature is more, so proper ventilation of transformer should be ensured.

**Cables**
- Cables contribution is highest in the overall technical loss in a distribution network therefore they shall be sized in such a way that their cable current rating shall ensure their suitability w.r.t maximum current.
- Cable length shall be selected with minimum numbers of joints. Joints in cables not only increase the loss but also result in to frequent break downs.
- It is recommended to slightly oversize cable if length of cable is more.
- A good quality of cable termination is also recommended.
- The distribution network shall be designed to ensure a voltage drop less than 3% at highest load conditions.

**Switch Gears**
- Switch gears contribute loss both due to heating and also may be due to their own consumptions so better class of switchgear should be taken. All the switch gear shall be appropriately sized and shall have good quality of termination and adequate capacity of terminals.
- Power consumption monitoring shall be done in automation process, in solenoids etc. continuously.
- Sparking at terminals not only increases chances of break down but also affects the technical loss. Design & specification shall ensure no sparking.

**Motors**

- All permanently wired polyphase motors of 0.375 kW or more serving the building and expected to operate more than 1500 hours per year and all permanently wired polyphase motors of 50 kW or more serving the building and expected to operate more than 500 hours per year shall have a minimum acceptable nominal full load motor efficiency (refer ECBCUser guide) not less than IS 12615 for Energy Efficient motors.

- Motors of horsepower differing from those listed in the table shall have efficiency greater than that of the next listed kW motor.

- Motor horsepower ratings shall not exceed 20% of the calculated maximum load.

- Motor nameplates shall list the nominal full load motor efficiencies and the full load power factor.

- Motor users should insist on proper rewinding practices for rewound motors. If the proper rewinding practices cannot be assured, the damaged motor should be replaced with a new, efficient one rather than suffer the significant efficiency penalty associated with typical rewind practices.

- Certificates shall be obtained and kept on record indicating the motor efficiency. Whenever a motor is rewound, appropriate measures shall be taken so that the core characteristics of the motor is not lost due to thermal and mechanical stress during removal of damaged parts. After rewinding, a new efficiency test shall be performed and similar records shall be maintained.

- Motors should be installed with soft start energy savers and Variable Speed drives based on the application required.

**Instrumentations**

- Instrumentations in network increases joints and contribute in to technical loss due to own consumptions. Duplication of instruments in network shall be avoided and it shall be installed in such a way that there should be only one instrument for current, PF and energy measurement

- The more number of instruments in network affect measurements by over burdening CTs and PTs of distribution elements. Installation of CT normally results in two joints.
Capacitor bank

- Power distribution companies have tariff based on KVAh unit consumption. Thus control of power factor using auto power factor correction (APFC) is very important. Ideally a capacitor should have zero Copper loss but practically it has loss due to capacitor ESR. Low Tan δ MPP type capacitors shall be preferred.

- Technical loss could be high in spite of taking all precautions regarding selection of components, if network health parameters are not monitored and maintained. Following are few critical parameters that shall be monitored and maintained in a network in order to minimize the technical loss.

  - Unbalance current: It plays the most important role. Ideally the load on three phases should be same. Theoretically if entire load is put on one phase the technical loss in cable will become many times. Unbalance can be monitored by plotting current of all three phases on a single graph and then studying the trend. The exercise to balance the load should be done periodically.

  - Unbalance voltage: There are few three phase load whose efficiency get severely affected if the three phase voltages are not equal. Electric motor efficiency is highly affected by unbalance voltages. Unbalance in voltage can be due to unbalance transformer winding and can also be due to unbalance load on network. If unbalance is more than 2% it can severely affect the efficiency of motors.

Power factor

- As the technical loss is dependent upon flowing current, so it is important to ensure apparent current is equal to active current. The network should have APFC units to monitor and control power factor automatically. This also helps in regulating voltage levels. However it shall be ensured that capacitor bank should be switched off, whenever load is switched off. APFC panel shall be as near to load as possible.

Harmonics

- Presence of harmonics can increase technical loss, can cause heating, can increase neutral current, can affect measurements and lastly can reduce efficiency of devices. Feeders where load generates harmonics shall be isolated, so that it does not affect other load. If same is not possible harmonics filters shall be installed.
Neutral current

- Neutral current and Neutral to Earth voltage are also useful and informative health parameters. By monitoring the same and ensuring them as low as possible, low losses is ensured.

Voltage drop

- Higher the voltage drop between voltage feeding point and at load point indicates high level of technical loss.

- In case operation of one device affects the voltage and operation quality of other load, then entire wiring shall be checked. Loose joints results in voltage drop and so losses.

Cogeneration or Combined heat & power system

Various application in large development need both electric power and steam or hot water, and represent the ideal cases for planning and installation of cogeneration plants; also popularly known as combined heat and power (CHP) systems. These are the optimum systems for utilizing heat generated from a fuel. The utilization of heat may be in the form of hot gases or steam, depending upon the requirements. The cogeneration system is designed for specific application of the large development with focus on its heat (steam) needs and the fuel available. The system can be designed with fossil fuels (coal, oil, natural gas) or renewable fuels (biomass, bagasse etc.). If the cogeneration systems can be based on steam turbines or gas turbines depending upon fuel available. When the fuel available is oil or gas, it is preferred to use gas turbines and produce steam from the exhaust of hot flue gases. This steam could also be used in a condensing steam turbine to produce electricity. Such systems are called combined cycle power generation systems.

Cogeneration systems

The design of a cogeneration system starts from identifying the heat and electric power requirements for a given campus. Next thing to be considered is the fuel (s) availability throughout the year. The basic need which the cogeneration system is to fulfil first is the heat requirements at single or multiple pressures. The power output will then depend upon the selection of basic prime movers- gas turbine-generator or steam turbine-generator. If premium fuels (natural gas, oil, coal gas) are available, the gas turbine based cogeneration system in generally preferred. If fossil fuels or renewable fuels are available, the preferred system is steam turbine-generator based. The final selection will depend upon the overall techno-economic based on cost of power generation from the cogeneration scheme versus the cost of electric power supplied by the utility company through the grid. The cost of steam for
such calculations is taken as its cost when low/medium pressure boilers are used for meeting the process steam requirements.

**Steam turbine based Cogeneration systems**

The steam turbine based cogeneration systems can use any fuel– coal, oil, natural gas, bagasse, rice husk, rice straw, agricultural waste, municipal solid waste, industrial refuse etc. The boiler is designed for the fuels (single or multiple), which would be available in the required quantities throughout the year. The steam is produced at temperatures and pressures greater than those required for the industrial process, and then expanded through a steam turbine for generation of electric power. The exhaust steam parameters of the steam turbine are designed based on the parameters required for applications.

**Gas turbine based cogeneration systems**

In a gas turbine, a clean fuel–natural gas /oil/coal gas, is burned directly with compressed air, and the combustion products are then expanded through different stages of the turbine to near atmospheric pressure. The centrifugal compressor, attached to the common shaft of turbine, also produces the required compressed air. It’s compression ratio would depend upon the pressure at the inlet to the turbine. The inlet gas temperature to the turbine may vary from 750 oC to 1200 0 C, and the exhaust temperature could be in the range 450 to 550 oC. The gas turbine are not tailor- made to suit the power demand of each customer as is possible in case of steam turbines. Different modules of gas turbines are developed by different organisations. These depend upon the designs and materials of the blades (generally patented) and the user has to select a module nearest to ones power requirement. Typical sizes, for initial reference & understanding, are given in table below

**Table 13.8: Typical natural gas fired turbine and cogeneration system**

<table>
<thead>
<tr>
<th>Sr No</th>
<th>Electrical Output (k We)*</th>
<th>Energy Input (k We)</th>
<th>Electrical Efficiency (%)</th>
<th>Saturated steam from HRSG at 10 kg/cm²(a) (kg/h)</th>
<th>Overall Cogeneration efficiency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>504</td>
<td>2468</td>
<td>20.5</td>
<td>2045</td>
<td>36.1</td>
</tr>
<tr>
<td>2</td>
<td>3051</td>
<td>11559</td>
<td>26.4</td>
<td>9864</td>
<td>36.2</td>
</tr>
<tr>
<td>3</td>
<td>3507</td>
<td>12262</td>
<td>28.6</td>
<td>10091</td>
<td>36.5</td>
</tr>
<tr>
<td>4</td>
<td>9194</td>
<td>27800</td>
<td>33.1</td>
<td>19227</td>
<td>46.6</td>
</tr>
<tr>
<td>5</td>
<td>26300</td>
<td>92443</td>
<td>28.45</td>
<td>70265**</td>
<td>89.3</td>
</tr>
</tbody>
</table>

* At ISO conditions – 15 oC, 60 % relative humidity, sea level  
** Superheated steam at 25 kg/cm² (a) and 250 oC
In the open cycle mode the efficiency may range from 20% to 35% of the heat inputs to the gas turbine. In this case, the exhaust from the turbine at 450 to 550°C is simply let out to the atmosphere. The energy efficiency can be improved by 6 to 8% by adopting regenerative cycle. Here a tubular recuperator is used to recover heat from the exhaust of the gas turbine through preheating of the compressed air before it enters the combustion chamber.

The most efficient way to recover the exhaust heat is in the form of steam through heat recovery steam generator and let out the flue gases to atmosphere at a temperature slightly above its dew point. The steam produced can be produced at multiple parameters and used for industrial processes. The energy efficiency can reach up to 85 to 90%, depending upon the gas turbine chosen and the end-use steam parameters, as may be seen from the typical data given in table above.

The starting point for the design of the cogeneration scheme is establishing the electric load and the steam parameters required by the application. Then suitable gas turbine is selected using catalogues of manufacturers or handbook. For example, if the power requirement is between 25 to 30 MW and steam requirement is around 70 t/h at 25 kg/cm²(a) and 250°C (m-s,pse,tse), the gas turbine at S. No. 5 in table 2.1.2.1 may be selected.

**Diesel generators and natural gas fired gen-sets based**

Diesel-oil-fired generating sets normally used are for ratings from a few kilowatts to 2000 kW. However, larger rating sets are also available now for generating power for medium and large industry. A typical output of electricity and steam for cogeneration plants is in the range of 1250-2000 kW. It may be seen that only low temperature steam can be produced from such systems.

Natural gas-fired gensets are in the range of 500-3000 kW output. The engine efficiency is in range of 38%-42%, whereas the cogeneration efficiency is in the range of 65-68%. A typical output of electricity and steam for the plants is given in Table below. The steam produced is at 10-bar pressure, which is the normal requirement for such buildings.

**Table 13.9: Cogeneration based on diesel generators**

<table>
<thead>
<tr>
<th>Electrical Output (kWe)</th>
<th>Energy Input (kWe)</th>
<th>Electrical efficiency (%)</th>
<th>Generation from HR system</th>
<th>Steam Pressure (bar)/hot water temp (°C)</th>
<th>Quantity stream hot water (kg/h)</th>
<th>Overall energy efficiency (%)</th>
</tr>
</thead>
</table>
### Table 13.10: Cogeneration based on natural-gas-fired gensets

<table>
<thead>
<tr>
<th>Electrical Output efficiency (kWe)</th>
<th>Energy input (kWe)</th>
<th>Electrical efficiency (%)</th>
<th>Steam from exhaust gas at 10 bar (kg/h)</th>
<th>Overall energy efficiency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>625</td>
<td>1615</td>
<td>38.68</td>
<td>420</td>
<td>65.8</td>
</tr>
<tr>
<td>836</td>
<td>2154</td>
<td>38.81</td>
<td>559</td>
<td>66.1</td>
</tr>
<tr>
<td>1048</td>
<td>2692</td>
<td>38.93</td>
<td>700</td>
<td>66.5</td>
</tr>
<tr>
<td>1461</td>
<td>3529</td>
<td>41.40</td>
<td>820</td>
<td>66.8</td>
</tr>
<tr>
<td>1944</td>
<td>4706</td>
<td>41.30</td>
<td>1094</td>
<td>67.2</td>
</tr>
<tr>
<td>2717</td>
<td>6481</td>
<td>41.42</td>
<td>1476</td>
<td>68.0</td>
</tr>
</tbody>
</table>

*Includes heat used from engine casing water circuit for heating BFW (boiler feed water) from 30 °C to 80 °C*

Note: A typical plant in North India (second row from the top) will give an output of 803 kW_{e} and 750 kg/h steam at 10 bar.
Guideline 14: Energy Efficient Street Lighting

Introduction

Street lighting is a very important element in the large development and consume up to 10% of the total energy used. Because of this large investment in energy use, methods for designing optimised systems using efficient lighting equipment and controls while maintaining aesthetically pleasing installation would not only provide energy efficiency benefits, but also provide potential economic benefits by increased commercial activity due to properly lit and safe circulation in large developments.

Planners and engineers of large development do not understand opportunities for effective energy efficient street lighting from energy savings and a high quality design and performance perspective. Currently available street lighting resources and guides provide technology information, design layout guidance or recommended photometric performance. However, additional information on how to combine photometric, design and energy saving performance of street lighting installation is also required.

Purpose of the guidelines

Guidelines for efficient street lighting have been developed in response to large development street lighting informational needs. These guidelines integrate technical, performance and design guidance for effective energy efficient street lighting systems. The guidelines provide energy standards to ensure energy efficiency at the design of street lighting system and offer specific technical & design information to designers & engineers. In addition to these guidelines can also be used

- To communicate the benefits of effective energy efficient street lighting to decision makers
- To understand the important elements and issues of effective energy efficient street lighting, and gain the knowledge to make informed street lighting procurement decisions
- To complement existing street lighting design specifications, such as NBC-2005 & ECBC-2007.

Energy efficient street lighting principles

At present, most of the street lighting is selected based solely on providing a recommended amount of light to the streets as per accepted standards using general types of poles and fixtures. Effective energy efficient street lighting design integrates efficient lamp technologies, optimum pole placement, efficient fixture photometric (light distribution), and aesthetics while using
the least amount of energy and meeting various requirements for visibility & appropriate light levels.

**Energy efficient street lighting opportunities and benefits**

New effective energy efficient street lighting offer the greatest opportunities given that efficient designs and technologies can easily be integrated in to the plan.

Effective energy efficient street lighting installations offer the following benefits to large development. These opportunities and benefits need to be understood by the electrical consultant & landscape architect to help develop a holistic approach to street lighting design for the large development.

- Energy Savings—Through use of efficient technologies and design practices, excess energy use can be avoided.
- Capital cost savings—Using the proper spacing and placement can reduce capital costs because more efficient systems can use fewer poles and fixtures.
- Maintenance cost savings—Using lamps with longer lives and layouts with proper spacing and placement means reduced costs for fixing burnouts and paintings or replacing damaged poles.
- Improved sense of security—Selection of efficient equipment and incorporating proper design can make an area appear safer and more secure without increasing light levels. In fact, light levels which are too high will not make an area seem safer. Direct glare and high light levels reduce perceptions of safety making visibility more difficult. Attention to uniformity described as even light distribution on the horizontal surface and light distribution on the vertical surface add to a person’s sense of security.
- Evenly lit roads and walkways—Good design improves visibility by avoiding overly bright and dark patches on roads and walkways.
- Reduce glare and improved visibility—Overly high light levels create unwanted glare that decreases visibility. Careful selection of fixtures and lamps that enhances visibility and improves detection of pedestrians by drivers and increases seeing distances beyond those provided by automotive headlights alone.
- Economic development—Communities see street lighting as an important part of improving economic development efforts in large development.

**Guidance Note**

Energy efficient street lighting design includes following steps:

- Identification of road type
- Lighting level requirements
- Energy standards
• Design basics & lighting system arrangements
• lamp selection
• Luminare selection
• Controls

Identification of road types
All the roads in large development shall be classified as follows:

<table>
<thead>
<tr>
<th>S No.</th>
<th>Classification</th>
<th>Road Type</th>
<th>Width of Carriageway (Meter)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>A1</td>
<td>Dual/Single Carriageway</td>
<td>&gt;14</td>
</tr>
<tr>
<td>2</td>
<td>A2</td>
<td>Single Carriageway</td>
<td>&gt;7 up to 14</td>
</tr>
<tr>
<td>3</td>
<td>A3</td>
<td>Single Carriageway</td>
<td>&lt;7</td>
</tr>
<tr>
<td>4</td>
<td>Slip/Service Road</td>
<td>Single Carriageway</td>
<td>4, 5, 6</td>
</tr>
<tr>
<td>5</td>
<td>Pedestrian Walkways/Cyclist Pathway</td>
<td>Single Carriageway</td>
<td>3</td>
</tr>
</tbody>
</table>

Illumination level requirements
All the roads shall be designed to meet the minimum illumination levels & uniformity coefficient as recommended below:

<table>
<thead>
<tr>
<th>S No.</th>
<th>Classification</th>
<th>Road Type</th>
<th>Lighting levels (lux)</th>
<th>Uniformity Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>A1</td>
<td>Dual/Single Carriageway</td>
<td>30</td>
<td>0.4</td>
</tr>
<tr>
<td>2</td>
<td>A2</td>
<td>Single Carriageway</td>
<td>20</td>
<td>0.4</td>
</tr>
<tr>
<td>3</td>
<td>A3</td>
<td>Single Carriageway</td>
<td>15</td>
<td>0.4</td>
</tr>
<tr>
<td>4</td>
<td>Slip/Service Road</td>
<td>Single Carriageway with slow</td>
<td>15</td>
<td>0.4</td>
</tr>
<tr>
<td>S No.</td>
<td>Classification</td>
<td>Road Type</td>
<td>Lighting levels (lux)</td>
<td>Uniformity Coefficient</td>
</tr>
<tr>
<td>-------</td>
<td>----------------------</td>
<td>-----------------------------------------------</td>
<td>-----------------------</td>
<td>------------------------</td>
</tr>
<tr>
<td>5</td>
<td>Pedestrian Walkways/Cyclist Pathway</td>
<td>Single Carriageway with no motorized traffic</td>
<td>8</td>
<td>0.3</td>
</tr>
</tbody>
</table>

**Energy standards**

Lighting power per meter run of the road (W/meter) for main traffic roads shall not be more than what is specified below:

**Table 14.3: Recommended energy standards for different road types & carriageway widths**

<table>
<thead>
<tr>
<th>S No.</th>
<th>Classification</th>
<th>Road Type</th>
<th>Width of Carriageway (Meter)</th>
<th>Lighting Power per run (W/M)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>A1</td>
<td>Dual/Single Carriageway</td>
<td>14</td>
<td>14.5</td>
</tr>
<tr>
<td>2</td>
<td>A1</td>
<td>Dual/Single Carriageway</td>
<td>17.5</td>
<td>17.5</td>
</tr>
<tr>
<td>3</td>
<td>A1</td>
<td>Dual/Single Carriageway</td>
<td>21</td>
<td>21.5</td>
</tr>
<tr>
<td>4</td>
<td>A2</td>
<td>Single Carriageway</td>
<td>10.5</td>
<td>11.5</td>
</tr>
<tr>
<td>5</td>
<td>A2</td>
<td>Single Carriageway</td>
<td>7</td>
<td>10.5</td>
</tr>
</tbody>
</table>

**Design Basics**

1. Mounting height (H)- The vertical distance between the centre of the luminaire and the surface of the carriageway measured vertically is called the mounting height of lighting installation. The optimum mounting height should be chosen by taking into account the light output of the sources, the light distribution of luminaries, and the geometry of installation. Table below shows the recommended mounting heights for different category of roads and carriageway width.
2. Spacing (S)- The distance, measured horizontally, along the centre line of the carriageway, between successive luminaries in an installation is defined as spacing of lighting schemes.

3. Carriageway-That portion of a highway intended primarily for vehicular traffic.

4. Dual carriageway-Dual carriage is defined as a layout of two separated carriageways, each reserved for traffic in one direction only.

5. Carriageway width (W)- The distance between kerb lines measured at right angles to the length of the carriageway is width of carriageway.

6. Overhang (O)- The distance measured horizontally between the centre of a luminaire mounted on a bracket and the adjacent edge of the carriageway is defined as overhang.

7. Span- That part of the highway lying between successive luminaries in an installation is termed as span.

8. Central verge-Central reserve is a longitudinal space dividing a dual carriageway.

9. Verge-Unpaved area flanking a carriageway, forming part of the highway and substantially at the same level as the carriageway I called verge.

10. Kerb-Kerb is formed at the edge of a carriageway with the help of border of stone, concrete or other rigid material.

**Types of Arrangement in street lighting**

Four fundamental types of arrangement are considered in road lighting design:

**Single side arrangement**

In single-side arrangement, all the luminaries are on one side of the carriageway. It is recommended for small road width.
Staggered arrangement

In staggered type arrangement, the luminaries are situated on either side of the carriage-way and may be employed when the width of the carriage-way is of medium size.

Opposite

In opposite arrangement, the luminaries situated on either side of the carriage-way opposite to one another is advisable when the width of the carriage-way is big.

Axial or twin central

In axial arrangement, the luminaries are placed along with axis is usually considered for major roads.

Other arrangements exist, but they result from the combination of the four preceding fundamental types.

Table 14.4: Recommended street light arrangement & pole heights

<table>
<thead>
<tr>
<th>S No.</th>
<th>Classification</th>
<th>Road Type</th>
<th>Individual Carriageway Width (Meter)</th>
<th>Type of pole position</th>
<th>Effective Height above g.l. (Meter)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>A1</td>
<td>Dual Carriageway</td>
<td>14–21</td>
<td>Centre verge/Opposite</td>
<td>12</td>
</tr>
<tr>
<td>2</td>
<td>A2</td>
<td>Single Carriageway</td>
<td>14</td>
<td>Single sided</td>
<td>11</td>
</tr>
<tr>
<td>3</td>
<td>A2</td>
<td>Single Carriageway</td>
<td>10.5</td>
<td>Single sided</td>
<td>11</td>
</tr>
<tr>
<td>4</td>
<td>A2</td>
<td>Single Carriageway</td>
<td>7</td>
<td>Single sided</td>
<td>11</td>
</tr>
<tr>
<td>5</td>
<td>A3</td>
<td>Single Carriageway</td>
<td>7</td>
<td>Single sided</td>
<td>8</td>
</tr>
<tr>
<td>6</td>
<td>Slip road/Pedestrian pathway</td>
<td>Single Carriageway</td>
<td>3–6</td>
<td>Single sided</td>
<td>7.5</td>
</tr>
</tbody>
</table>

Street lighting system

Based in their performance, the lighting components can be grouped in three systems.

Structural system

- Poles & pole foundation or base
Optical system
- Luminaires

Electrical system
- Lamps, ballasts, and service cabinet or fuse box

Lamps
- Street lighting systems generally use three types of high intensity discharge (HID) lamps. They are high pressure sodium vapour (HPSV) lamps, metal halide (MH) lamps, and high pressure mercury discharge (HPMV) lamps.

- HPSV lamps produce yellowish light; have very high efficiency, high lumen maintenance, very long life but very poor colour rendition.

- MH lamps are also having high efficiency and very good colour rendering and being recommended for new installation but they tend to have a shorter life and poor lumen maintenance.

- HPMV lamps are not very frequently used in street lighting now. They are least energy efficient among HID lamps but they have colour rendition better than HPSV lamps.

- Light-emitting diode (LED) technology is a fast developing one with significant energy saving potential and very long life. They do not use ballasts or starters and have excellent colour rendering quality, however, their upfront cost is quite high as compared to HID lighting systems.

150 W, 250 W & 400 W High pressure lamps
- Luminous efficacy of lamps should be in the range of 110 ~ 130 lumen/watt.

- Lamps should have fast ignition time which should be less than 180 seconds.

- Lamps should have high maintenance of 95% at the end of 15000 hrs.

- Lamp life at 50% mortality should be more than 30,000 hrs.

250 W Quartz metal halide lamps
- The luminous efficacy of the lamp should be more than 76 (lumen/watt).

- These lamps should function at a minimum supply voltage of 198 volts and the CRI should be more than 80.
It should be possible to operate these lamps both with electronic as well as electromagnetic ballasts.

Ceramic discharge metal halide lamps
- Its luminous efficacy should be more than 93 (lumen/watt).
- The compact single/double ended 150 W with CRI more than 80 should function with electromagnetic and electronic ballast.

150 W, 250 W Ceramic discharge metal halide lamps
- The luminous efficacy of these lamps should be more than 93 lumens per watt.
- They should operate even at a low supply voltage of 198 volts and have CRI more than 80 and Correlated colour temperature (CCT) which defines the light colour of 4200 K.

Ballasts & Igniters
Ballasts are required for all HID lamps. They provide proper open circuit voltage to start the lamp, keep the lamp operating within the desired parameters and help adapt lamps to any one of the line voltages commonly available. But because of their configurations they tend to have power loss.

- Ballasts & igniters should conform to IS standards.
- Power delivery to lamp should be more than 95%.
- Ballasts should be vacuum impregnated open construction type.
- Ballasts should be low loss ballasts and the power loss in HID fixtures should not be more than as specified below.
  - 150 W - <18 Watts
  - 250 W - < 24 Watts
  - 400 W - < 44 Watts

Luminaires
The liminaire has a double role of protecting the light source from the weather and redistributing its liminous flux.

In the choice of the liminaire the following points should be considered:
• Nature and power of the source or source
• Nature of the optical arrangements and the light distribution which they provide
• Light output ratio
• Whether the luminaire is open or closed type
• Resistance to heat, soiling and corrosion
• Protection against collection of dust and insects
• Resistance to atmospheric conditions
• Ease of installation and maintenance
• Presence or absence of auxiliaries and
• Fixing arrangements, the weight and area exposed to wind pressure

The influence of all these factors varies according to local circumstances, and it is difficult to recommend one solution or each type of lighting installation.

However, one essential characteristic of luminaires the choice of which directly influences and quality of the lighting. That is, the general form of its distribution curves of luminous intensity particularly in directions near the usual directions of vision. Three fundamental forms of light distribution are considered according to the degree of glare which is acceptable:

• Cut-off luminaires,
• Semi-cut-off luminaires, and
• Non-cut-off luminaires

**Cut-off luminaire**

A luminaire whose light distribution is characterized by a rapid reduction of luminous intensity in the region between 800 and horizontal 900. The intensity at the horizontal should not exceed 10 cd per 1000 lm of flux from the light sources and the intensity at 800 is of the order of 30 cd per 1000 lm. The direction of the maximum intensity may vary but should be below 650.

The principal advantage of the cut-off system is the reduction of glare and its use is favoured under the following conditions:
• Matt carrigeway surfaces
• Absence of buildings
• Presence of large trees
• Long straight sections
• Slight humps, bridges, and
• Few intersections and obstructions

Semi-cut-off luminaire
A luminaire whose light distribution is characterized by a less severe reduction in the intensity in the region 800 to 900.

The intensity at the horizontal should not exceed 50 cd per 1000 lm of flux from the light sources and the intensity at 800 is of the order of 100 cd per 1000 lm. The direction of the maximum intensity may vary but should be below 750. The principal advantage of the semi-cut-off system is a greater flexibility in siting, and its use is favoured under the following conditions:

• Smooth carrigeway surfaces
• Buildings close to carriageway, especially those for architectural interest
• Many intersections and obstructions

Non-cut-off luminaire
A luminaire whose luminous intensity in directions making an angle equal to or greater than 800 from the downward vertical is not reduced materially and the intensity of which at the horizontal may exceed the values specified for the simi-cut-off distribution, but should not nevertheless exceed 1000 cd. Non-cut-off luminaires are permissible only when a certain amount of glare may be accepted and when the luminaires are of large size and of reduced brightness. In certain cases they have some advantages in increasing the illumination on facades.

Table 14.5: Recommended lamp type & wattage & luminaire type

<table>
<thead>
<tr>
<th>S No.</th>
<th>Classification</th>
<th>Road Type</th>
<th>Individual Carriageway Width (Meter)</th>
<th>Type of pole positions</th>
<th>Recommended lamp wattage</th>
<th>Recommended luminaire type</th>
</tr>
</thead>
<tbody>
<tr>
<td>S No.</td>
<td>Classification</td>
<td>Road Type</td>
<td>Individual Carriageway Width (Meter)</td>
<td>Type of pole positions</td>
<td>Recommended lamp wattage</td>
<td>Recommended luminaire type</td>
</tr>
<tr>
<td>-------</td>
<td>----------------</td>
<td>----------------------</td>
<td>-------------------------------------</td>
<td>------------------------</td>
<td>-------------------------</td>
<td>---------------------------</td>
</tr>
<tr>
<td>1</td>
<td>A1</td>
<td>Single Carriageway</td>
<td>21</td>
<td>Opposite</td>
<td>HPSV-400W</td>
<td>Cutoff</td>
</tr>
<tr>
<td>2</td>
<td>A1</td>
<td>Single Carriageway</td>
<td>17.5</td>
<td>Opposite</td>
<td>HPSV-400W</td>
<td>Cutoff</td>
</tr>
<tr>
<td>3</td>
<td>A1</td>
<td>Single Carriageway</td>
<td>14</td>
<td>Opposite</td>
<td>HPSV-400W</td>
<td>Cutoff</td>
</tr>
<tr>
<td>4</td>
<td>A2</td>
<td>Single Carriageway</td>
<td>10.5</td>
<td>Single sided</td>
<td>HPSV-250W</td>
<td>Cutoff</td>
</tr>
<tr>
<td>5</td>
<td>A2</td>
<td>Single Carriageway</td>
<td>7</td>
<td>Single sided</td>
<td>HPSV-250W</td>
<td>Cutoff</td>
</tr>
<tr>
<td>6</td>
<td>A3</td>
<td>Single Carriageway</td>
<td>7</td>
<td>Single sided</td>
<td>HPSV-150W</td>
<td>Semi-cuttoff</td>
</tr>
<tr>
<td>7</td>
<td>Pedestrian pathway</td>
<td>Single Carriageway</td>
<td>3-6</td>
<td>Single sided</td>
<td>HPSV-150W</td>
<td>Semi-cuttoff</td>
</tr>
<tr>
<td>8</td>
<td>Slip roads/Service roads</td>
<td>Single Carriageway</td>
<td>5-6</td>
<td>Single sided</td>
<td>CDM-150W</td>
<td>Semi-cuttoff</td>
</tr>
</tbody>
</table>

Street lighting system controls

Auto Switching

In India the streetlights are switched on and off either manually or electromechanical on/off timer, which is, prefixed at a time when it switches on/off the light. However, the days are longer and shorter depending on the season but these timers do not take this seasonal variation into account and as a result the street lights are switched on much before the dusk and they remain switched on even after dawn which adds to the energy wastage. Therefore it is recommended that a device or a timer which is sensitive to this seasonal variation and adjusts on & off time based on actual length of day/night should be used.

1. Microcontroller Time Switches

Microcontroller based timeswitch, which has inputs like Real time, Date, Month, Year, plus and minus offset is one of such
device which could be used. It can be set through available tactile switches and with help of seven-segment display.

Memory of the unit has date wise yearly sunset and sunrise timings for the required city, as the date advances output relay gets ON as per the concurrent Sunset and Sunrise Timings. In case if it is required to change this timing, it can be done with help of plus and minus offset. Micro controller’s RTC has got 5 years backup through battery; hence the set program remains intact even in power failure condition. Enough precautions for line supply surge are taken. The Output channel relay operates the electrical contactor that ultimately controls the lamp load. Due to its versatile concept of switching at Sunset and Sunrise Timings throughout year, it gives saving in electrical units, which ultimately result in, reduced electric bills.

2. Passive infrared sensor operated Switches
These devices sense the radiations equivalent to allowable light levels and switch on and off the fixtures at dusk & dawn.

Dimming of lights during late night hours
Dimming of street lighting is possible with the help of new types of fixtures which are now equipped with change over or multi-tap ballasts. Instead of one, fixtures are fitted with two ballasts and same lamp can operate at two different wattages at set change over time which can be set with a timer. Power/time switch an auto dim device which can perform auto dimming. At mid night when traffic gets thin auto dim can change over from higher wattage ballast to lower wattage ballast.

Figure : Dimming of street lighting installation

Use of Renewable Energy in Street lighting system
Solar powered street lighting systems particularly using Photo Voltaic system are available in the market and installed. Use of solar power reduces the
dependence of street lighting system on non-renewable energy sources and make then sustainable.

15% of the total connected street lighting load shall be catered through RE power with grid backup. This can be provided either through standalone solar lighting system or centralised RE power system.

Street lighting systems designed for slip roads or pedestrian roads where height of pole is in between 3 to 5 meter, standalone solar power system is recommended. The lighting schemes may use compact fluorescent lamps (CFL), light emitting diodes (LEDs) or 2’ fluorescent lamp (14 W T-5) as light generating sources fitted in efficient fixtures.

For wider roads where HID lamps of higher wattage are used, centralised PV power plant is recommended to provide power to 15% of the load. Electrical cables from these centralised plants can be drawn and connected to feeder pillars providing power to connected lighting poles.

**Lighting level calculation & measurement**

Street lighting systems are designed to provide recommended lighting level & uniformity as per accepted standards. Lighting designs need to be checked both at the designing stage and after installation.

Lighting levels shall be calculated or measured at a grid of not more than 1M*1M on road surface between one spacing of street lighting system. The illumination level on the street will be the average of all these lighting levels and uniformity coefficient will be calculated by dividing minimum lighting level by illumination level of the street.

**Electrical system for street lighting**

Electrical distribution for road lighting shall be designed to maintain a power factor more than 0.95 lag and a voltage fluctuation of not more than 5% throughout the year.

**Monitoring of street lighting system**

It is very important and necessary to continuously monitor the energy consumption in the street lighting system in order to maintain a desired level of energy efficiency in the system.

A dedicated feeder shall be provided for street lighting at the main LT panel. Electronic energy meters shall be installed both at main LT panel and sub panels which cater to different types of road lightings. The electronic meters shall be equipped with the device which can transfer the data to the installed energy management system and all the electrical parameters shall be monitored and recorded at a time interval of 15 minutes.
Street lighting design – Case study

The proposed case study demonstrates the benefit of street lighting design based on optimization technique as recommended in the proposed guidelines over the conventional one which is based on the recommendations of Indian standards and municipalities’ guidelines.

Street design details
Type: A1
Carriageway type : Dual
Carriageway width : 16 meter

Conventional design based on existing standards & guidelines
Arrangement type : Twin central
Pole height : 12 meter
Overhang : 1 meter
Tilt : 10 degree
Spacing : <40 meter
Fixture type : SRP-21 of Philips
Lamp type : SONT
Lamp wattage : 400 W
Ballast power loss : 42 W
Luminous efficacy : 123 lm/W

Design results
Average illumination level : 35.7 lux
Uniformity coefficient : 0.38
Power per meter run off road : 22.1 W/meter

Optimized design
Fixture type-1 : SGP338 of Philips
Fixture type-2 : SRX086 of Philips
Fixture type-3 : SRP-21 of Philips
Design requirements

Average illuminance: >35 lux
Uniformity coefficient: <0.4
Lighting power/meter: <17.4 W/meter

Optimization: Spacing shall be maximized in such a way the above requirements shall always be met

Optimized design results: As shown below

Table 14.6: Analysis of optimized street lighting scheme

<table>
<thead>
<tr>
<th>Type of lamp</th>
<th>Installation</th>
<th>Road width (m)</th>
<th>Pole height (m)</th>
<th>Pole spacing (m)</th>
<th>Average Lighting level (Lux)</th>
<th>Uniformity (Min/Avg)</th>
<th>Lighting power density (W/m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Twin central</td>
<td>16</td>
<td>12</td>
<td>60</td>
<td>40</td>
<td>0.4</td>
<td>14.8</td>
<td></td>
</tr>
<tr>
<td>Twin central</td>
<td>16</td>
<td>12</td>
<td>55</td>
<td>41</td>
<td>0.4</td>
<td>16.2</td>
<td></td>
</tr>
<tr>
<td>Twin central</td>
<td>16</td>
<td>12</td>
<td>50</td>
<td>43</td>
<td>0.46</td>
<td>17.8</td>
<td></td>
</tr>
</tbody>
</table>

Type-1 meets the design requirements as well as minimum lighting power per meter run, therefore it is the optimized lighting design for the street.

The lighting load of this scheme would be 33% more efficient as compared to the conventional street lighting scheme.

Operation and Maintenance

This aim of street lighting should permit users of the road to move about with greatest possible safety and comfort so that the traffic capacity of the road at night is as much equal to that planned for the daytime as possible.

Maintenance of a lighting installation should include:
- Replacement of faulty and missing lamps and accessories.
- Systematic replacement of lamps that have reached end of life and hence operating at reduced efficiency
- Cleaning of luminaries and lamps.
- Maintenance of cables and columns.
- Inspection of main earthling arrangements, gaskets, the tracing of defects and broken lamps, and control of switching equipment.
- Mounting height and angle of tilt should be maintained for desired light levels.
- Proper clearance should be maintained between carriageway and the light pole to avoid accidents and for safety.
- Care should be taken so that fuse carriers are provided in proper enclosures. Similarly fuses of appropriate rating should be used so that uninterrupted lighting is available during night time to ensure safety and security.
- Trimming of trees can be taken up to ensure good lighting is available, if trees are obstructing the light levels on the street.
Guideline 15: Efficient Pumping Systems for Large Development

Like energy, water is also an important resource which is consumed in large developments. Water is distributed by pumping systems and an efficient design of pumping system is important from both reducing water wastage and energy wastage. Pumps which are used in circulating water in pumping system consume significant amount of energy and pump selection optimization reduces energy wastage in pumping system. The main reason for water wastage is due to poor monitoring of water consumption and monitoring of pumping system.

Guidelines for optimization of pump selection

- Pumps shall be selected in such a way that they will never operate below 70 to 80% of its best efficiency point.
- As far as possible lower rpm pumps shall be preferred over higher rpm pumps as they are more reliable.
- Use of double suction impeller shall be avoided as they are less stable at off-design conditions than single suction impellers.
- Single stage pumps shall never be selected with a maximum diameter impeller. There may be a need to increase the impeller diameter in the future.
- Pumps with suction specific speed less than 11000 shall be selected, less than 9000 is even better.
- The minimum acceptable pump flow selection shall be based on hydraulic stability rather than the temperature rise.
- All the motors fitted with pumps shall be energy efficient motors.

Guidelines for monitoring of pumping system

- It is recommended that individual water meters should be installed at each load centre which contributes to water consumption in large development.
- The pumping system monitoring shall be carried out at the central level using centralised system such as Supervisory Control & Data Acquisition (SCADA).

SCADA system

SCADA refers to a system that collects data from various sensors in a pumping system and sends the same to a central system, which in turn, manages and controls the data. A SCADA system usually includes signal hardware, controllers, networks, user interface, communication equipments.
and software. Typically, there are three major elements that make up a SCADA system:

1. The master terminal unit (MTU) –

   The MTU acts as the heart of the entire system. The MTU unit initiates all communication, gathers data, stores information, sends information to other systems, and interfaces with operators. The MTU also communicates with other peripheral devices in the facility like monitors, printers, and other information systems. The primary interface to the operator is the monitor or CRT that portrays a representation of valves, pumps, etc. As incoming data changes, the screen is updated.

2. The remote terminal unit (RTU) –

   The RTU unit gathers information from the remote site from various input devices, like valves, pumps, alarms, meters, etc. Essentially, data is either analogue, digital, or pulse data (e.g., counting the revolutions of a meter). Many remote terminal units hold the information gathered in their memory and wait for a request from the MTU to transmit the data. Other more sophisticated remote terminal units have microcomputers and programmable logic controllers (PLC) that can perform direct control over a remote site without the direction of the MTU.

3. The communications equipment –

   Communication equipments are required for bi-directional communications between RTU and the MTU. This can be done through public transmission media or atmospheric means.

SCADA can monitor and control remotely following parameters –

- Data monitoring – Under data monitoring, SCADA system can check the pump ON/OFF status and can continuously provide information on parameters like set pressure, actual pressure, actual speed, actual frequency, current drawn, actual power, energy (kWh), logged data, logged faults.

- System Controlling – Through this feature, the data can be changed remotely as and when required, without an actual visit to the site. Parameters that can be tweaked are listed as under
  
  - Set pressure
  
  - Cut-off pressure
- No. of pumps in working and standby pumps
- Pump bypass
- Staging frequency
- De-staging frequency
- Sleep Frequency

Benefits of SCADA system

- SCADA saves both time and money by eliminating the need for site visits for inspection, adjustments and data collection
- SCADA software not only helps monitor the operations of pumping system in real time, but also make modifications to the system, auto-generate reports and trouble-shoot
- It reduces operational costs and improves efficiency of the pumping system
- SCADA systems can make immediate critical corrections in the operating pumping system, thus improving life-period of equipments and can save costly maintenance works.
- It highlights the tasks that require human involvement by computing saved man-hours
- SCADA’s auto-generated reporting system ensures compliance with regulatory principles.
Guideline 16: Energy resource planning including utilisation of renewable energy and smart grids

Large developments have large energy and resource footprints. Energy demand for such developments is significant and such developments have varying energy demand daily and seasonally. The energy demand may be electrical or thermal or mixed type. There shall be typically various load centres with varying demand round the day. Loads may be essential and non-essential in nature and may vary seasonally. On the other hand, supply side requirements may be met through renewable forms of energy in addition to conventional energy sources. Optimisation of demand and supply side is crucial to ensure that generated energy is appropriately channelized and utilised with minimum wastage.

The following process should be followed to ensure the above:

Step 1: Load profiling and categorization.

A larger development e.g a campus of institutional buildings or a large townships consists of various building typologies with varying demands of energy round the day. Some of these loads such as air-conditioning may be varying seasonally. Loads such as lighting shall vary with time of day. Some loads may be critical and some loads may be non-critical e.g energy demand for a server room is a critical load. The first step to design of a smart mini grid is load profiling and categorization for the buildings and site.

- Hourly load profiling for all proposed buildings and site (e.g street lighting, water pumping etc) should be done for a typical day of all predominant seasons of the year. An hour by hour forecasting of various loads in a building or a typical set of building should be made and aggregation of hourly loads for all buildings and site level demand should be done.

- Loads should be further categorized based on daytime or nigh time demand and essential loads and non-essential loads. This is necessary for renewable energy planning (e.g solar energy is generated during daytime and it is prudent to assign daytime loads to be met through solar energy thus minimizing storage battery requirement). Categorization of essential and non-essential loads is necessary for prioritization of supply to essential loads and ensuring reliability of the system,

- The next step is to design the distribution system as per categorization e.g: all essential loads of a building could be on a circuit which shall have
uninterrupted power supply. The electrical wiring and distribution system of all buildings and site should be done keeping in mind the load categorization and prioritization. E.g. all perimeter lights in a daylight building may be on separate circuit to be put off during daytime when daylighting is adequate to meet the indoor illumination level. This shall then be categorized as non-critical load during daytime hours.

**Step 2: Energy resource planning: Renewable and non-renewable**

The next step of smart mini grid design for a large campus shall involve identification and assessment of the supply options for energy. The supply options could be renewable sources (e.g. wind, solar, bio mass) or fossil fuel based supply options that are typically non-renewable e.g. grid power or captive generation from gas or diesel. Since availability of renewable energy resources varies with time of day, season, terrain and various other parameters, it is essential to carry out a detailed resource assessment of renewable energy resources.

**2. Renewable energy resource profiling for technology selection**

**Steps for Solar and wind energy assessment for large townships**

**Solar photovoltaic energy assessment**

Assessment of a solar PV power plant can be possibly done in two ways:

1. **Fixed area basis:**
   
   Objective: A possible maximum power can be extracted from the specified area.

2. **Fixed nominal capacity basis:**

   Objective: A nominal capacity of power generation is achieved.

**Steps for solar PV capacity estimation:**

For estimating the fraction of township’s electricity requirements to be met using solar energy, both of the above cases has to be considered. Optimization of nominal capacity of installation and area occupied is necessary. Steps to be followed for planning of a township powered by solar PV power are given below:
1. For estimating the electricity generation potential in a particular site, one needs to establish the solar radiation at the respective location using available reliable sources such as NASA surface meteorology (http://eosweb.larc.nasa.gov/cgi-bin/sse/grid.cgi?email=). Or solar radiation data could be procured from ISHRAE and Metenorm (http://meteonorm.com/)

2. It is estimated that minimum Annual Average Horizontal Daily Solar Radiation of 5.0 kWh/m²/day is suitable for solar power feasibility.

3. Shadow free area availability in the large township (e.g open fields, rooftop, common areas, etc) for PV installation can be established. This would enable estimation of generation potential from the particular site and the number of PV panels required for specific capacity solar PV installation can be estimated. This can be estimated by using the following formulae.

   - Area required (for known nominal capacity of SPV plant) = ((Total PV capacity required in kW)/(capacity of one PV panel in Wp))*(Area of each PV panel in m²)

   - Area required for fixed annual electricity generation required from SPV plant = (Required annual electricity generation in kWh)/{(Annual Average solar radiation)*(Solar to electricity conversion efficiency of the plant)}

4. If only limited area is available then more efficient SPV technology could be examined.

5. Estimate the maximum electricity / energy that can be extracted.

6. Estimate the maximum capacity of the SPV project that can be installed in the available area.

Annual electricity outputs at some of the locations in India are presented in Table1. Some of the assumptions for a detail evaluation are listed below.

Slope: Latitude of the location

SPV technology

   - Type: mono-Si
   - Model: mono-Si-NT-175U1
   - Capacity per unit: 175 Wp
- Efficiency: 13.5%
- Frame area: 1.3 m²

Power Capacity: 1,000 kW
Number of units: 5715
Miscellaneous losses: 10.0 %

Inverter:
- Efficiency = 90%
- Capacity = 4 kW
Miscellaneous losses = 0%

Table 16.1: Electricity output from a 1 MW capacity solar PV power plant at some of the locations in India

<table>
<thead>
<tr>
<th>Location</th>
<th>Slope</th>
<th>Annual Average Daily Solar Radiation (Horizontal) kWh/m²/day</th>
<th>Annual Average Daily Solar Radiation (Tilted) kWh/m²/day</th>
<th>Solar Collector Area m²</th>
<th>Capacity Factor %</th>
<th>Electricity Output MWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ahmedabad</td>
<td>23.1</td>
<td>5.62</td>
<td>6.01</td>
<td>7,436</td>
<td>18.3</td>
<td>1,600.4</td>
</tr>
<tr>
<td>Surat</td>
<td>21.2</td>
<td>5.23</td>
<td>5.52</td>
<td>7,436</td>
<td>16.9</td>
<td>1,478.23</td>
</tr>
<tr>
<td>Jodhpur</td>
<td>26.3</td>
<td>5.60</td>
<td>6.09</td>
<td>7,436</td>
<td>18.5</td>
<td>1,623.6</td>
</tr>
<tr>
<td>Kota</td>
<td>25.2</td>
<td>5.08</td>
<td>5.46</td>
<td>7,436</td>
<td>16.8</td>
<td>1,475.02</td>
</tr>
<tr>
<td>Udaipur</td>
<td>24.6</td>
<td>5.16</td>
<td>5.55</td>
<td>7,436</td>
<td>17.1</td>
<td>1,497.34</td>
</tr>
<tr>
<td>Hyderabad</td>
<td>17.5</td>
<td>5.00</td>
<td>5.18</td>
<td>7,436</td>
<td>15.9</td>
<td>1,394.17</td>
</tr>
<tr>
<td>Vishakhapatnam</td>
<td>17.7</td>
<td>5.30</td>
<td>5.52</td>
<td>7,436</td>
<td>16.8</td>
<td>1,472.68</td>
</tr>
<tr>
<td>Tiruchchirapalli</td>
<td>10.8</td>
<td>5.20</td>
<td>5.25</td>
<td>7,436</td>
<td>16.0</td>
<td>1,400.48</td>
</tr>
<tr>
<td>Rameswaram</td>
<td>9.3</td>
<td>5.48</td>
<td>5.51</td>
<td>7,436</td>
<td>16.9</td>
<td>1,478.47</td>
</tr>
</tbody>
</table>
Wind energy assessment

1. Check if the location is in the area of sites approved as wind farmable sites by Centre for Wind Energy Technology (C-WET) based on the wind monitoring work carried out under Ministry of New and Renewable Energy Technology. The criteria for declaration of the site as wind farmable site are that the annual average Wind Power Density (WPD) at the site is above 200 W/m² at 50 m level from ground.

2. If the selected site is within 10 km of the approved wind farmable site, then wind power can be considered as feasible.

3. If the site is not nearby the approved wind farmable site, then check the availability of wind data for that site. The sources of the wind data may be:
   - Indian Meteorological department
   - Data measured at the site by the project developer
   - NASA surface meteorological data
   - Others

4. If the complete wind data is available and the annual wind power density can be derived from it, then just check if the WPD at 50 m is above 200 W/m² or not. Or else if the annual average wind speed is found to be equal to or above 5 m/s at 20 m height then the site can be considered as feasible for wind power project. In all the cases a detailed assessment is need to be carried out for annual energy generation estimation from the wind turbines in the selected site.

5. The next step is to analyse the site conditions, i.e. it’s topography, the obstacles to wind like high rise buildings, forest areas, aviation facility etc. Following facts must be considered before planning wind as energy source
The site shall be far from any civil/defense aviation facility

There shall not be any high rise building or trees in upwind direction as they would have major impact on the wind availability.

The wind turbine location shall not be very near to residences (minimum about 1.0 km) as the noise from wind turbine would create problem.

6. The footprint of a single wind turbine is about 1 ha/MW.

7. The best possible capacity and the rating of wind turbine can be selected after the detailed analysis.

Above points were for the case when planning for large wind turbines i.e. WTG capacity rating above 100 kWe. One may also think of smaller wind turbines (capacity rating up to 20 kWe). As per MNRE, for smaller wind turbines installation, the average wind speed at 10 m level should be 4m/s. The footprint of smaller wind turbine is approximately 10-20 m²/kW.

**Step-3: Optimization process for selecting the appropriate RE technology and its system**

Once the load profiling with load categorization and renewable energy resource assessment is completed, various sizing and design softwares such as RETSCREEN, PVSYS, Designpro, HOMER, Transys can be used to optimally select the renewable energy technologies along with the size and capacity of different renewable energy system.

Once the size and capacity of different renewable energy system is finalized and the type of load is defined the simulation software such as MAILAB, PSCAD, P-SIM can be used to carry out the appropriate power system and control design. The complete power system analysis both at steady state and in transient states should be analysed.

**Step-4: Finalize the load dispatch strategies and automation requirement**

Simultaneously (along with Step-4), the load dispatch strategies based on load profile, load categorization and resource availability should be decided. The necessary automation requirement along with its details specifications for load and energy resource transition should also be finalized.
Once the entire RE power system and control design is made along with automation requirement, the next step is to design the electrical distribution system. Application of smart grid concept is advisable for large developments.

**What is smart mini grid**

A Smart Mini-Grid (SMG), or Micro-Grid, is an intelligent electricity distribution network, operating at or below 11 KV, in order to provide electricity to a community. Smart Mini-Grids use advanced sensing, communication, and control technologies to generate, manage, distribute, and utilize electricity more intelligently and effectively. The electricity is supplied by a diverse range of distributed Energy Resources (DERs), which typically include small conventional generators such as diesel gensets, and a range of renewable generators such as solar PV, micro-hydro power plants, wind turbines, biomass, and so on, in combination with each other. Smart Mini-Grids can either be connected to the conventional utility grid or be isolated, providing electricity for localized loads only.

**Essential Features of Smart Mini-Grids**

- Intelligent load and energy resource management through smart controllers and advanced control techniques
- Accommodation of multiple DERs and energy storage into the common grid
- Self healing (ability of the grid to rapidly detect, analyse, respond, and restore itself in case of any disturbances), self configuring, plug and play
- Maximum utilization of renewable energy system
- Maximum reliability, stability and resilience
- Optimum efficiency
- Facilitating user autonomy

**Step-5: Finalizing the control strategies along with the communication protocol**

Generally there are two control strategies which can be adopted in a smart mini-grid system
1. **Distributed Control System** :- Each energy system has both the local control and overall mini grid /global control

2. **Central Control System** :-
   
   - Local controller to each of the energy generating resource which control the local parameters (such as voltage regulation, current regular frequency, regulation etc.)
   
   - Central Control (SCADA) which talks to each of the smart local controller and decide the optimum dispatch of load from different energy generating resources based on parameters (energy availability, energy economics)

**Step-6: Installation of entire RE power system along with its control systems, Data Acquisition System and automation system**

- Based on the simulated design and control strategies adopted, the entire RE power system should be installed. The smart local controller of each of the energy resource should be appropriately selected and installed in such a way that it can ensure the maximum utilization of their respective energy resource at any given point of time. Local controller to each of the energy generating resource will also control the local operating parameters (such as voltage regulation, current regular frequency, regulation etc.). While selecting these controllers, maximum attention should be given towards the flexibility, reliability, efficiency and safety of the system. This controller should be digitally controlled.

- Once the RE power system is installed, the DAS is setup with an objective to acquire and monitor various physical and electrical parameters (for example: voltage, current, active power, frequency, energy etc) at different points of the entire smart mini-grid system. A list of all relevant parameters at different points which may affect the performance of the entire system should be made prior to setting up the DAS.

- The communication protocol between different local controllers, DAS should be finalized and should be selected in such a way that it is universally used and compatible to most of the available systems

- Several programs should be written in both local and central controller based on the load dispatch strategies, resources availability, automation requirement etc.
## Renewable Energy Applications

<table>
<thead>
<tr>
<th>Sector</th>
<th>Renewable Energy Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hostels</td>
<td>Solar Water Heaters, Biomass gasifier based cooking, Biomass gasifies based electricity generation, Solar Cooking, Kitchen Waste based plants, Solar Lightings etc.</td>
</tr>
<tr>
<td>Vegetable Markets</td>
<td>Solar Lanterns for Road Shops, Market Waste based biogas generation Plants, Solar lightings, Solar cold storages etc.</td>
</tr>
<tr>
<td>Sewage Treatment Plants</td>
<td>Sewage sludge based, Biogas Generation Plants, Power Generation from Biogas, Biogas Cooking, Solar lightings etc.</td>
</tr>
<tr>
<td>Sector</td>
<td>Renewable Energy Options</td>
</tr>
<tr>
<td>------------------</td>
<td>------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Roads</td>
<td>Solar Street Lighting Systems, Road Studs, Solar Traffic Signals, Solar Street Light Controls etc.</td>
</tr>
<tr>
<td>Transport</td>
<td>Battery Operated Vehicles, Biodiesel based Buses/Vehicles, Hydrogen based vehicles etc.</td>
</tr>
<tr>
<td>Advt. Hoardings</td>
<td>Solar Hoardings, CFL/LED replacement in hoardings</td>
</tr>
<tr>
<td>Hotels</td>
<td>Solar Water Heaters for water preheating (air-conditioning plant, laundry, kitchen, swimming pool), Waste based Plants, Solar Garden Lights, Solar Road Studs, solar streetlights with automatic control,</td>
</tr>
<tr>
<td>Hospitals</td>
<td>Solar Water Heaters (air-conditioning plant, laundry, kitchen, incinerators/autoclaves), Solar Roof Top Power Plants, Solar Lightings, Solar Street Lights, Road Studs</td>
</tr>
<tr>
<td>Restaurants</td>
<td>Solar Water Heaters, Solar Lightings, Solar Cooking, Gasifier Based Cooking</td>
</tr>
<tr>
<td>Schools</td>
<td>Solar Cooking for Midday Meals, Solar Lightings,</td>
</tr>
<tr>
<td>Sector</td>
<td>Renewable Energy Options</td>
</tr>
<tr>
<td>--------------</td>
<td>------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Data Center</td>
<td>Solar lighting, solar air conditioning</td>
</tr>
<tr>
<td>MSW Sites</td>
<td>Suitable Technology for MSW Treatment i.e., Inciration, Landfill, Biomethanation, Palletization</td>
</tr>
<tr>
<td>Industry</td>
<td>Waste heat recovery, process heat recovery, biogas production for thermal and captive power plant, biomass gasification, cogeneration, biomass based power plants, SPV power plants in place of conventional diesel generation, Solar Water Heaters, solar street lights for industry campus with automatic control, solar drying, Solar air conditioning etc.</td>
</tr>
</tbody>
</table>
Guideline 17: Climate responsive planning for layout in large developments and energy efficiency parameters for specific building typologies

1. All new developments shall be planned and designed such that the buildings are optimally oriented; preferably the larger facades of the buildings should be facing north south cardinal directions.

2. The built form shall reflect climate responsiveness of the building. The self-shading characteristics and surface to volume ratio shall be enhanced.

3. Space planning of building shall be meticulously worked out in order to create thermal buffer zones for spaces, which need precise thermal conditions inside.

4. Solar shading shall be designed to avoid/invite solar radiation inside the building as per the climatic conditions.

5. Layout of the large developments shall be designed such that all buildings are provided access to adequate natural light/ daylight at least on two faces.

Background

The principal purpose of passive design strategies is to reduce or avoid the need for active electro-mechanical systems while maintaining or even improving occupant comfort. Some of the key elements of the solar passive design which have significant impact on the overall energy performance of a building or a group of building are –

- Site and Orientation
- Building form
- Space arrangement
- Solar Shading
- Daylighting

Site and Orientation

There are several site considerations which can significantly affect the passive design approach which includes urban design opportunities and constraints, building orientation on the site, shade from other buildings, wind patterns, proximity to other natural elements. All these needs to be addressed to optimize
the integration of passive design strategies and some may pose design conflicts also. Integration of site considerations such as landscaping, wind and microclimate can also influence the local architectural appearance of a building.

Building facade orientation is one of the key elements for any passive design strategy. Facade orientation affects the energy and comfort implications of solar shading, window to wall area ratio, window position and performance.

It’s the orientation of a building which prima facie determines the amount of solar radiation it receives. The roof surface receives the maximum solar intensity compared to all the exposed surfaces. Building facades, which can have a significant window to wall area ratio, also receive sun in various amounts.

The south facade will capture desirable solar gains during winter when the sun angle is low, making it ideal for passive solar heating during winter. On the other hand, window should be carefully placed on the east and west facades since they receive the second highest radiation intensities. Excessive solar heat gains on the west side can be particularly problematic as maximum solar intensity coincides with the hottest part of the day.

It is thus desired that a building or a group of building shall be such planned that the exposed area to outside can be minimized. This can ideally be achieved by placing the longer facades of the building towards north and south cardinal directions.

**Building Form –**

Building shape has great potential to reduce building energy intensity, but they are often under the influence of complex array of factors (planning considerations, building type and use, feasibility and initial cost). Certain common building shapes greatly decreases surface to volume ratio, thus enhances building energy performance in cooling dominant buildings compared to a similar square footage, buildings with a larger exposed surface area. Compact building shapes significantly reduces the building’s energy intensity, size of the cooling/heating systems and sometimes even can reduces the need for active mechanical systems if the ventilation strategies have been designed appropriately.
**Space Arrangement** – Spaces which need more precise indoor thermal conditions i.e. air-conditioned spaces shall be sandwiched in between the semi-conditioned or unconditioned spaces. For example the service areas such as stairs, store-rooms, washroom etc can be placed on the east-west corners of the building so that they can reduce the solar load of the air-conditioned spaces. Thus locating the cooling dominant spaces on the north or in the centre of the building away from any perimeter solar gain can substantially reduce the cooling energy consumption. Similarly the heating dominant spaces can be located on the south or southwest area of the building.

**Solar Shading** –

Solar shading elements can be applied to the exterior or interior side of the windows.

![Figure 17.1: Analysis to calculate shading](image)

External solar shading is the use of overhangs, blinds, louvers, trellises, or anything else that blocks the sun’s rays from heating the building envelope and entering the building through windows. The external shading devices can be designed in various ways to stop the solar radiation entering through the window. The figures of the commonly found shading devices are given below –
Shading devices are designed to cut down the solar radiations during the critical hours. The horizontal shadow angle and vertical shadow angle are calculated in order to provide the appropriate horizontal and vertical projections. The critical HSA (horizontal solar angle) and VSA (vertical shadow angle) for different orientations for various latitudes have been provided in the table below for designing the shading devices.
### Latitude at 10°

**City**

Tiruchirapalli

<table>
<thead>
<tr>
<th>Latitude</th>
<th>10.8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Longitude</td>
<td>78.7</td>
</tr>
</tbody>
</table>

**Solar Angles to be cut on various cardinal directions**

<table>
<thead>
<tr>
<th>Cardinal</th>
<th>Date</th>
<th>HSA</th>
<th>VSA (Vertical)</th>
</tr>
</thead>
<tbody>
<tr>
<td>North</td>
<td>June 2nd</td>
<td>66</td>
<td>78</td>
</tr>
<tr>
<td>East</td>
<td>April 30th</td>
<td>-</td>
<td>50</td>
</tr>
<tr>
<td>West</td>
<td>April 30th</td>
<td>-</td>
<td>50</td>
</tr>
<tr>
<td>South</td>
<td>February 15th</td>
<td>-45</td>
<td>65</td>
</tr>
<tr>
<td>North-East</td>
<td>April 30th</td>
<td>40</td>
<td>50</td>
</tr>
<tr>
<td>North-West</td>
<td>April 30th</td>
<td>-</td>
<td>58</td>
</tr>
<tr>
<td>South-East</td>
<td>April 30th</td>
<td>-</td>
<td>60</td>
</tr>
<tr>
<td>South-West</td>
<td>April 30th</td>
<td>50</td>
<td>60</td>
</tr>
</tbody>
</table>

### Latitude at 15°

**City**

Belgaum

<table>
<thead>
<tr>
<th>Latitude</th>
<th>15.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Longitude</td>
<td>74.3</td>
</tr>
</tbody>
</table>

**Solar Angles to be cut on various cardinal directions**

<table>
<thead>
<tr>
<th>Cardinal</th>
<th>Date</th>
<th>HSA</th>
<th>VSA (Vertical)</th>
</tr>
</thead>
<tbody>
<tr>
<td>North</td>
<td>June 8th</td>
<td>70</td>
<td>82</td>
</tr>
<tr>
<td>East</td>
<td>April 9th</td>
<td>-</td>
<td>44</td>
</tr>
<tr>
<td>West</td>
<td>April 9th</td>
<td>-</td>
<td>54</td>
</tr>
<tr>
<td>South</td>
<td>March 2nd</td>
<td>-50</td>
<td>66</td>
</tr>
<tr>
<td>North-East</td>
<td>April 9th</td>
<td>49</td>
<td>53</td>
</tr>
<tr>
<td>North-West</td>
<td>April 9th</td>
<td>-</td>
<td>62</td>
</tr>
<tr>
<td>Direction</td>
<td>Date</td>
<td>HSA</td>
<td>VSA</td>
</tr>
<tr>
<td>-----------------</td>
<td>------------</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>South-East</td>
<td>April 9th</td>
<td>-</td>
<td>50</td>
</tr>
<tr>
<td>South-West</td>
<td>April 9th</td>
<td>36</td>
<td>59</td>
</tr>
</tbody>
</table>

**Latitude at 20°**

<table>
<thead>
<tr>
<th>City</th>
<th>Latitude</th>
<th>Longitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bhubneshwar</td>
<td>20.2</td>
<td>85.8</td>
</tr>
</tbody>
</table>

Solar Angles to be cut on various cardinal directions

<table>
<thead>
<tr>
<th>Cardinal</th>
<th>Date</th>
<th>HSA</th>
<th>VSA</th>
</tr>
</thead>
<tbody>
<tr>
<td>North</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>East</td>
<td>June 6th</td>
<td>-</td>
<td>56</td>
</tr>
<tr>
<td>West</td>
<td>June 6th</td>
<td>-</td>
<td>46</td>
</tr>
<tr>
<td>South</td>
<td>March 21st</td>
<td>-57</td>
<td>70</td>
</tr>
<tr>
<td>North-East</td>
<td>June 6th</td>
<td>34</td>
<td>57</td>
</tr>
<tr>
<td>North-West</td>
<td>June 6th</td>
<td>-</td>
<td>50</td>
</tr>
<tr>
<td>South-East</td>
<td>June 6th</td>
<td>-</td>
<td>66</td>
</tr>
<tr>
<td>South-West</td>
<td>June 6th</td>
<td>57</td>
<td>61</td>
</tr>
</tbody>
</table>

**Latitude at 25°**

<table>
<thead>
<tr>
<th>City</th>
<th>Latitude</th>
<th>Longitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allahabad</td>
<td>25.5</td>
<td>81.7</td>
</tr>
</tbody>
</table>

Solar Angles to be cut on various cardinal directions

<table>
<thead>
<tr>
<th>Cardinal</th>
<th>Date</th>
<th>HSA</th>
<th>VSA</th>
</tr>
</thead>
<tbody>
<tr>
<td>North</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>East</td>
<td>June 11th</td>
<td>-</td>
<td>55</td>
</tr>
<tr>
<td>West</td>
<td>June 11th</td>
<td>-</td>
<td>50</td>
</tr>
</tbody>
</table>
Latitude at 30°

<table>
<thead>
<tr>
<th>City</th>
<th>Latitude</th>
<th>Longitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dehradoon</td>
<td>30.3</td>
<td>78.0</td>
</tr>
</tbody>
</table>

Solar Angles to be cut on various cardinal directions

<table>
<thead>
<tr>
<th>Cardinal</th>
<th>Date</th>
<th>HSA</th>
<th>VSA</th>
</tr>
</thead>
<tbody>
<tr>
<td>North</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>East</td>
<td>June 16th</td>
<td>-</td>
<td>52</td>
</tr>
<tr>
<td>West</td>
<td>June 16th</td>
<td>-</td>
<td>50</td>
</tr>
<tr>
<td>South</td>
<td>April 16th</td>
<td>-56</td>
<td>70</td>
</tr>
<tr>
<td>North-East</td>
<td>June 16th</td>
<td>43</td>
<td>58</td>
</tr>
<tr>
<td>North-West</td>
<td>June 16th</td>
<td>-</td>
<td>60</td>
</tr>
<tr>
<td>South-East</td>
<td>June 16th</td>
<td>-</td>
<td>58</td>
</tr>
<tr>
<td>South-West</td>
<td>June 16th</td>
<td>46</td>
<td>62</td>
</tr>
</tbody>
</table>

Note –

1. The negative values for HSA here means the anti clockwise rotation

2. The values given here have been derived as generic design guidance values. For a more precise case specific solution, one can use the solar analysis simulation tool.
Day lighting

Day-Lighting in Office and Residential Buildings –

It should be noted that all the recommendations in this section of day-lighting are indicative and have been provided to help the master planners to develop the layout to provide required access to the natural light for all buildings. Several parameters such as projection over windows, the window frame area or the reflectance values can vary on a case to case basis. So a detailed analysis should be carried out for estimation of daylight availability in such cases.

Case I - When there are surrounding obstruction (other buildings) to a Building –

This is the most commonly occurring case in an urban scenario where every building is surrounded by other buildings. In such cases the day-light received through the fenestration in a space is quite affected by various factors such as height and distance of adjacent building, continuity of the buildings (width of the buildings), geometry of the adjacent building, the reflectance values of the external surfaces opposite to the window etc.

To study the impact of surrounding building on day-lighting, analysis has been carried out to understand impact of a few definitive parameters such as Height, Separation, Window Wall Ratio, and Visible Light Transmittance of Glass for two adjacent buildings in two different settings. In one scenario the building at the daylight receiving end is an office building and the other one considered is a residential building.

Office Building with surrounding obstructions (buildings) -

Correlation between Height, Separation, WWR (window wall ratio) and VLT (visible light transmittance) for two buildings to achieve required daylight in spaces: –

As per the figure shown here

H = Height of the building
W = Width of the road
X = Setback on both side
S = Separation between two buildings i.e.

S = W + 2X
To achieve adequate daylight (required daylight factor as mentioned in SP41, at the centre of daylighted zone as defined in ECBC 2007, in a space situated on ground floor) in ‘air-conditioned office type of space’ the WWR and required VLT with respect to various H/S ratios should be read from the graph given below -

![Graph showing correlation between height and separation, visible light transmission and window to wall ratio](image)

Figure 17.7: Corelation between height and separation, visible light transmission and window to wall ratio

Example explaining the above graph – If two buildings are located such that the H:S is 1:2, then to achieve the adequate daylight in a space having 60% WWR one need to provide a glass of VLT around 37% or for the same H:S as 1:2 and for a glass of VLT around 45% the WWR around 40% will be required for adequate daylighting.

In the above graph various VLTs have been considered as in the air-conditioned office spaces we usually find the glasses are having different light transmittances. If the building is non conditioned, in that scenario, for a particular H:S ratio and corresponding WWR, one will quite easily achieve the adequate daylighting as in non conditioned building windows will be opened for admission of outside air and hence at the same time the amount of daylight entering through fenestration
will be much more as compared to a closed window with certain value of VLT for the glass.

**Residential building with surrounding obstructions (buildings) –**

To achieve adequate daylight in ‘non-conditioned residential spaces’ where clear glass is installed the WWR required with respect to various H/S ratios should be read from the table given below –

**Table 17.1: Recommended minimum WWR for H/S ratios**

<table>
<thead>
<tr>
<th>H/S ratios (height to separation between buildings)</th>
<th>Minimum WWR (%)Required for adequate daylighting</th>
</tr>
</thead>
<tbody>
<tr>
<td>1:5</td>
<td>10</td>
</tr>
<tr>
<td>1:4</td>
<td>10</td>
</tr>
<tr>
<td>1:3</td>
<td>10</td>
</tr>
<tr>
<td>1:2</td>
<td>20</td>
</tr>
<tr>
<td>1:1</td>
<td>20</td>
</tr>
<tr>
<td>2:1</td>
<td>50</td>
</tr>
<tr>
<td>3:1</td>
<td>60</td>
</tr>
</tbody>
</table>

**Energy efficiency related design requirements for Hospital buildings in medical college campuses**

Hospital facilities have multiple spaces with varying requirements. In hospitals, offices and patients rooms reflect mixed-use areas with both residential and administrative functions. Some areas in these buildings require extensive ventilation, without contamination, for long-operating hours and hence energy intensive. There are spaces, which need to be non daylit, whereas natural lighting is preferable in some.

Lighting systems need to be efficient and controlled for all spaces. Where circulation corridors are provided externally in cold climate, they can be orientated on south, so as to act as sunspaces. Thermal mass walls can be provided between corridors and main working space in cold climates. Top lighting is beneficial in patient rooms. North facing walls can have small, well-spaced view window.
Atriums can be incorporated both as a means to bring daylight in waiting areas and OPDs. Solar water heating can be used for meeting hot water demand.

The following are recommended standards (prescriptive) for hospital buildings as per Indian codes and standards

**Table 17.2: Envelope**

<table>
<thead>
<tr>
<th></th>
<th>U Factor (w/m²°C)</th>
<th>Maximum U Factor (w/m²°C)</th>
<th>Minimum R Factor (m²·°C/W)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Composite/Hot dry/Warm Humid</td>
<td>Moderate</td>
</tr>
<tr>
<td>Wall Assembly</td>
<td>0.440</td>
<td>0.440</td>
<td>0.369</td>
</tr>
<tr>
<td>Roof Assembly</td>
<td>0.261</td>
<td>0.409</td>
<td>0.261</td>
</tr>
<tr>
<td>Window</td>
<td>3.30</td>
<td>6.90</td>
<td>3.30</td>
</tr>
<tr>
<td>Skylight (With Curb)</td>
<td>11.24</td>
<td>11.24</td>
<td>11.24</td>
</tr>
<tr>
<td>Skylight (With Curb)</td>
<td>7.71</td>
<td>7.71</td>
<td>7.71</td>
</tr>
</tbody>
</table>

**Table 17.3: Other Parameters - Window Wall Ratio (WWR)**

<table>
<thead>
<tr>
<th></th>
<th>WWR</th>
<th>SHGC</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Composite</td>
</tr>
<tr>
<td>Vertical Fenestration</td>
<td>WWR ≤ 40%</td>
<td>0.25</td>
</tr>
<tr>
<td></td>
<td>40% &lt;WWR ≤ 60%</td>
<td>0.20</td>
</tr>
<tr>
<td>Skylights (with Curb)</td>
<td>0-2% SRR</td>
<td>0.40</td>
</tr>
<tr>
<td></td>
<td>2.1-5% SRR</td>
<td>0.25</td>
</tr>
</tbody>
</table>
### Table 17.4: Minimum Visible light transmission (VLT) Requirement

<table>
<thead>
<tr>
<th>Window Wall Ratio</th>
<th>Minimum VLT</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-0.3</td>
<td>0.27</td>
</tr>
<tr>
<td>0.31-0.4</td>
<td>0.2</td>
</tr>
<tr>
<td>0.41-0.5</td>
<td>0.16</td>
</tr>
<tr>
<td>0.51-0.6</td>
<td>0.13</td>
</tr>
</tbody>
</table>

### Table 17.5: Heating Ventilation and Air conditioning (HVAC) Indoor Design Condition

<table>
<thead>
<tr>
<th>Category</th>
<th>Inside design condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recovery rooms</td>
<td>DB 24 to 26°C, RH 45 to 55%</td>
</tr>
<tr>
<td>Patient rooms</td>
<td>DB 24 to 26°C, RH 45 to 55%</td>
</tr>
<tr>
<td>Operation theatres</td>
<td>DB 17 to 27°C, RH 45 to 55%</td>
</tr>
</tbody>
</table>

### Table 17.6: Outdoor air requirements

<table>
<thead>
<tr>
<th>Application</th>
<th>Outdoor Air Requirement (l/s/person)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient rooms</td>
<td>13</td>
</tr>
<tr>
<td>Medical procedure</td>
<td>8</td>
</tr>
<tr>
<td>Operating rooms</td>
<td>15</td>
</tr>
<tr>
<td>Procedure Recovery and</td>
<td>20</td>
</tr>
</tbody>
</table>
## Application

<table>
<thead>
<tr>
<th>Application</th>
<th>Outdoor Air Requirement (l/s/person)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICU</td>
<td></td>
</tr>
<tr>
<td>Autopsy</td>
<td></td>
</tr>
<tr>
<td>Physical therapy</td>
<td>8</td>
</tr>
<tr>
<td>Correctional Cells</td>
<td>10</td>
</tr>
<tr>
<td>Dining halls</td>
<td>8</td>
</tr>
<tr>
<td>Guard Stations</td>
<td>8</td>
</tr>
</tbody>
</table>

### Table 17.7: Lighting

<table>
<thead>
<tr>
<th>Space</th>
<th>NBC 2005</th>
<th>ECBC 2007</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nurse Station</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day</td>
<td>200-300-500</td>
<td>10.8</td>
</tr>
<tr>
<td>Night Desk</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>Operating room</td>
<td></td>
<td></td>
</tr>
<tr>
<td>General</td>
<td>300-500-750</td>
<td>23.7</td>
</tr>
<tr>
<td>Local</td>
<td>10000 - 50000</td>
<td></td>
</tr>
<tr>
<td>Recovery rooms</td>
<td>200-300-500</td>
<td>8.6</td>
</tr>
<tr>
<td>Examination</td>
<td>750-1000-1500</td>
<td>16.1</td>
</tr>
<tr>
<td>Corridor</td>
<td>100-150-200</td>
<td>10.8</td>
</tr>
<tr>
<td>Waiting Room</td>
<td>100-150-200</td>
<td>12.9</td>
</tr>
</tbody>
</table>
Guidelines and benchmarks for Green Large Area Developments Final report

<table>
<thead>
<tr>
<th></th>
<th>NBC 2005</th>
<th>ECBC 2007</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laboratories</td>
<td>300-500-750</td>
<td></td>
</tr>
<tr>
<td>Bed Head</td>
<td>30-50</td>
<td>7.5</td>
</tr>
<tr>
<td>Observation</td>
<td>200-300-500</td>
<td></td>
</tr>
<tr>
<td>X-Ray area (General)</td>
<td>150-200-300</td>
<td></td>
</tr>
</tbody>
</table>


### Educational buildings

These buildings cater to a diverse range of functions. Glare free daylighting in the class-rooms/lecture halls, controlled conditions in the laboratories and thermally and visually comfortable conditions in the support facilities is a necessity. Light-shelves, light pipes appropriately designed for diffused lighting in deep spaces may be considered, placement of openings for increased ventilation, building envelope with radiant barriers and reflective roofs, roof monitors in gymnasiums, dining halls, cafeterias, workshops, solar water heating and photovoltaic systems will be immensely appropriate in such buildings.

#### Table 17.8: Envelope parameters

<table>
<thead>
<tr>
<th></th>
<th>Maximum U Factor (w/m²°c)</th>
<th>Minimum R Factor (m²·°C/W)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Composite/Hot-dry/Warm-Humid</td>
<td>Moderate</td>
</tr>
<tr>
<td>Wall Assembly</td>
<td>0.44</td>
<td>0.44</td>
</tr>
<tr>
<td>Roof Assembly</td>
<td>0.409</td>
<td>0.409</td>
</tr>
<tr>
<td>Window</td>
<td>3.30</td>
<td>6.90</td>
</tr>
<tr>
<td>Skylight (With Curb)</td>
<td>11.24</td>
<td>11.24</td>
</tr>
<tr>
<td>Skylight (With Curb)</td>
<td>7.71</td>
<td>7.71</td>
</tr>
</tbody>
</table>
### Heating Ventilation and Air Conditioning

**Table 17.9: Indoor Design Condition**

<table>
<thead>
<tr>
<th>Category</th>
<th>Inside design condition (Summer)</th>
<th>Inside design condition (Winter)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class Rooms</td>
<td>DB 23 to 26°C</td>
<td>DB 23 to 24°C</td>
</tr>
<tr>
<td></td>
<td>RH 50 to</td>
<td>RH not less than</td>
</tr>
<tr>
<td>Museums &amp; Libraries</td>
<td>DB 20 to 22°C</td>
<td>DB 20 to 22°C</td>
</tr>
<tr>
<td></td>
<td>RH 40 to 55%</td>
<td>RH 40 to 55%</td>
</tr>
</tbody>
</table>

**Table 17.10: Outdoor air requirements**

<table>
<thead>
<tr>
<th>Application</th>
<th>Outdoor Air Requirement (l/s/person)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classrooms</td>
<td>8</td>
</tr>
<tr>
<td>Laboratories</td>
<td>10</td>
</tr>
<tr>
<td>Training shop</td>
<td>10</td>
</tr>
<tr>
<td>Music rooms</td>
<td>8</td>
</tr>
<tr>
<td>Libraries</td>
<td>8</td>
</tr>
<tr>
<td>Auditoriums</td>
<td>8</td>
</tr>
</tbody>
</table>

**Table 17.11: Lighting**

<table>
<thead>
<tr>
<th>Space</th>
<th>NBC</th>
<th>ECBC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assembly Halls</td>
<td>200-300-500</td>
<td></td>
</tr>
<tr>
<td>Teaching Space</td>
<td>200-300-500</td>
<td></td>
</tr>
<tr>
<td>Seminar Rooms</td>
<td>300-500-750</td>
<td></td>
</tr>
<tr>
<td>Art Rooms</td>
<td>300-500-750</td>
<td></td>
</tr>
<tr>
<td>Needlework Rooms</td>
<td>300-500-750</td>
<td></td>
</tr>
<tr>
<td>Laboratories</td>
<td>300-500-750</td>
<td></td>
</tr>
<tr>
<td>Libraries</td>
<td>200-300-500</td>
<td></td>
</tr>
<tr>
<td>Music Rooms</td>
<td>200-300-500</td>
<td></td>
</tr>
<tr>
<td>Sports Halls</td>
<td>200-300-500</td>
<td></td>
</tr>
<tr>
<td></td>
<td>NBC</td>
<td>ECBC</td>
</tr>
<tr>
<td>---------------</td>
<td>-------</td>
<td>--------</td>
</tr>
<tr>
<td>Workshops</td>
<td>200-300-500</td>
<td></td>
</tr>
</tbody>
</table>

Guideline 18: Sustainable construction processes, commissioning, monitoring, operation and maintenance

Sustainable construction holds key to proper execution of a project as per intended sustainability parameters. The construction process can have a significant impact on environmental resources. Environmentally conscious construction practices can largely reduce site disturbance, waste generation, and the use of natural resources during construction. When approaching construction from a sustainable perspective, a builder should ensure that the construction contract and specifications address the design and construction teams’ environmental requirements for the construction process.

The framework for sustainable construction practices includes the following issues, which are detailed out in the subsequent sections:

- Pre-construction requirements
- Planning for sustainable construction and management
- Monitoring environmental parameters
- Sustainable work execution procedures
- Post construction closeout

Pre-construction and requirement

Sustainable construction requires preparation of efficient design proposals to ensure efficient utilization of materials and resources during construction. The following checklist enumerates the pointers to preconstruction requirements for ensuring sustainable construction

- Efficient and optimised architectural and structural design to minimize wastage, ensure efficient utilization of space and materials, avoid overdesign, ensure “defect free” design.
- Sustainable construction deployment including development of digital models, simulated work flows under working conditions, phasing and phasewise planning, prefabrication. It is essential for construction works that involve a fair amount of pre-fabrication, especially off-site, so that the fabrication is compatible and the installation procedures are fail-safe. Construction materials and technologies that impact the environment, especially during processing of materials, such as cutting, mixing,
fabrication etc. causing noise, dust and possibly release of fumes need to be identified and procedures planned to mitigate impacts. Selection of efficient plants, equipments and machineries and their proper scheduling of operation are key considerations for sustainable deployment.

- Sustainable procurement policy and contracting for sourcing of services, materials, and products, award of works and contracts. Appointment of sustainability construction management professional should be mandated.

**Planning for sustainable construction and management:** The following are the key issues to be addressed during construction

- Prevention and management of construction disasters by following National Building Code recommended guidelines and other relevant IS codes and standards

- Preparation and establishment of of sustainable construction management plan (site and project). Reference should be made to IS 15883(Part1): 2009 ‘Guidelines for Construction Project Management: Part 1 General’ for detailing out construction project management processes.

- Establishment of management systems to ensure quality of construction, environmental management of construction, health and safety of workers should be done in accordance with relevant IS codes. The GRIHA criteria on the above may be referred to for details.

- Work execution procedures to facilitate minimum wastage, rework, repair and to ensure acceptable performance. In this respect following need to be specifically addressed:

Reference to standards for materials and completed works

Quality assurance verification

Material handling, storage, and protection

Work procedures and including working on materials / fabrication, placing / installation

Inspection and testing procedures

Quality controls, records

Protection after completion of work
Monitoring of environmental parameters

Environmental Impact Assessment (EIA) of large developments shall require characterization of the existing status of the land, water, air, biological and socio-economic environment in the project area and its surroundings. It is carried out to identify potential environmental impacts of the project, and formulation of an effective Environmental Management Plan (EMP) to prevent, control and mitigate the adverse environmental impacts, and ensure the compliance with the environmental legislations.

Depending on the nature of project, construction agencies would be required to establish infrastructure and procedures for monitoring soil monitoring, water quality monitoring, ambient air quality monitoring, noise monitoring, tree counting and traffic survey.

Post construction closeout

Project closeout is a very significant stage from the sustainability considerations. At this stage, it is essential to ensure that the obligations of the project, in terms of physical delivery of works as enshrined in the briefing documents as well as environmental commitments are achieved. Project management closeout would ensure that the contractual obligations are complied with. However, consequences of construction activities too need appropriate determination.

Commissioning, operation and maintenance

Introduction and Overview

The energy, water & waste management systems should be commissioned as designed and should be installed to operate as per intent.

A commissioning flow for all systems should be included as part of construction documents. A commission report should be completed and verified. A commissioned project provides optimized energy efficiency, water efficiency & ensures that operational & maintenance costs are minimum.

The commissioning process commences with start of project by documentation of project proponent’s requirement. The process continues through the project cycle including post construction monitoring for a minimum period of one year after occupancy. Training management staff is a key parameter of commission plan. The commissioning process should include the following systems:

1. Energy systems at campus levels and building level (street lighting, water pumping, electrical systems, distribution networks, building energy systems).
2. Renewable energy systems & technologies

3. Water efficiency technologies, rain water harvesting, waste water treatment systems.

4. Waste management systems, waste treatment facilities.

5. Environmental management systems.

The following steps should be followed for a proper commissioning of large development project.

- Engage a commissioning authority at project inception. The commissioning authority should not be part of project or construction team. It should specify the requirement fairly early at project stage. A competent team should be formed comprising of owners, users, O & M staff & other project stakeholders. The team is fully responsible for the entire process.

- The project requirements that are verifiable & measurable are documented at design stage. This act as reference document that gets verified through the project implementation cycle. Design basis for all systems are to be documented and presented to proponent as part of commissioning plan.

- A comprehensive commissioning plan is prepared which has the following components: -
  - Scope of commissioning plan
  - Team configuration and responsibilities.

- Description of management, communication & reporting methods.

- Over view of activities throughout the project cycle (design, construction, O & M, design review, working drawings, construction phase verification, testing protocols, post occupancy review)

- Milestone & deliverables

- The following components should be part of contract documents
  - Submittal review procedure
  - O & M protocol for each system
  - Training of maintenance staff
- Annual maintenance contract
- Implementation plan
- Testing & verification protocol
- Post occupancy monitoring

The following shall be completed on each commissioned items: -

Verify installation & checklist of commissioning items: - Regular site visits are to be conducted during commissioning process to ensure proper commissioning as per contract & manufacturer’s introduction.

The entire process needs to be documented and verified against a checklist that lists out the deliverables and the process. In case of large projects it may not be feasible to check commissioning for 100% of all systems. In such cases, a suitable sample size may be selected that is representative of the entire system. Sampling verification ensures early detection of systems issues and enables fixing them to avoid rework at complete system checkout.

Setting up testing protocol: the commissioning authority is required to prepare test procedures for all systems to be commissioned. The test procedures and their frequency and scheduling needs to be discussed with the contractor, and agreed upon. The sequence needs to address start-up, shut down, switch overs, auto & manual modes, part & full load operations, alarms, interface with other systems, overloading situations and any other sequence as deemed necessary by the commissioning authority. Sampling techniques may be applied to do testing for a representative sample size of system.

O & M manual and training of O & M staff: The O & M manuals must be complete in all respects and should have instructions for installation, maintenance, replacement, startup, maintenance, routine checks, spare part list, instrumentation requirement, logbook requirements for keeping records, annual maintenance contract information, guarantee & warranty information. The O&M plan should be a “living document,” that is, that is amended as requirements change. The intention should be to update O&M document periodically as new procedures and technologies are developed and employed. A Web-based version can also be implemented for “live” updates.

A comprehensive operation and maintenance (O&M) protocol that has been designed specifically for improving the performance of building’s electrical and mechanical systems can reduce significant running costs.

Broadly an operation and maintenance program would comprise of:
• Regularly performance monitoring of the building systems.

• Correct operation of equipments as per the guidelines specified by the manufacturers/suppliers.

• Repair and upgradation of building systems as and when required to ensure smooth functioning of equipments and processes.

• Adjustment of the mechanical and electrical systems to function as per the varying occupant needs.

Detailed operating information should be included as part of O & M manuals.

Detailed training for O and M staff shall be conducted. The training should cover system information familiarization with O & M manual, modes of operations (normal & emergency), adjustments to impact energy efficiency, interface with other systems, troubleshooting, health & safety issues, tenant / owner issues, environmental issues. One of the key ways to enhance building operations and maintenance and thereby achieving the efficiency goals of buildings/facilities are well trained building operators and managers. Lack of properly trained operators and high turnover of building operators contributes significantly to inefficient building operation and maintenance. Without the right skill sets and proper training, building operators and managers may not be able to manage the facility optimally even with the most advanced systems. A competent O&M program requires the participation of staff from five well-defined areas: Operations, Maintenance, Engineering, Training, and Administration. However a successful O&M program requires cooperation, dedication, and participation at all levels including Energy managers, practitioners, and technical staff.

To operate buildings efficiently, in addition to a good controls infrastructure, the following is also necessary:

• Increase the skill level of operators and maintenance personnel.

• Provide adequate engineering supervision of technician work to ensure that knowledge of fundamental processes is brought to bear on operation and maintenance actions.

• Provide operators with system performance feedback.

• Provide incentives for correcting problems.

• Educate everyone who influences the planning, budget, design, and procurement of energy and related systems.
A detailed commissioning report comprising of afore mentioned information should be submitted to the project proponent for further use & reference.

**Periodic audits of systems**

In addition to incorporation of ‘green’ design features during design and construction of a development, it is equally significant to ensure that energy and environmental systems incorporated are performing as predicted during the design and development stage. Through audits, the performance of these systems can be evaluated and the validity of the predicted performance can be determined. Incase a system is not performing as expected; the audit process will identify the cause for deterioration in the performance and also provide recommendations regarding any need for upgradations or modifications in the systems.

**Solution**

Conducting an audit is the first step towards ensuring that the building systems are performing as designed. Audit process will provide an idea on how efficiently a particular system is working and will also identify areas (if any) where there is any potential for improvement.

Following are three major areas of a building and site that should be audited to assess the overall performance of a building:

- **Energy audit**: Energy audits are conducted to assess the overall energy performance of site and buildings and identify opportunities of energy conservation. Audit of total energy consumption of the buildings and site parameters (street lighting, water pumping, site level energy systems) provides an understanding of the different forms of energy that are being used in the large development and energy consumption of specific end uses.

**Type of Energy Audit**

Energy audit may range from a simple walk-through survey, to one that may extend over several phases. These phases will include a preliminary walk-through survey, followed by monitoring of energy use in the building services, and then detailed analysis of building and site level energy use patterns using computer simulation software.

**Preliminary audit or walk-through Audit**: Preliminary energy audit is a relatively quick and simple exercise. It involves brief interviews with site-operating personnel, a brief review of the utility bills and other operating data, and a walk-through of the facility/campus to:
• Become familiar with the building operation and operation of the sitelevel energy systems
• Establish energy consumption of the development
• Estimate the potential for energy saving
• Identify any glaring areas of energy wastage or inefficiency
• Identify immediate improvements/energy saving measures

Walk-through audits use existing, or easily available data and typically only major problem areas can be identified during this type of audit. Immediate corrective measures are briefly described, and quick estimates of implementation cost, potential operating cost savings, and simple payback periods are provided. This level of detail, while not sufficient for reaching a final decision on implementing proposed measures, is adequate to prioritize energy-efficiency projects. Walk through audits help in determining the need for a more detailed audit.

**Detailed Energy Audit:** The detailed energy audit expands on the preliminary audit by collecting more detailed information about building and site level operation and by performing a more detailed evaluation of energy conservation measures. Additional metering through appropriate instruments is often installed to supplement utility data. In-depth interviews with facility operating personnel are conducted to get a better understanding of major energy consuming systems and to gain insight into short and long term energy consumption patterns. Detailed energy audit evaluates all major energy using systems in a building and provides a comprehensive energy conservation implementation plan for the building. This type of audit provides accurate estimate of energy and cost savings. An in-depth financial analysis is performed for each measure based on detailed implementation cost estimates; site-specific operation cost savings, and the building owner’s investment criteria.

**Water and waste audit**

**Water audit:** Water audits are conducted to understand the water supply, consumption and discharge pattern in a building. It can be very effective water management tool in a campus/large development. Water audit identifies measures that can be taken to reduce the water consumption and losses and estimates the potential of water saving.
While conducting a water audit, the complete movement of water from its point of entry into the site and its buildings and to its discharge is studied. The unaccountable water losses are quantified and water leakage points are identified. A detailed water audit will inspect the different areas in which a site and building uses water like sanitation, kitchen, HVAC systems, landscaping, and the quantity of water used for each application.

In addition to water consumption, water audits will also take into consideration the quality of water and the procedure for management of waste water on site. Large amounts of water savings can be achieved by recycling waste water and use of harvested rain water.

**Waste audit:** Waste audit is conducted to quantify the amount and types of waste generated in a building and site level operations. It will evaluate the existing waste management system including the segregation, storage and disposal. Purpose of a waste audit is to assess the effectiveness of the solid waste management system of the building and identify any opportunities for improvement.
SECTION E: WATER & WASTE WATER MANAGEMENT SYSTEMS

Guideline 19: Sustainable water management

To develop and integrate a water strategy at the community level to ensure that the landscape water requirement at the community level is reduced compared to the conventional case and preferably be at least less than 3 l/sq m/day).

Soil amendment strategy if applicable, Irrigation system strategy and management plan should be incorporated to ensure above.

If any artificial water body such as swimming pool, pond, lake is proposed as part of the landscape plan, prefeasibility to check the source for replenishment of supply on account of evapotranspiration should be sought and in no circumstances, potable water supply from municipal sources/groundwater to be diverted.

Benefits

With an ever increasing population, water availability per person is increasingly becoming scarcer in India. Even places situated near surface water sources, rivers, lakes, etc. are facing water stress situation at least during the peak summers. Conventionally, large developments and campuses have a certain fraction of land meant for open spaces and recreational uses. If these green open spaces are rationally planted with more of native trees, shrubs and ground covers, there is a huge potential to save the large landscape water requirement.

Improving the efficiency of water use for landscape is possible in two ways-

1. Planting appropriate vegetative species-Native vegetation/flora and xeriscaping

2. Using efficient irrigation system, and management plan

Some of the advantages of following the above approach are:

- Appropriate planting and efficient irrigation systems can reduce irrigation water use by 50% to 70% and overall water consumption by 25% or more which helps in extending the water supplies available.

- Native species and xeriscape vegetation give the twin advantages of water efficiency and ease of maintenance.
The wealth of color and form found in the native flora greatly surpasses that found in cultivated plats. Natives have interesting growth forms, provide year round beauty and respond to minimal care with an abundance of beautiful flowers.

When native trees and plants get increasingly replaced by exotic, introduced species, the ecological balance will shift in unfavorable directions for the existence of other dependent species and can result in ecological damages that cannot be repaired. Properly-designed native landscaping can improve the value of the site, improve aesthetics, enhance biodiversity,

- Increase soil and water quality, and absorb noise and if properly done can also provide favourable shade during summers or vice versa.

- Conventional irrigation systems often result in over-irrigating leading to flooding and runoff also causing top soil erosion, etc in the absence of control systems/ personnel. Irrigation practices are also not scientifically regulated to gain maximum benefits. Native flora is effective in reducing runoff rate and volume from impervious areas in infiltration practices and removes sediment and pollutants to improve water quality.

Guidance Notes

Methodology

Calculating landscape water demand using landscape water demand calculator

The sequential steps to be followed for arriving at the Landscape water demand is given in this section.

The water requirement of the landscape can be estimated using the following equation:

$$\text{Water requirement(lpd) = Canopy area(sq.m) \times Evapotranspiration rate(mpd) \times plantfactor \times}$$

Where,

*Monthly Evapotranspiration rate (ET0)*: The potential evapotranspiration rate (PET) is the climate factor, refers to the amount of water required by the plant for healthy growth (depending on the climate). Evapotranspiration rate determines the rate at which plants lose water through evaporation. It is affected by humidity and temperature at a given time. These rates vary with the season and
are different for different months. The data is available with the Indian Meteorological Department for different stations. The data can be procured from Additional Director General of Meteorology (Research), Shivajinagar, Pune – 411 005.

Canopy area is the area covered by shrubs, grass covers, and for trees it is the plan view and is assumed as 25 sq. m per tree.

The Plant factors are categorized as

1       for lawns, evergreen fruit trees, lush ground covers
0.7    for exotic species (non-native species)
0.4    for plants native to the areas
0       for native trees

1. Irrigation systems types and efficiency

The efficiencies of irrigation systems differ widely. Further, to improve the efficiency certain measures can be followed, which includes use of a pressure regulator for pressures greater than 30 psi which will significantly reduce the loss during watering. Efficiencies of different kinds of irrigation equipment are given in table below

Table 19.1: Efficiency of Irrigation equipment

<table>
<thead>
<tr>
<th>Irrigation system</th>
<th>Efficiency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Micro, drip</td>
<td>85</td>
</tr>
<tr>
<td>Micro, spray</td>
<td>80</td>
</tr>
<tr>
<td>Multiple sprinkler</td>
<td>75</td>
</tr>
<tr>
<td>Sprinkler, large guns</td>
<td>70</td>
</tr>
<tr>
<td>Seepage</td>
<td>50</td>
</tr>
<tr>
<td>Crown flood</td>
<td>50</td>
</tr>
<tr>
<td>Flood</td>
<td>50</td>
</tr>
</tbody>
</table>
2. Irrigation schedule

Irrigate with the Proper Amount of Water

To conserve water and maintain a healthy landscape, irrigation should be as infrequent as possible, and each irrigation should moisten the soil root zone. Frequent, light irrigations result in plants with shallow root systems that dry rapidly when under water stress. Infrequent deep irrigation encourages the development of extensive root systems which fully utilize the entire soil profile.

To correctly apply enough water to moisten the root zone without losing excess water to deep drainage requires an understanding of soils. Soil is much like a sponge that holds water. Once the soil is moistened, plants are able to obtain water from the soil. As more water is added to a soil, it will eventually become saturated and excess water simply drains through and is lost to ground water.

Determination of the quantity of water to be added to soil on each irrigation, in turn, depends in large part on the texture of the soil. Coarse, sandy soils have rapid infiltration rates, good aeration, and poor water retention whereas finer, clay-loam type soils have slower infiltration rates and greater water retention.

The lawn requires the same amount of water regardless of soil type. Therefore, since sandy soils hold less water than clay soils, they must be irrigated more frequently, with smaller amounts, to meet the plant’s needs.

Efficient irrigation requires uniform application of a known amount of water to the landscape. It is therefore, crucial to select the optimum irrigation system.

Irrigate at the Right Time

Irrigate as infrequently as possible, and only when plants have used most of the available soil moisture. In general, irrigating once or twice a week is ideal. Irrigation timing can be determined in two ways. The first method is to monitor the plants and/or soil in the landscape or garden. The second method is to determine the amount of water that has been lost from the landscape and how much will be needed to replace it.

Scheduling Irrigation Based on Evapotranspiration

Irrigation scheduling can also be determined by using evapotranspiration (ET) data. ET is the sum of water lost from the landscape through evaporation from the soil surface and transpiration through the leaves of plants. ET is determined by the plant species and the climatic conditions. By knowing the water storage capacity of a soil and the daily ET rate, one can calculate when the available moisture will be near depletion and irrigation is needed. For example, if a loam soil holds 3.8 cm of water in the top 30.4 cm, and during the summer the ET rate
is 0.6 cm per day, after 6 days (6 x 0.6 = 3.6) the available water would be depleted and irrigation would be required. To replenish the soil moisture 3.8 cm of water would need to be applied. This method is known as the “checkbook” system of irrigation scheduling and simple, yet effective. Because ET rates vary depending on climatic factors such as solar radiation, temperature, humidity, wind speed, clouds, and fog, irrigation requirements also vary accordingly. In the summers, ET reaches peak values while in the winter, ET is virtually zero; but it increases during the spring with increased sunshine and temperature to a maximum in midsummer.

Other practices for Conserving Water in the Landscape

Irrigating at the right time and in the right amount can permit water conservation and optimum plant growth. There are several other local practices that can be used to conserve irrigation water.

- Irrigate early in the morning when temperatures are cool and when the wind is not blowing so that less water is lost to evaporation.
- Maintain irrigation systems so that water is applied at appropriate pressures, leaks are repaired, and alignment is correct.
- Mow lawn grass frequently at a height of 6 to 7 cm. This improves tolerance of hot, dry conditions.
- Segregate landscape plants according to water requirements to reduce over watering of low-water use plants yet maintain high-water use plants.
- Use drip or trickle irrigation systems to reduce the amount of water used in the landscape.

Soil amendment strategies

The foundation of water conservation in the landscape lies in creating soils that have high water retention ability. Good soil has following characteristics:

- Holds water well
- Provides nutrients
- Is aerated to allow water to penetrate several cm to reach deep roots
- Has large particles that allow water flow and absorption. Dense soils such as clay are slow to absorb water, so they’re prone to runoff.

To enable soil to better absorb and hold water, as well as allow for deeper roots, one needs to add a soil amendment prior to planting. For new landscapes, it is
required to begin with good topsoil, usually a minimum of 15 cm deep and then adding a minimum of 6 cm of organic matter such as compost to the soil. Dig and mix the organic matter into the soil at least 15 cm deep. The one exception to this is landscaping with native plants. With the natives, soil amendments do not need to be nearly as extensive, as they prefer soil that is not too rich. For many native plants, the only soil preparation necessary is to loosen the soil as long as there is some naturally occurring topsoil. In cases where the landscape is done on subsoils and topsoil being removed, it becomes essential to do some soil preparation and add amendments.

**Conservation of water bodies**

If the site consists of any water bodies such as ponds, reservoirs, streams, etc. within the designated area, at least 50% of such area should preferably be conserved.

Such natural water bodies are rich sources of biodiversity and help in maintaining the hydrological cycle of the place.
Guideline 20: All large development should have provision for adequate quality of water for potable and non-potable applications and to ensure the above, a stringent monitoring plan should be adopted through periodic audits.

Benefits

The quality of water, whether it is used for drinking, irrigation, or recreational purposes, is significant for health worldwide. The quality of drinking-water is a powerful environmental determinant of health. Assurance of drinking-water safety is a foundation for the prevention and control of waterborne diseases. In case treated wastewater is used for any applications (non-potable), it should meet the quality standards specified for those applications. In the absence of Indian standards, best practices establish in the world should be followed.

Maintaining the quality of drinking water helps to ensure safe drinking water to the consumer.

To ensure safe drinking water, both municipal, groundwater and/or harvested rainwater has to be treated before use to varying levels depending on the water quality of the source.

1. Municipal Water:

- Requires treatment for biological contamination to ensure safe water
- As simpler and cheaper treatment systems are sufficient to treat biological contamination, advance treatment systems such as Reverse osmosis and Ion exchange systems are not recommended unless the municipal water supplied gets secondary contamination to a considerable extent.
- RO systems waste water at the rate of 2 to 3 l for every litre of purified water
- RO systems reduce essential mineral content in drinking water

Ground Water:

If ground water is used for drinking without proper treatment, it could lead to health risks. Hence, advance systems such as reverse osmosis system and ion exchange systems may be installed to ensure safe drinking water. Regular water quality checks have to be conducted in order to maintain drinking water quality.
However, these treatment systems should be used to treat the quantity of water required for drinking and cooking purposes only in order to reduce wastage.

**Guidance notes**

**What is water Quality?**

Water Quality refers to those characteristics or range of characteristics that make water appealing and useful.

The term "water quality" is defined as "those physical, chemical or biological characteristics of water by which the user evaluates the acceptability of water". For example for the sake of man’s health, it is required that his water supply is pure, wholesome, and potable. Similarly, for agriculture, we require that the sensitivity of different crops to dissolved minerals and other toxic materials is known and either water quality or type of crops is controlled accordingly.

For management of water quality, one has to define the water quality requirements or water quality goal. Each water use has specific water quality need. Therefore, for setting water quality objectives, it is essential to identify the uses of water.

The quality of water need not be the same for all activities. The purest form of water is required for drinking, while lesser quality can be used to other purposes like washing, gardening etc. In India water quality standards were formulated as early as 1940 and the standards were modified later from time to time. Although there are at least three standards formulated by ICMR, BIS and CPHEEO, the one recommended by Bureau of Indian Standards (BIS) is widely adopted.

**Water Quality Recommendations for other purposes**

Each water use has specific quality need. Therefore, to set the standard for the desire quality of a water body, it is essential to identify the uses of water in that water body. In India, the Central Pollution Control Board (CPCB) has developed a concept of designated best use. According to this, out of the several uses of water of a particular body, the use which demands highest quality is termed its designated best use. Five designated best uses have been identified. This classification helps the water quality managers and planners to set water quality targets and design suitable restoration programs for various water bodies.
Table 20.1: CPCB recommended water quality based designated best use categories

<table>
<thead>
<tr>
<th>Designated-Best-Use</th>
<th>Class of water</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drinking Water Source</td>
<td>A</td>
<td>1. Total Coliforms Organism MPN/100ml shall be 50 or less</td>
</tr>
<tr>
<td>without conventional treatment but after disinfection</td>
<td></td>
<td>2. pH between 6.5 and 8.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. Dissolved Oxygen 6mg/l or more</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4. Biochemical Oxygen Demand 5 days 20°C 2mg/l or less</td>
</tr>
<tr>
<td>Outdoor bathing (Organised) – Indoor use for bathing</td>
<td>B</td>
<td>1. Total Coliforms Organism MPN/100ml shall be 500 or less</td>
</tr>
<tr>
<td>cleaning, etc</td>
<td></td>
<td>2. pH between 6.5 and 8.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. Dissolved Oxygen 5mg/l or more</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4. Biochemical Oxygen Demand 5 days 20°C 3mg/l or less</td>
</tr>
<tr>
<td>Drinking Water Source</td>
<td>C</td>
<td>1. Total Coliforms Organism MPN/100ml shall be 5000 or less</td>
</tr>
<tr>
<td>after conventional treatment and disinfection</td>
<td></td>
<td>2. pH between 6 and 9</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. Dissolved Oxygen 4mg/l or more</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4. Biochemical Oxygen Demand 5 days 20°C 3mg/l or less</td>
</tr>
<tr>
<td>Propagation of Wild life and Fisheries</td>
<td>D</td>
<td>1. pH between 6.5 and 8.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Dissolved Oxygen 4mg/l or more</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4. Free Ammonia (as N) 1.2 mg/l or less</td>
</tr>
<tr>
<td>Irrigation, Industrial Cooling, Controlled Waste disposal</td>
<td>E</td>
<td>1. pH between 6.0 and 8.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Electrical Conductivity at 25°C micro mhos/cm Max.2250</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. Sodium absorption Ratio Max 26</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4. Boron Max 2mg/l</td>
</tr>
<tr>
<td>Below –E</td>
<td></td>
<td>Not meeting A, B, C, D &amp; E Criteria</td>
</tr>
</tbody>
</table>
In India, CPCB has identified water quality requirements in terms of a few chemical characteristics, known as primary water quality criteria. Further, Bureau of Indian Standards has also recommended water quality parameters for different uses in the standard IS 2296:1992.

CPCB’s water quality requirements in terms of a few chemical characteristics are shown in the table below:

**Table 20.2: CPCB water quality standards—Chemical constituents**

<table>
<thead>
<tr>
<th>Class</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Designated best use</td>
<td>Drinking Water source (with disinfection)</td>
<td>Outdoor bathing</td>
<td>Drinking Water source (with conventional treatment and disinfection)</td>
<td>Propagation of Wild life and Fisheries</td>
<td>Irrigation, Industrial Cooling, Controlled Waste disposal</td>
</tr>
<tr>
<td>Dissolved Oxygen (DO) mg/l, min</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>4</td>
<td>-</td>
</tr>
<tr>
<td>Biochemical Oxygen demand (BOD) mg/l max</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Total coliform organisms MPN/100ml, max</td>
<td>50</td>
<td>500</td>
<td>5000</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>pH value</td>
<td>6.5-8.5</td>
<td>6.5-8.5</td>
<td>6.0-9.0</td>
<td>6.5-8.5</td>
<td>6.0-8.5</td>
</tr>
<tr>
<td>Colour Hazen units, max</td>
<td>10</td>
<td>300</td>
<td>300</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Odour</td>
<td>Un-objectionable</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Taste</td>
<td>Tasteless</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Total dissolved solids, mg/l, max</td>
<td>500</td>
<td>-</td>
<td>1500</td>
<td>-</td>
<td>2100</td>
</tr>
<tr>
<td>Total hardness (as CaCO3) mg/l, max</td>
<td>200</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Class</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>E</td>
</tr>
<tr>
<td>-------------------------------------------</td>
<td>-------</td>
<td>-------</td>
<td>-------</td>
<td>-------</td>
<td>-------</td>
</tr>
<tr>
<td>Calcium hardness (as CaCO3) mg/l, max</td>
<td>200</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Magnesium hardness (as CaCO3), mg/l, max</td>
<td>200</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Copper (as Cu), mg/l, max</td>
<td>1.5</td>
<td>-</td>
<td>1.5</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Iron (as Fe), mg/l, max</td>
<td>0.3</td>
<td>-</td>
<td>0.5</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Manganese (as Mn), mg/l, max</td>
<td>0.5</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Chlorides (as Cu), mg/l, max</td>
<td>250</td>
<td>-</td>
<td>600</td>
<td>-</td>
<td>600</td>
</tr>
<tr>
<td>Sulphates (as SO), mg/l, max</td>
<td>400</td>
<td>-</td>
<td>400</td>
<td>-</td>
<td>1000</td>
</tr>
<tr>
<td>Nitrites (as NO), mg/l, max</td>
<td>20</td>
<td>-</td>
<td>50</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Fluorides (as F), mg/l, max</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Phenolic compounds (as C2H5OH), mg/l, max</td>
<td>0.002</td>
<td>0.005</td>
<td>0.005</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Mercury (as Hg), mg/l, max</td>
<td>0.001</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Cadmium (as Cd), mg/l, max</td>
<td>0.01</td>
<td>-</td>
<td>0.01</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Selenium (as Se), mg/l, max</td>
<td>0.01</td>
<td>-</td>
<td>0.05</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Arsenic (as As), mg/l, max</td>
<td>0.05</td>
<td>0.2</td>
<td>0.2</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Cyanide (as CN), mg/l, max</td>
<td>0.05</td>
<td>0.05</td>
<td>0.05</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
### Water Quality Standards for Irrigation

The BIS standards for irrigation is indicated in Table 20.3. It is important to conform to the prescribed standards while using water from various sources such as ground water, municipal water, rain water or treated waste water.

**Table 20.3: Standards for irrigation**

<table>
<thead>
<tr>
<th>Parameter for Irrigation</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total dissolved solids (mg/litre)</td>
<td>2100</td>
</tr>
<tr>
<td>Chlorides as chlorine (mg/litre)</td>
<td>500</td>
</tr>
<tr>
<td>Boron (mg/litre)</td>
<td>2</td>
</tr>
<tr>
<td>Sulphates (as SO4)(mg/litre)</td>
<td>1000</td>
</tr>
<tr>
<td>Parameter for Irrigation</td>
<td>Standard</td>
</tr>
<tr>
<td>-------------------------</td>
<td>----------</td>
</tr>
<tr>
<td>Conductivity at 25o C (us/cm)</td>
<td>2.25</td>
</tr>
<tr>
<td>pH</td>
<td>6.0 – 8.0</td>
</tr>
</tbody>
</table>

*Source: Manual on norms and standards for environment clearance of large construction projects* – *MoEF, Government of India*

**Minimum Required Quantities of Minerals in Drinking water and Associated Health Risks of drinking Demineralised/Distilled Water**

Awareness of the importance of minerals and other beneficial constituents in drinking water has existed for thousands of years, being mentioned in the Vedas of ancient India. In the book Rig Veda, the properties of good drinking water were described as follows: —Sheetham (cold to touch), Sushihi (clean), Sivam (should have nutritive value, requisite minerals and trace elements), Istham (transparent), Vimalam lahu Shadgunam (its acid base balance should be within normal limits)— (Sadgir and Vamanrao 2003).

Demineralised water is defined as water almost or completely free of dissolved minerals as a result of distillation, deionization, membrane filtration (reverse osmosis or nanofiltration), electrodialysis or other technology. The total dissolved solids (TDS) in such water can vary but TDS could be as low as 1 mg/l. The electrical conductivity is generally less than 2 mS/m and may even be lower (<0.1 mS/m).

Artificially-produced demineralised waters have been used mainly for industrial, technical and laboratory purposes. These technologies became more extensively applied in drinking water treatment in the 1960’s as limited drinking water sources in some coastal and inland arid areas could not meet the increasing water demands resulting from increasing populations, higher living standards, development of industry, and mass tourism.

It was clear from the very beginning that distilled or demineralised water without further enrichment with some minerals might not be fully appropriate for consumption.

There were three evident reasons for this:
1. Demineralised water is highly aggressive and if untreated, its distribution through pipes and storage tanks would not be possible. The aggressive water attacks the water distribution piping and leaches metals and other materials from the pipes and associated plumbing materials.

2. Distilled water has poor taste characteristics and it has been reported that that it is less thirst quenching as well.

Associated health risks of drinking demineralised water are numerous. There is little or no intake of calcium and magnesium and other micro elements. The intestinal mucous membrane, mineral homeostasis and metabolism are adversely affected by drinking excessive quantities of demineralised water. There will be a risk of increased toxic metals dietary uptake due to the lower protective capacity of water already low in calcium and Magnesium, and higher risk of leaching of metals from materials in contact with the demineralised water.

**Choosing a Water Treatment system based on Common Contaminants**

In order to ensure safe drinking water, it needs to be treated before use. Treated water is that which has gone through the treatment process for removing contaminants like bacteria and other constituents as per Drinking Water Standards.

The table below lists out the various treatment systems that could be used for each type of contaminant.

<table>
<thead>
<tr>
<th>Contaminant</th>
<th>Treatment methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical Parameter</td>
<td></td>
</tr>
<tr>
<td>Turbidity/Transparency</td>
<td>Slow sand filter</td>
</tr>
<tr>
<td></td>
<td>Candle filter</td>
</tr>
<tr>
<td></td>
<td>Cloth filtration</td>
</tr>
<tr>
<td></td>
<td>Coagulation</td>
</tr>
<tr>
<td></td>
<td>Sedimentation</td>
</tr>
<tr>
<td>Odour</td>
<td>Aeration/Oxidation</td>
</tr>
<tr>
<td></td>
<td>Activated carbon filter</td>
</tr>
<tr>
<td>Contaminant</td>
<td>Treatment methods</td>
</tr>
<tr>
<td>------------</td>
<td>-------------------</td>
</tr>
<tr>
<td>Colour</td>
<td>Charcoal</td>
</tr>
<tr>
<td></td>
<td>Activated carbon filter</td>
</tr>
<tr>
<td></td>
<td>Slow sand filter</td>
</tr>
<tr>
<td></td>
<td>Resins</td>
</tr>
<tr>
<td>Fluoride</td>
<td>Activated Alumina</td>
</tr>
<tr>
<td>Nitrate</td>
<td>Reverse Osmosis</td>
</tr>
<tr>
<td>Ammonia</td>
<td>Chlorine</td>
</tr>
<tr>
<td></td>
<td>Boiling</td>
</tr>
<tr>
<td>Iron</td>
<td>Oxidation and Settling</td>
</tr>
<tr>
<td>Hardness</td>
<td>Boiling and settling/Filtration</td>
</tr>
<tr>
<td></td>
<td>Reverse Osmosis</td>
</tr>
<tr>
<td></td>
<td>Resin</td>
</tr>
<tr>
<td></td>
<td>Ion Exchange water softeners</td>
</tr>
</tbody>
</table>
### Contaminant Treatment methods

<table>
<thead>
<tr>
<th>Contaminant</th>
<th>Treatment methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chloride/Free chlorine</td>
<td>Reverse Osmosis</td>
</tr>
<tr>
<td></td>
<td>Activated carbon filter</td>
</tr>
<tr>
<td>Bacterial Contamination</td>
<td>Slow sand filtration</td>
</tr>
<tr>
<td></td>
<td>Boiling</td>
</tr>
<tr>
<td></td>
<td>Chlorination</td>
</tr>
<tr>
<td></td>
<td>U V Radiation</td>
</tr>
<tr>
<td></td>
<td>Resins</td>
</tr>
<tr>
<td></td>
<td>Ozonation</td>
</tr>
</tbody>
</table>

*Source: 2009, TERI and TVPL, Environmental Building Guidelines for Hyderabad Metropolitan Area, HMDA.*

However, integration of a purification techniques and the type of technology to be used will depend on several factors:

1. Kind of contaminant
2. Extent of contamination
3. Simple & durable
4. Low maintenance
5. Dependency on power
6. Profile of the water users
7. Affordability

Often, in spite of precautions, contamination of water can occur during its storage or transportation to the point of consumption. Hence storage and maintenance of treated water is as essential as is the purification process.
Principles of Water Purification

All the water treatment technologies essentially follow three main principles of primary purification. Ideally all the three principles should be followed rigidly in the same order. One cannot omit or substitute any principle. All principles must be followed to get a good quality safe drinking water

1. Sedimentation
2. Filtration
3. Disinfection.

Primary Treatment

1. Sedimentation

Sedimentation is a process whereby suspended matters in water settle down and which can be separated by straining. It also means storage of water. Physical and chemical events take place during sedimentation.

a. Physical - Quality of water improves by merely storing it. About 90% of the suspended and colloidal impurities settle down within 24 hours by gravity. The water becomes cleaner and allows penetration of sunlight, initiating a further purification process. Settled suspended particles are seen at the bottom. For successful sedimentation, water should not be disturbed during storage.

b. Chemical - Interaction between constituents also aids in purification. Certain lighter suspended particles may not settle quickly, or may not settle down at all. In that case coagulation is necessary. Alum can be used at home to facilitate settling of suspended impurities, to get clear water. This is mainly practiced in rainy seasons when the water is much more turbid. Use of coagulants helps to reduce color, odor and improve taste of the water.

2. Filtration

Filtration is the second stage of purification and is the most important step in purification. The process of passing the water through beds of fine granular materials (called filters) such as sand is known as filtration. Filtration helps in removing color, odor, turbidity and pathogenic bacteria.

The settled particles in water can be effectively removed by this process. There are three action involved in filtration:

1. Mechanical Straining: The suspended particles present in water, which are of a bigger size than the size of the voids (empty spaces) in the sand
layers of the filter, cannot pass through these voids and get arrested in them. The resultant water is free from suspended particles.

2. **Sedimentation**: The voids between sand grains of filter act more or less like a tiny sedimentation/coagulation tank. The impurities are adhered to the sand surface and slowly a gelatinous film or coating is developed on sand grains. Colloidal matter and bacteria present in water stick to this film. The impurities thus settle down in the voids and get removed.

3. **Electrolytic changes**: The purifying action of the filter can also be explained by theory of ionisation.

According to this, a filter helps in purifying the water by changing the chemical characteristics of water. Sand grains of the filter media and the impurities in the water carry electrical charges of opposite nature. When they come in contact with each other, they neutralise each other, thereby changing the characteristics of water and making it purer.

### 3. Disinfection of Water

This treatment destroys harmful germs (bacteria, viruses, protozoa, etc.) by either killing them or making them inactive. Water can be disinfected by several means:

- Application of heat or other physical agents
- Surface active chemicals
- Resin (iodine based, e.g. Zero-B)
- Radiation by ultraviolet light and radioactive ions
- Alkalis and acids
- Metal ions like silver, copper, mercury.
- Oxidants with halogen, ozone other chemical compounds like potassium permanganate, bromine, iodine and chlorine. *(Ozone at 0.5 ppm takes about 5 minutes to kill bacteria. Chlorine at 1ppm takes about 2 hours and silver takes about 4 to 10 hours.)*

Municipalities commonly use chlorine, iodine and silver to kill bacteria. UV radiation and ozonation are also used for large water supplies in companies/townships. These techniques have been made available in individual household level also.
Secondary Treatment

There are several treatment methods that have been developed which are effective and can remove pollutants to desirable concentrations. Techniques have been devised according to the specific contaminants (Table). Generally the techniques adopted for water purification are based on aeration, precipitation, coagulation, filtration, demineralization, adsorption, ion exchange and membrane processes like reverse osmosis. The technologies like ion exchange and reverse osmosis are highly effective but expensive and are unable to reach the masses. Many other technologies have been developed which are less expensive like precipitation and coagulation. Though not as effective as the membrane utilising technologies, they are effective in removing specific contaminants like Fluoride, Arsenic etc at community and individual household level.

These Secondary level treatment technologies have been broadly classified on the principle of water purification:

1. Disinfection: UV radiation, Ozonation, Solar Disinfection
2. Filtration/Demineralization: Ion Exchange, Activated Carbon Filtration,
3. Membrane Processes (Micro filtration, Nano filtration, Ultra filtration, Reverse Osmosis, Electrodialysis)

**1. Disinfection**

**Ultra Violet radiation (UV):**

UV is nature's way of purification. It is a band of invisible light in the electromagnetic spectrum. This range 200 nm -285 nm is the germicidal range. Proteins and nucleic acid, which all micro-organisms contain as their main constituents, absorb UV radiation energy. After absorption, the UV energy destroys or inactivates the DNA, thus preventing the microorganisms from reproducing. UV is also known to bring down Total Organic Carbon (TOC) considerably in water.

**Precaution:**

The water entering the UV unit must necessarily be clear as suspended solids provide a shielding effect to microorganisms. Hence Pre-treatment is necessary.
Ozonation:
Ozone is the strongest oxidising agent for water treatment. By virtue of its properties, ozone is also the strongest disinfectant.

Solar Disinfection:
A simple method of improving the quality of water with the help of sunlight. It employs use of solar UVA radiation and temperature to inactivate pathogens. The disinfection process is effective through a 2way process- exposure to UV-A radiation and increased water temperature. If the water temperature rises above 50°C, the disinfection process may take one hour.

2. Filtration/ Demineralization

Ion Exchange
Ion exchange is a process that includes two very similar applications of the same technology for removal of excess amounts of Hardness, Iron, Nitrates

Water softening
This is the process of removing ions from the water and replacing/exchanging them with sodium ions and chloride ions. Ion Exchange water softeners employ the use of NaCl (sodium chloride) for a cation exchange process. Na or K replaces Ca, Mg, Fe, Mn etc in the water. The most common use for this is at household level.

Deionization:
Here, the hardness and other ions that are initially in the water are removed and replaced with H+ and OH- ions, which can combine to form water. Hence, it reduces deposits and scale formation because of high level of hardness. This is used in applications where extremely pure water is required.

Activated Carbon Filtration
Activated carbon is extremely porous with a very large surface area. It employs a process called adsorption, in which molecules of the contaminants attach themselves to the surface of the carbon either by physical or chemical attraction.

The two main reasons that chemicals adsorb onto activated carbon are- a "dislike" for water, and attraction for the activated carbon.
3. Membrane Processes

Reverse Osmosis (RO), Nano Filtration (NF), Ultra Filtration (UF) and Micro Filtration (MF) are the commonly used pressure driven membrane processes in the order of increasing pore opening.

Membrane material

Cellulose acetate, Aromatic polyamide, nylon derivatives, Polyvinyl alcohol derivative etc. These membranes have a preferential attraction for water and rejection for charged ionic substances.

The filtration is dependent on the pore size, pore size distribution and pressure.

Micro Filtration

A very low-pressure (less than 1 Kg/sq. cm) process which separates particles above 0.05 microns and below 1 micron from the solvent. MF membranes are primarily used to remove particulate matter and bacteria from water.

Ultra Filtration

This is a low pressure (less than 10 Kg/sq. cm) separation process which allows low molecular solutes (>1000 MW) are retained. Ultra filtration membranes (1nm to 10nm) are used to remove particulate, colloidal matter, bacteria, pyrogen and viruses from water.

Nano Filtration

This is a process in between ultra filtration and reverse osmosis. The NF allows monovalent salts like NaCl, CaCl2 to pass through and retains divalent anionic salts like Na2SO4, MgSO4 along with solutes having molecular weights greater than 300. NF membranes are often called a loose RO and are used as softening membranes or to remove dyes and organic compounds from water and liquid effluents.

Reverse Osmosis

Reverse Osomosis is a high pressure (15 Kg/sq. cm); energy efficient separation process. Low organic salts are concentrated while water is allowed to pass. The pore size of 5-20AD of the membrane retains over 95-99% of the dissolved salts. In this process, water is forced through a semi-permeable membrane under pressure, because of which the dissolved salts are held back in discharge.

All dissolved salts, sugars, bacteria, viruses, pyrogens, proteins, dyes and other particles with a weight greater than 150-250 daltons can be removed by RO to the
highest extent. It is also used to remove inorganic salts, TDS from brackish water, seawater and waste water. While ordinary filters can only remove suspended particles and sediments from water, RO can also remove high percentages of dissolved contaminants - molecule by molecule - from water.

**Electrodialysis:**
Electrodialysis units are normally used to desalinate brackish water. It involves the separation of dissolved cations and anions by the use of ion exchange membranes.

**Electromembrane (electrodialysis)**
Because of its low sensitivity towards impurities in water and simplicity of models, electrodialysis seems more attractive for small applications like homes, tourist cottages, hotels and yachts.

*For a large development, water should preferably be treated at a centralised level and then supplied to individual buildings. Precautions are recommended for storage and conveyance of the treated water to prevent any contaminants.*

*Alternatively, water for potable application should be centrally treated to at least primary level and then supplied to individual buildings for further treatment and end-use application.*

**Water quality standards for irrigation**
The BIS standards for irrigation are indicated in Table XX. It is important to conform to the prescribed standards while using water from various sources such as ground water, municipal water, rain water or treated water.

**Table 20.5: Water quality standards for irrigation**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Irrigation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total dissolved solids (mg/litre)</td>
<td>2100</td>
</tr>
<tr>
<td>Chlorides as chlorine (mg/litre)</td>
<td>500</td>
</tr>
<tr>
<td>Boron (mg/litre)</td>
<td>2</td>
</tr>
<tr>
<td>Sulphates (as SO) (mg/litre)</td>
<td>1000</td>
</tr>
<tr>
<td>Conductivity at 25° C (us/cm)</td>
<td>2.25</td>
</tr>
<tr>
<td>pH</td>
<td>6.0-8.0</td>
</tr>
</tbody>
</table>
As far as application of recycled water for irrigation is concerned, it is important to be careful about few things such as use of such water for plants used for human consumption. Impact of long-term and short-term use of different constituents on plants have been studied in different parts of the world to some extent and presented in table 20.6.

**Table 20.6: Recommended Limits for Constituents in Reclaimed water for Irrigation**

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Long-Term Use (mg/l)</th>
<th>Short-Term Use (mg/l)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminum</td>
<td>5.0</td>
<td>20</td>
<td>Can cause nonproductiveness in acid soils, but soils at pH 15.5 to 8.0 will precipitate the ion and eliminate toxicity.</td>
</tr>
<tr>
<td>Arsenic</td>
<td>0.10</td>
<td>2.0</td>
<td>Toxicity to plants varies widely, ranging from 12 mg/L for Sudan grass to less than 0.05 mg/L for rice.</td>
</tr>
<tr>
<td>Beryllium</td>
<td>0.10</td>
<td>0.5</td>
<td>Toxicity to plants varies widely, ranging from 5 mg/L for kale to 0.5 mg/L for bush beans</td>
</tr>
<tr>
<td>Boron</td>
<td>0.75</td>
<td>2.0</td>
<td>Essential to plant growth, with optimum yields for many obtained at a few-tenths mg/L in nutrient solutions. Toxic to many sensitive plants (e.g. citrus) at 1 mg/L. Usually sufficient quantities in reclaimed water to correct soil deficiencies. Most grasses are relatively tolerant at 2.0 to 10 mg/L.</td>
</tr>
<tr>
<td>Cadmium</td>
<td>0.01</td>
<td>0.05</td>
<td>Toxic to beans, beets, and turnips element Conservative limits recommended due to lack of knowledge on toxicity to plants.</td>
</tr>
<tr>
<td>Chromium</td>
<td>0.1</td>
<td>1.0</td>
<td>Not generally recognized as an essential growth element. Conservative limits recommended due to lack of knowledge on toxicity to plants.</td>
</tr>
<tr>
<td>Cobalt</td>
<td>0.05</td>
<td>5.0</td>
<td>Toxic to tomato plants to 0.1 mg/L in nutrient solution. Tends to be inactivated by neutral and alkaline soils.</td>
</tr>
<tr>
<td>Copper</td>
<td>0.2</td>
<td>5.0</td>
<td>Toxic to a number of plants at 0.1 to 1.0 mg/L in nutrient solution.</td>
</tr>
<tr>
<td>Constituent</td>
<td>Long-Term Use (mg/l)</td>
<td>Short-Term Use (mg/l)</td>
<td>Remarks</td>
</tr>
<tr>
<td>------------------</td>
<td>----------------------</td>
<td>-----------------------</td>
<td>--------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Fluoride</td>
<td>1.0</td>
<td>15.0</td>
<td>Inactivated by neutral and alkaline soils.</td>
</tr>
<tr>
<td>Iron</td>
<td>5.0</td>
<td>20.0</td>
<td>Not toxic to plants in aerated soils but can contribute to soil acidification and loss of essential phosphorus and molybdenum</td>
</tr>
<tr>
<td>Lead</td>
<td>5.0</td>
<td>10.0</td>
<td>Can inhibit plant cell growth at very high concentrations</td>
</tr>
<tr>
<td>Lithium</td>
<td>2.5</td>
<td>2.5</td>
<td>Tolerated by most crops at concentrations up to 5 mg/L mobile in soil. Toxic to citrus at low doses – recommended limit is 0.075 mg/L</td>
</tr>
<tr>
<td>Manganese</td>
<td>0.2</td>
<td>10.0</td>
<td>Toxic to a number of crops at a few-tenths to a few mg/L in acidic soils.</td>
</tr>
<tr>
<td>Molybdenum</td>
<td>0.01</td>
<td>0.05</td>
<td>Nontoxic to plants at normal concentrations in soil and water. Can be toxic to livestock if forage is grown in soils with high levels of available molybdenum.</td>
</tr>
<tr>
<td>Nickel</td>
<td>0.2</td>
<td>2.0</td>
<td>Toxic to a number of plants at 0.5 to 1.0 mg/L reduced toxicity at neutral or alkaline pH.</td>
</tr>
<tr>
<td>Selenium</td>
<td>0.02</td>
<td>0.02</td>
<td>Toxic to plants at low concentrations and to livestock if forage is grown in soils with low levels of selenium.</td>
</tr>
<tr>
<td>Tin, Tungsten,</td>
<td>-</td>
<td>-</td>
<td>Effectively excluded by plants; specific tolerance levels unknown</td>
</tr>
<tr>
<td>Titanium</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vanadium</td>
<td>0.1</td>
<td>1.0</td>
<td>Toxic to many plants at relatively low concentrations.</td>
</tr>
<tr>
<td>Zinc</td>
<td>2.0</td>
<td>10.0</td>
<td>Toxic to many plants at widely varying concentrations; reduced toxicity at increased pH (6 or above) and in fine-textured or organic soils.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Recommended Limit</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>6.0</td>
<td>Most effects of pH on plant growth are indirect (e.g.,</td>
</tr>
<tr>
<td>Constituent</td>
<td>Long-Term Use (mg/l)</td>
<td>Short-Term Use (mg/l)</td>
</tr>
<tr>
<td>---------------------</td>
<td>----------------------</td>
<td>-----------------------</td>
</tr>
<tr>
<td>TDC</td>
<td>500 – 2,000 mg/l</td>
<td></td>
</tr>
<tr>
<td>Free Chlorine Residual</td>
<td>&lt;1 mg/l</td>
<td></td>
</tr>
</tbody>
</table>

Source: Adapted from Rowe and Abdel-Magid, 1995.
Water quality standards for air-conditioning

Water with hardness less than 50 ppm of CaCO₃ is recommended for air-conditioning applications. Untreated water if used in air-conditioning system can lead to scale formation, corrosion and organic growth. Hence, it is essential to analyse the supply source for various constituents including dissolved solids.

Hardness in water is represented by calcium and magnesium salts, which may also include aluminium, iron, manganese, zinc etc. Temporary hardness is attributed to carbonates and bicarbonate of calcium and / or magnesium expressed in parts per million (ppm) as CaCO₃. The permanent hardness is due to sulphates, chloride, nitrites of calcium and / or magnesium expressed in ppm as CaCO₃.

Temporary hardness is primarily responsible for scale formation, which results in poor heat transfer resulting in increased cost of energy for refrigeration and air conditioning.

Permanent hardness (non-carbonate) is not a critical factor in water conditioning due to its solubility. In many cases, water may contain as much as 1200 ppm of non-carbonate hardness and not deposit a calcium sulphate scale. A chemical analysis of water sample should provide number of total dissolved solids (TDS) in parts per million (ppm) as also composition of each of the salts in parts per million. Also, water with pH less than 5 is quite acidic and corrosive to ordinary metals and needs to be treated.

Water quality standards for Flushing

There are no Indian Standards for using recycled water for flushing applications. Standards and to some extent testing protocol exist in some countries of Europe and in US. Findings from a study done by the CMHC, Canada is presented in the following table 20.7.

Table 20.7: Recommended water reuse standards

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Units</th>
<th>Toilet flushing</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Median*</td>
</tr>
<tr>
<td>BOD</td>
<td>mg/L</td>
<td>≤10</td>
</tr>
<tr>
<td>TSS</td>
<td>mg/L</td>
<td>≤10</td>
</tr>
</tbody>
</table>
### Guidelines and benchmarks for Green Large Area Developments Final report

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Units</th>
<th>Toilet flushing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turbidity</td>
<td>NTU</td>
<td>≤ 2 (alternative to TSS)</td>
</tr>
<tr>
<td>Fecal Coliforms</td>
<td>CFU/100 ml</td>
<td>&lt; 1</td>
</tr>
<tr>
<td>E Coli</td>
<td>CFU/100 ml</td>
<td>&lt; 1</td>
</tr>
<tr>
<td>CI residual</td>
<td>mg/L</td>
<td>0.1 to 1.0 +</td>
</tr>
</tbody>
</table>

*Medium based on data collected following the US EPA ETV testing protocol, or a minimum of five samples collected over a 30-day period.

Source: 2005, Research report on Water reuse standards and testing protocol, Healthy Housing and Community Series, CMHC, Canada

Whatever may be the reuse application, it is strongly recommended that cross-connection concerns be addressed by using an air gap between potable water supply for makeup water and reuse water storage. Also, guidelines prescribed in NBC, 2005 and Uniform Plumbing Code, 2008 should be followed.
Guideline 21: To ensure adequate water monitoring and leak detection plan at the community level in large developments, occasional water audits or preferably regular monitoring through SCADA system is recommended.

Water audit for the entire complex during operational phase- Undertake a water audit at least once a year and the report must contain the following:

- Amount of municipal water available and total water utilized from both municipal water supply and other sources
- Water losses and efficiency of the system along with reasons for such losses
- Measures to check water losses and improve efficiency

In lieu of the increasing municipal water supply-demand gap in all parts of the country and when unaccounted for water stands at 30-50%, it becomes extremely important to have a strict monitoring plan. Regular water audits or real time based monitoring through SCADA system has the potential to save this loss of water. To enable this, this guideline for large development is proposed.

Guidance Notes

What is a Water Audit?

Water audit determines the amount of water lost from a distribution system due to leakage and other reasons such as theft, unauthorised or illegal withdrawals from the systems and the cost of such losses to the utility. Comprehensive water audits give a detailed profile of the distribution system and water users, thereby facilitating easier and effective management of the resources with improved reliability.

Scope and Essential Tasks of Water Audit

The development can undertake two types of water audit. Based upon the consumption of water, with a minimum limit of 10ML/year (>25,000 L/day), the large development may undertake either a standard water audit or a detailed water audit. The various aspects covered and the essential tasks that need to be undertaken in each of these audit types are outlined below.
<table>
<thead>
<tr>
<th>S. No</th>
<th>Standard Audit (≥10 to &lt;50ML/year)</th>
<th>Detailed Audit (≥50ML/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Site Inspection - At least 3 site visits: 1st visit involves site introduction, scoping and determination of any requirement for sub metering; 2nd visit requires a detailed site inspection and inventory of water use processes, leak identification etc. User interview and management diagnostics can also be conducted. 3rd visit is to read meters, possibly remove data loggers and follow up tasks.</td>
<td>Site Inspection - As per standard audit but more comprehensive to meet requirements as discussed below. 1st visit will need to produce a detailed sub-metering plan with meters installed prior to the 2nd visit.</td>
</tr>
<tr>
<td>2</td>
<td>Meter Reading &amp; Monitoring - Read meters at the start and end of the monitoring period and data over 4 continuous weeks. Obtain 24-months billing consumption history and tariff details.</td>
<td>Meter Reading &amp; Monitoring - Read meters as outlined in standard audit. It is highly preferred to install permanent data logging equipment on the main supply meters to provide hourly average data on at least a daily basis.</td>
</tr>
<tr>
<td>3</td>
<td>Sub Meters - Use existing sub meters plus install sub-meters on supply to any single facility, end use or equipment accounting for 30-50% of total water use.</td>
<td>Sub Meters - Use existing sub meters plus install sub-meters on supply to any single facility, end use or equipment accounting for 15-25% of total water use.</td>
</tr>
<tr>
<td>4</td>
<td>Site Water Balance - Develop model or “flow chart” of estimated water consumption on the site utilizing the equipment/device inventory and design flows for the equipment (e.g., from supplier, equipment manuals) and sub-meter data. Reconcile this with total water use.</td>
<td>Site Water Balance - As per standard audit with model or flow chart of estimated water consumption on the site utilizing the equipment/device inventory and design flows for the equipment (e.g., from supplier, equipment manuals) and sub-meter data.</td>
</tr>
<tr>
<td>5</td>
<td>Site Usage Breakdown &amp; Water Balance - Breakdown of site water use across the site by end use category. Use loggers to quantify and identify the cause of any after-hours base flow or unusual use as usual flow patterns and assist closure in water balance.</td>
<td>Site Usage Breakdown &amp; Water Balance - As per standard audit with model or flow chart of estimated water consumption on the site utilizing the equipment/device inventory and design flows for the equipment (e.g., from supplier, equipment manuals) and sub-meter data.</td>
</tr>
<tr>
<td>6</td>
<td>Maintenance &amp; Repair - Identify any obvious water wastage for which immediate corrective actions are possible, which should be addressed during the monitoring period. Where wastage is repaired, this should be highlighted on the graphical outputs.</td>
<td>Maintenance &amp; Repair - As per standard audit.</td>
</tr>
<tr>
<td>7</td>
<td>Water Sources Breakdown - Identify and note the nature and capacity of the various water sources viz., piped supply, bore wells, tank, storm water, wastewater treatment, grey water reuse etc.</td>
<td>Water Sources Breakdown - Table or graph showing type and estimated use of water from various sources as well as permit and quality details for extracted sources. Outline scope of opportunities for the use of alternative water sources.</td>
</tr>
<tr>
<td>8</td>
<td>End Use Investigation &amp; Inventory - Identify any major water use process or equipment likely to use a significant proportion of the total water use and prepare a water use inventory. Specifically address mandatory measures such as tap, shower, urinal, toilet, cooling towers etc.</td>
<td>End Use Investigation &amp; Inventory - As per standard audit except provide a detailed investigation of each water using device, equipment item and process across the site. Also required an inventory, current water consumption, description of water use, O&amp;M, cleaning procedures, control systems, start up and shut down procedures.</td>
</tr>
<tr>
<td>9</td>
<td>Trends &amp; Patterns - Use 24 month historical billing data to identify and longer term, monthly, quarterly consumption trends and comment. Any changes in water use patterns identified during the technical review should be examined and explained.</td>
<td>Trends &amp; Patterns - As per standard audit for major uses, processes and equipment. Identify usage trends and patterns utilizing monitoring, water consumption indicators and identification of appropriate water use targets. Quantification of out-of-hours flow and identification of measures to reduce out-of-hours flow should be performed.</td>
</tr>
<tr>
<td>10</td>
<td>Baseline Usage - Determine site water usage and primary consumption values for at least 3-4 years and calculate site baseline. Also use audit data to monitor any single end use accounting for significant portion of total water use.</td>
<td>Baseline Usage - Use last 12 months water consumption as the baseline to establish benchmarks to assess water consumption and savings. Use audit data to monitor each end use accounting for significant proportion of total water use.</td>
</tr>
<tr>
<td>11</td>
<td>Benchmarking - Compilation of site/premises monthly data with other similar benchmarks (where available) for baseline water consumption, with consideration of site specific factors viz., climate, rainfall etc.</td>
<td>Benchmarking - As per standard audit but also benchmark each end use accounting for significant proportion of water use.</td>
</tr>
<tr>
<td>12</td>
<td>Water Saving Opportunities - Identify measures to improve efficiency and conservation. Estimate water saving, estimate of other related savings, measured costs and savings, payback periods and estimate time to implement the identified measures.</td>
<td>Water Saving Opportunities - As per standard audit with full assessment of all measures viz., wastewater treatment &amp; reuse, etc. Options to be costed, IRR to be calculated in addition to payback. Also identify ways to improve O&amp;M procedures as well as provide advice on alternative water sources, water reuse and efficient recycling.</td>
</tr>
<tr>
<td>13</td>
<td>Tariffs &amp; Charges - Identify fixed and variable costs for water and wastewater and evaluate ratio of fixed to variable and the total variable cost per KL.</td>
<td>Tariffs &amp; Charges - As per standard audit plus check billing meter sizing, any rates or factors used as a basis for charging viz., wastewater discharge fee, storm water fee etc. and advice necessary action.</td>
</tr>
</tbody>
</table>
Steps in a Water Audit

Step 1: The Water Use Inventory

It is important that facility manager/owner/user develop an understanding of exactly how and where their large development uses water. To do this, an inventory of all water use points in the site premises with flow rates must be developed. The complex may or may not have many typologies of buildings. Conduct sample audits of typical building types in the premises.

The inventory should also include the mechanical system installed (if water based), its location, its capacity, and the rate at which it uses water for cooling. In some cases, the owner’s manual will identify the water flow rate. However, it may be necessary to use a stopwatch and a bucket to determine the actual water flow rate.

Step 2: Metering

Readings from water meters provide an indication of how a building compares to other buildings, but it will not show where to look for areas where water use can be reduced, particularly if the building is large or complex. Narrowing use down to possible areas where use can be reduced requires sub-metering.

Where and how sub-meters are installed depends to a great extent on the design of the water system serving the large development. Ideally, meters and sub-meters would be installed on each building and respective floors of the building. Equipment with large water use rates, such as cooling towers and process cooling equipment, would each have separate sub-meters. Separate metering is also required for community landscaping and wherever public use water facility is provided.

Each meter should be read at least monthly. All meter readings should be logged and reviewed on a regular basis for unexplained changes.

Tracking water meter readings provides a baseline of water use for the entire large development. The key to gaining useful information from sub-meters is to have the meters read on a regular basis, and as frequently as possible. Frequent readings help to quickly identify and locate leaks.

Step 3: The Water Efficiency Plan

Once information has been gathered on how water is being used within the large development, the report will give the water balance, places of leaks, leaking pipes, based on which an action plan can be established for reducing water use within the complex. The plan may set specific water use reduction goals for the
entire development depending on the residents/occupants’ desire and aspirations. Those goals must be measurable, achievable and realistic. The plan must also identify a mechanism for periodically reviewing the success of the program in meeting those goals. The water efficiency plan should set the priorities for implementation based on costs, benefits and available manpower.

**Water audit for irrigation system**

This should comprise of:

- Measuring the flow rate of sprinklers
- Checking for leaks in the sprinkler, hose, drip or any other irrigation systems
- Checking the position of sprinklers

Water scheduling plan in different seasons and recommendations based on:

- Best time of day for watering
- Frequency of watering
- Length of time for watering

**SCADA for water and waste water management of large developments**

SCADA stands for Supervisory Control and Data Acquisition systems. SCADA is electronic and capable of automation from the basic level to a very high level of sophistication. As the name indicates, it is not a full control system, but rather focuses on the supervisory level. As such, it is a purely software package that is positioned on top of hardware to which it is interfaced, in general via Programmable Logic Controllers (PLCs), or other commercial hardware modules. SCADA are used for many applications including water supply, waste water treatment and management systems.

Many Indian city corporations have started using the system for managing water supply systems. In large development, not much is known about their use. Recently, a residential complex (with 20 buildings) in Pune is using the system.

**Advantages of SCADA to the user**

There are a number of advantages of SCADA for users. A few are:

![Image](http://www.ecy.wa.gov/programs/wr/measuring/images/pdf/scada_systems.pdf)
Water users do not have to manually read and record meter readings at regular intervals because data on water use is collected automatically;

Data can be downloaded at the users convenience;

Can be rigged for telemetry access by radio, satellite, cell phone, or telephone landline

and allow the user to remotely control the entire supply system and access data instantly.

Water accounting should also be promoted focusing on

- Total source withdrawals(including ground water, tankers, etc.),
- adjustments for source meter error,
- accounting for all metered water to residences, commercial buildings, industries(if any),
- Process water at treatment plant,
- Sewer cleaning,
- Swimming pools, water bodies,
- construction sites,
- Firefighting,
- Street cleaning, etc.

Water accounting can be facilitated through SCADA.
Guidelines on sustainable wastewater management

Guideline 22: All large developments should have provision of the Dual Plumbing/Dual Water Distribution System to recycle and reuse the treated waste water.

Growing urbanization accelerates the situation of increasing water demands for domestic, industrial, commercial, and agricultural purposes. As water demands and environmental needs grow, water recycling will play a greater role in our overall water supply. By working together to overcome obstacles, water recycling, along with water conservation can help us to conserve and sustainably manage our vital water resources.

Water recycling is reusing treated wastewater for beneficial purposes such as agricultural and landscape irrigation, industrial processes, toilet flushing, and replenishing a ground water basin (referred to as ground water recharge).

The term water recycling is generally used synonymously with water reclamation and Recycled water can satisfy most water demands, as long as it is adequately treated to ensure water quality appropriate for the use. As for any water source that is not properly treated, health problems could arise from drinking or being exposed to recycled water if it contains disease-causing organisms or other contaminants.

Water recycling is a sustainable approach and can be cost-effective in the long term, the treatment of wastewater for reuse and the installation of distribution systems can be initially expensive compared to such water supply alternatives as imported water or ground water. The additional cost of providing a dual system added only 9-10% to the cost of plumbing.

Benefits

Water recycling and reuse is required due the following reasons:

- To facilitate a more forward-looking focus on water-starved areas of the country
- Help to stretch or increase water supplies, satisfy the demands of growing populations, protect environmental needs, and strengthen local economies.
- Minimize water crises all over the country.
- To reduce the load of water pollution.
- To reduce health hazards spread by water borne diseases.
- Provide a balanced, practical approach to water management.

Water recycling and reuse is beneficial as it eliminate dependence of developmental area on local water supply authority’s upto a large extent. And also contribute towards more green and sustainable developmental activity as there is no discharge of waste effluents from the developmental area premises. The use of the treated effluent results in substantial savings in irrigation water costs and reduces the likelihood of water pollution, assuming that the effluents would otherwise have been disposed of treated/untreated through STP’s.

Reuse technology eliminates the need to use potable water supplied by the Municipal local authorities for irrigation and makes it available for other uses.

**Guidance notes:**

**What is Dual water distribution system**

As the name implies, dual distribution systems involve the use of water supplies from two different sources in two separate distribution networks. The two systems work independently of each other within the same service area. Dual distribution systems are usually used to supply potable water through one distribution network and non-potable water through the other. The systems would be used to augment public water supplies by providing treated waste water for purposes other than drinking. Such purposes could include firefighting, sanitary flushing, street cleaning, or irrigation of ornamental gardens or lawns.

**Technical Description of the system**

The systems are designed as two separate pipe networks: a potable water distribution system, and a system capable of distributing treated water from waste water treatment facility for non-potable water application. The system includes distribution pipes, valves, hydrants, standpipes, and a pumping system, if required. Pipes in the systems are generally cast iron or ductile iron, although other materials have also been used.
Pumps may be required to lift wastewaters from treated wastewater sumps or other collection points. The pumping systems consist of a pumping station containing the water intake, a pumping well, and an elevated storage tank for emergency use. The pumps require foot valves, or one-way valves, in order to retain their charge of water. The water is pumped through a manifold into the secondary or alternative distribution system.

**Operation and Maintenance**

Depending on the use (i.e., intermittent use in the case of fire-fighting supplies or regular in the case of irrigation supplies) in the dual distribution system, regular testing of the system is recommended.

**Where Treated water can be used (Refer Figure: 22.1)**

Recycled treated waste water from treatment facility can be used for various non-potable purposes including:

- Irrigation of parks/garden/open area surrounding buildings and facilities
- Commercial uses such as vehicle washing facilities, laundry facilities, external space washing, and mixing water for pesticides, herbicides, and liquid fertilizers.
- Dust control and concrete production for construction projects.
- Toilet and urinal flushing in buildings.

![Suggested Water Recycling Treatment and Reuse](image)

**Figure 22.1: Suggested Water Recycling Treatment and Reuse**

Source: Based on Report on Water Recycling and Reuse: The Environmental Benefits, USEPA
How treated water is supplied to Users

The treated water/reclaimed water from treatment facility is delivered to customers/users through a parallel network of distribution mains separate from the community’s potable water distribution system. The reclaimed water distribution system becomes a third water utility, in addition to wastewater and potable water. Reclaimed water systems are operated, maintained, and managed in a manner similar to the potable water system.

Design Considerations for Water Reuse

Water reuse systems have 2 major components:

1. Water recycling facilities
2. Recycled water distribution system, including storage and pumping facilities

Water Recycling Facilities:

Water recycling facilities must provide the required treatment to meet appropriate water quality standards for the intended use. In addition to secondary treatment, filtration, and disinfection are generally required for reuse in an urban setting. Because urban reuse usually involves irrigation of properties or other types of reuse where human exposure to the reclaimed water is likely, reclaimed water must be of a higher quality than may be necessary for other reuse applications.

Distribution Systems:

Recycled water operational storage and high-service pumping facilities are usually located onsite. When located near the pumping facilities, ground or elevated tanks may be used; when located within the system, operational storage is generally elevated.

Sufficient storage to accommodate diurnal flow variation is essential to the operation of a recycled water system. In order to maintain suitable water quality, covered storage is preferred to preclude biological growth and maintain chlorine residual.

Treatment Requirements

One of the most critical objectives in any reuse program is to ensure that public health protection is not compromised through the use of recycled water. Protection of public health is achieved by:
1. Reducing or eliminating concentrations of pathogenic bacteria, parasites, and enteric viruses in the recycled water,

2. Controlling chemical constituents in recycled water, and/or

3. Limiting public exposure (contact, inhalation, ingestion) to recycled water.

Determining the necessary treatment for the intended reuse application requires an understanding of the:

1. Constituents of concern in wastewater

2. Levels of treatment and processes applicable for reducing these constituents to levels that achieve the desired recycled water quality.

Levels of wastewater treatment are generally classified as preliminary, primary, secondary, and advanced. Advanced wastewater treatment, sometimes referred to as tertiary treatment, and is generally defined as anything beyond secondary treatment. A generalized flow sheet for domestic waste water treatment is shown in Figure 2:

The chlorine dosage required to disinfect wastewater to any desired level is greatly influenced by the constituents present in the wastewater. Some of the interfering substances are:

- Organic constituents, which consume the disinfectant
- Particulate matter, which protects micro-organisms from the action of the disinfectant
- Ammonia, which reacts with chlorine to form chloramines, a much less effective disinfectant species than free chlorine
Figure 22.2: Generalized flow sheet of waste water treatment
In India, a number of technologies for wastewater treatment have been applied for different scale applications. A comparative analysis is presented in Table XX based on various factors such as effluent quality, performance reliability, land requirement, capital cost, energy requirement, etc. Selection of the treatment system depends on many factors such as the quality of water required which in turn depends on the application type, cost constraints, operation and maintenance expertise and costs, energy requirement, etc. Besides, many applications at decentralized scale for DEWATS (Decentralized wastewater treatment system) for different scales exist in the country. However, it has not been covered in the above analysis.

Table 22.1: Assessment of Technology options for sewage/wastewater treatment

<table>
<thead>
<tr>
<th>Criteria</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
<th>16</th>
<th>17</th>
<th>18</th>
<th>19</th>
</tr>
</thead>
<tbody>
<tr>
<td>Performance in Terms of Quality of Treated Sewage</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potential of Meeting the RAP's TSS, BOD, and COD Discharge Standards</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potential of Total/Faecal Coliform Removal</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potential of DO in Effluent</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potential for Low Initial/Immediate Oxygen Demand</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potential for Nutrient Removal</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Performance Reliability</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Impact of Effluent Discharge</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potential of No Adverse Impact on Land</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potential of No Adverse Impact on Surface Waters</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potential of No Adverse Impact on Ground Waters</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potential for Economically Viable Resource Generation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manure/Soil Conditioner</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fuel</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Economically Viable Electricity Generation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Food</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Impact of STP</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potential of No Adverse Impacts on Health of STP Staff/Locals</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potential of No Adverse Impacts on surrounding Building/Properties</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potential of Low Energy Requirement</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potential of Low Land Requirement</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potential of Low Capital Cost</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potential of Low Recurring Cost</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potential of Low Rainvestment Cost</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potential of Low Level of Skill in O&amp;M</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. WSP (Unlined)                                         2. WSP (Lined)  3. ASP BIOFOR  4. ASP  5. UASB + FAL + 6. UASB + ASP
7. TF (Plastic, high rate)                               8. TF (Gravel, slow ra9. FAB  10. MBBR  11. SBR/CTECH 12. SAFF
13.TF (Gravel, high rate)                                14. ASP + C-F + RSF/DMF
19. SBR + C-F + RSF/DMF

WSP: Waste Stabilisation Ponds FAL: Facultative Aerated Lagoons
TF: Trickling Filter SAFF: Submerged Aerated Fixed Film
SBR: Sequential Batch Reactor MBBR: Moring Biological Bed Reactor
FAB: Fluidized Aerated Bed MBR: Membrane Bioreactor
UASB: Upflow Anaerobic Sludge Blanket C-F+RSF/DMF: Coagulation - Flocculation, Rapid Sand Filtration/dual media filtration
ASP: Activate Sludge Process

Centre for Science and Environment, 2008, Do-it-yourself: Recycle and Reuse wastewater-decentralized sewage treatment options.

Some of the water quality issues for non-potable applications such as irrigation, flushing, cooling tower, is discussed in the guideline on water quality. Further to this the following table summarises the water quality parameters of concern in case of water reuse application.

Table 22.2: Summary of Water Quality Parameters of Concern for Water Reuse

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Significance for Water Reuse</th>
<th>Range in Secondary Effluents</th>
<th>Treatments Goal in Reclaimed Water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suspended Solids</td>
<td>Measures of particles. Can be related to microbial contamination. Can interfere with disinfection.</td>
<td>5 mg/L – 50 mg/L</td>
<td>&lt;5 mg SS/L – 30 mg SS/L</td>
</tr>
<tr>
<td>Turbidity</td>
<td>Clogging of irrigation systems. Deposition.</td>
<td>1 NTU – 30 NTU</td>
<td>&lt;0.1 NTU – 30 NTU</td>
</tr>
<tr>
<td>BOD5</td>
<td>Organic substrate for microbial growth. Can favor bacterial regrowth in distribution systems and microbial fouling.</td>
<td>10 mg/L – 30 mg/L</td>
<td>&lt;10 mg BOD/L – 45 mg BOD/L</td>
</tr>
<tr>
<td>COD</td>
<td></td>
<td>50 mg/L – 150 mg/L</td>
<td>&lt;20 mg COD/L – 90 mg COD/L</td>
</tr>
<tr>
<td>TOC</td>
<td></td>
<td>5 mg/L – 20 mg/L</td>
<td>&lt;1 mg C/L – 10 mg C/L</td>
</tr>
<tr>
<td>Total coliforms</td>
<td>Measure of risk of infection due to potential of presence of pathogens. Can favor biofouling in cooling systems.</td>
<td>&lt;10 cfu/100mL-10^7 cfu/100mL</td>
<td>&lt;1 cfu/100mL – 200 cfu/100mL</td>
</tr>
<tr>
<td>Fecal coliforms</td>
<td></td>
<td>&lt;1-10^6 cfu/100mL</td>
<td>&lt;1 cfu/100mL – 10^3 cfu/100mL</td>
</tr>
<tr>
<td>Helminth eggs</td>
<td></td>
<td>&lt;1/L-10/L</td>
<td>&lt;0.1/L – 5/L</td>
</tr>
<tr>
<td>Viruses</td>
<td></td>
<td>&lt;1/L-100/L</td>
<td>&lt;1/50L</td>
</tr>
<tr>
<td>Heavy metals</td>
<td>Specific elements (Cd, Ni, Hg, Zn, etc) are toxic to plants and maximum concentration limits exist for irrigation</td>
<td>---</td>
<td>&lt;0.001 mg Hg/L</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>&lt;0.01 mg Cd/L</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>&lt;0.1 mg Ni/L – 0.02 mg Ni/L</td>
</tr>
<tr>
<td>Parameter</td>
<td>Significance for Water Reuse</td>
<td>Range in Secondary Effluents</td>
<td>Treatments Goal in Reclaimed Water</td>
</tr>
<tr>
<td>------------------</td>
<td>---------------------------------------------------------------------------------------------</td>
<td>------------------------------</td>
<td>-----------------------------------</td>
</tr>
<tr>
<td>Inorganics</td>
<td>High salinity and boron (&gt;1mg/L) are harmful for irrigation</td>
<td></td>
<td>&gt;450 mg TDS/L</td>
</tr>
<tr>
<td>Chlorine residual</td>
<td>To prevent bacterial regrowth. Excessive amount of free chlorine (&gt;0.05) can damage some sensitive crops</td>
<td>0.5 mg Cl/L - &gt; 1 mg Cl/L</td>
<td></td>
</tr>
<tr>
<td>Nitrogen</td>
<td>Fertilizer for irrigation. Can contribute to algal growth, corrosion (N-NH4) and scale formation (P).</td>
<td>10 mg N/L – 30 mg N/L</td>
<td>&lt;1 mg N – 30mgN/L</td>
</tr>
<tr>
<td>Phosphorus</td>
<td></td>
<td>0.1 mg P/L – 30 mg P/L</td>
<td>&lt;1 mg P/L – 20 mg P/L</td>
</tr>
</tbody>
</table>
Guideline 23: Ensure Operation and Maintenance (O & M) of Decentralised Wastewater Systems and Safe disposal of generated sludge in all large development

1. All decentralized waste water treatment systems installed in large developments should have at least one trained personnel on-site to perform the basic operations of the installed treatment system.

2. An annual maintenance contract (AMC) should be signed, preferably with the same agency which installed the treatment system to undertake the following:
   - Ensure quality of treated wastewater meets CPCB discharge standards for reuse and disposal though regular checks
   - Maintain the system to ensure smooth operation
   - Display monthly treated wastewater quality reports in the establishment office and on all common notice boards

3. Decentralized wastewater treatments systems must dispose of the residuals or sludge in a sustainable manner. Possible ways of disposing the sludge could be:
   - On site sludge processing by using Effective Micro organisms that eat the sludge or drying and converting it into organic manure
   - Entering into a contract with a sludge disposal company that will process the sludge

Benefits

It is mandatory to install a decentralised wastewater treatment systems for a certain capacity and above generation of domestic wastewater in a number of places like Delhi, Hyderabad. Often such systems are installed but hardly perform after one or two years of installation due to lack of proper operation and maintenance. Hence, for efficient functioning of the installed system, a continuous O & M contract is essential. Effective O & M would lead to:

- Consistency in the performance of the treatment system
- Achieve 100% treatment efficiency
- Economizing the running cost of the system
- Enhance the shelf life of the installed treatment system
- Increase the reuse and recycling potential of the treated discharge
- Improve and maintain the desired quality of environment.

**Guidance Notes**

**O & M compliance requirement:**
For an effective O & M, following requirement needs to be taken care of:

1. **Description of proposed wastewater system**
   - Flow diagram indicating all unit operations and components
   - Main line, re-circulated effluent, sludge flows and design average/peak values
   - Expected influent/effluent concentrations and design efficiencies

2. **Personnel Responsibilities**
   - Outline of responsibilities of STP service employee
   - Routine monthly work schedules
   - Training on operational procedures to service employee

3. **Operation of Facility**
   - Specific operational information and control techniques available for each unit operation
   - Common operating problems from past experience and remedies
   - Provision for sludge management viz., thickening, dewatering and reuse options

4. **Maintenance**
   - Measures for routine maintenance to be performed daily, monthly and annual basis
   - Provision for storeroom/tool room with a list of all major tools required for, emergency equipment inventory, spare parts inventory, schedules and references of suppliers, etc
5. Sampling and Laboratory Testing
   - Explanation of representative sampling of flows and the difference between grab and composite samples
   - Exact location of each sampling point
   - Description of how samples are to be collected in general
   - List of tests to be performed and their nature and purpose, with appropriate references to approved methods for conducting tests

6. Records and Reporting
   - Requirements for operator’s worksheets and daily operating logs, including: operational parameters for each unit operation; power consumption, etc.
   - Annual & monthly report requirements including: operating data with monthly averages of daily flows, quality parameters viz., BOD, SS levels etc.
   - Requirements for availability of records including O & M Manual, equipment suppliers’ manuals, construction photographs
   - Details of operating cost breakdown and a record system for monitoring plant costs

7. Treatment Works Safety
   - Description of safety hazards involved with the operation of each unit operation in the process
   - Description and requirements for an ongoing preventive safety program including education in safety procedures and training in first aid/emergency procedures
   - Listing of safety rules and process equipment and laboratory

8. Utilities
   - List of utilities servicing treatment works with contact personnel within utility company
   - Reliability of electrical service and effect on continuous operability of process
   - Breakpoints in utility/treatment plant responsibilities
Guideline 24: Water reuse and recycling (including rainwater harvesting) for Large Development

1. It is proposed that large developments should aspire for at least 10% of the entire annual water demand (other than the community level landscape water requirement) is met through adequately stored and maintained rainwater for potable/non potable applications and/or ensure at least entire potable water demand during scarcity days is met by rooftop harvested rainwater.

2. Ensure most of the community level irrigation water demand is met through recycled water.

3. It is proposed that large developments should aspire for at least minimum 50% of the entire annual water demand of the community is met through recycled and/or harvested rain water. For further reference and guidance, see GRIHA manual, Part IV.
**Guideline 25: Sustainable storm water management**

1. Large development should adhere to natural site contours and reduce hard paving

2. Large development should provide for an efficient storm water management system

3. If large development have basements, there should be adequate provisions for storm water management in basements

There shall be no disturbance, grading of the land or stripping of vegetation on slopes of 25% or steeper. If at all it is essential to disturb such areas for utility construction or roads, it should be shown via analysis of alternatives that such improvements are necessary and affect the sloped area to minimum extent possible (For further details refer the guideline on Sustainable Landuse Planning).

Roads and driveways should follow the natural topography to the greatest extent possible in order to minimise the cutting and grading of critical slope areas.

Reduction of hard paving on site to reduce stormwater runoff attenuation and infiltration and reduce Heat Island Effect as per GRIHA guidelines (Criterion 5)

Ensure that the storm water management system is based on the principles of Sustainable Urban Drainage Systems (SUDS); Ensure that the post-development peak run-off rate and quantity from 5-year 24-hour design storm does not exceed the pre-development peak run off rate and quantity; At least 50 % of the quantity should be treated by any of the SUDS techniques. The proposed system should be capable of also treating a minimum of 90% of storm water and achieve the following standards for quality control:

- 80% removal of Total Suspended solids
- Minimum 95% removal of litter
- Minimum 90% removal of hydrocarbons

Provide for adequate measures for storm water management in basements.

**Benefits**

The location of the site and its contours in the context of the local catchment area needs to be understood prior to commissioning of any construction project. The
design of the structure needs to be in tandem with the natural site level differences so that there are no major obstructions in the drainage patterns, post-development. This integrated approach to the existing site characteristics shall reap benefits in the following ways-

- With development mimicking the natural site undulations, the storm water runoff shall not have any obstructions, running directly into the natural water body/catchment area. This shall drastically reduce water logging and flash floods during monsoons in the low-lying areas also.

- This is especially helpful in reclaiming/maintaining all the man made/natural water bodies such as lakes, which unfortunately are deteriorating or already disappeared in most of the places in the country.

Most of the cities and towns in India have serious floods during monsoons due to reasons like lack of infrastructure specific for storm water discharge, clogging of drains and water bodies due to pollutant loading specially during and after storm events, blockage of natural drains from improper waste management, lack of systems to recharge ground water with runoff or to harvest rainwater, and unplanned urban development with relation to the drainage patterns.

Protection of rivers and ground waters from these effects requires changes to the approach to drainage and consideration of treatment facilities prior to discharge. A range of techniques as a part of Sustainable Drainage Systems are available to achieve this. They are a flexible series of options, which allow a designer to select those that best suit the circumstances of a particular site. It represents an integrated system of techniques aimed at storm water management and is the anti-thesis of the conventional drainage techniques followed for flushing storm water out of the site. This approach was practised in India in ancient times; however, as industrialisation and consequently urbanisation demanded more space for construction, this wisdom got neglected. SUDS can be understood simply as a formalised revival of these practices that aim at localised at-the-source management of storm water. Moreover, Structural storm water management solutions are capital intensive and require more stringent maintenance. Non-structural storm water management solutions (sustainable urban drainage systems) are more sustainable than conventional drainage methods because they:

- Contain and manage runoff flow rates at the site-level itself, reducing the impact of urbanisation on flooding

- Protect or enhance water quality by reducing pollutant concentration in storm water
- Are sympathetic to the environmental setting and the needs of the local community
- Provide a habitat for wildlife in urban watercourses for bio-diversity enhancement
- Encourage natural groundwater recharge (wherever appropriate)

Guidance notes

Guidance notes on reduction of Hard paving

Urban areas are characterized by their high–activity based buildings which require various subsidiary on-site requirements such as parking, walkways and similar other circulation arrangements. There is a pertinent need to categorize and demarcate these areas from other open areas which resulted in the paving of the same.

Increased Imperviousness:

Hard paving has led to increased imperviousness on site, which has resulted in increased storm water run-off during rains causing flooding and its associated unhygienic environs. They also have drastically reduced the infiltration potential of the ground, thus adversely affecting the natural recharging process of the ground water table. This presents a two-pronged effect where flooding is a water surplus issue and reduced percolation is a water shortage issue.

Impervious surfaces also collect massive organic and inorganic pollutants in various forms which get washed away along with storm water runoff. This runoff gets stagnated in habitated areas acting as propagation media for numerous pathogens spreading water-borne/related diseases apart from heavy metals. Pollutant-laden runoff has been responsible for most of the groundwater contamination and almost all surface water bodies are polluted. Lack of filtration channels—albeit natural or manmade, has resulted in this situation.

Higher ambient temperatures:

City temperatures are higher due to lack of trees, shrubs and other plants to shade the buildings, pavements etc. by intercepting solar radiation and cool the air through evaporation. Buildings and pavements made of dark materials absorbs solar radiation excessively causing the temperature of the surface and air in contact rise sharply.
Higher energy consumption:
Higher ambient temperatures in urban heat island lead to greater demand for air-conditioning resulting in higher power consumptions. Also for this increased demand of power, more fossil fuels are burnt in power plants; they increase both the pollution level and energy costs. Further more on an average demand for electrical power rises by 3% for every 1 degree Celsius change in the ambient temperature.

Poor air quality:
UHI also reduces the air quality by increasing percentage of smog in air. Smog is created by photochemical reactions of pollutants in the air. These reactions are more likely to occur and intensify at higher temperatures.

Reduction of hard paving onsite and increased vegetation has the following advantages-

- Increasing infiltration of storm water into the ground water table
- Attenuating storm water run off and consequently reduce water logging.
- Reducing the Urban Heat Island Effect or UHIE which causes higher ambient temperatures in an urban area due to improper balancing of radiation energy entering and exiting the earth’s atmosphere. This will result in lesser energy consumption for cooling.
- Lower ambient temperatures will facilitate in reduction of smog level as the rate of reactions will be slower at lower temperatures.
- Lower ground level ozone levels: Lower ambient air temperatures can decrease the amount of ground level ozone. Ozone is a photochemical oxidant and the major component of smog. While ozone in the upper atmosphere is beneficial to life by shielding the earth from harmful ultraviolet radiation from the sun, high concentrations of ozone at ground level are a major health and environmental concern. Ozone is formed through complex chemical reactions between precursor emissions of volatile organic compounds (VOC) and NOx in the presence of sunlight.

Where paving is required, the use of permeable, pervious or porous paving materials will have the following direct and indirect advantages-
Guidelines and benchmarks for Green Large Area Developments Final report

- Increased infiltration of storm water runoff into the ground water table or aquifer. Depending on design, paving material, soil type, and rainfall, permeable paving can infiltrate as much as 70% to 80% of annual rainfall.

- Grass pavers can improve site appearance by providing vegetation

- Provides onsite storm water run-off attenuation allowing infiltration thus reducing the risk of water-logging and flooding in low-lying areas

- Act as a primary water quality treatment medium that captures the suspended solids from trickling through, thus preventing the ground water contamination.

- It reduces the need for storm water conveyances and treatment structures, resulting in cost savings elsewhere.

- Reduces the amount of land needed for onsite storm water management as it may satisfy requirements for green space, allowing more paving on a site.

Guidance notes on SUDS

- Structural stormwater management solutions include engineered structures such as pipes, concrete channels, etc.

- Non structural stormwater management solutions include sustainable urban drainage systems (SUDS) such as ponds, vegetated swales, wetlands, etc. Water infiltrated through such systems is considered to be 100% treated, achieving all the requisite quality control standards.

SUDS are primarily aimed at optimal storm water management by-

- Dealing with runoff close to where the rain falls

- Managing potential pollution at its source for present and future site conditions

- Protecting water resources from point pollution (such as accidental spills) and diffused sources.

SUDS can be designed to fit into all developments, from hard surfaced areas to soft landscaped features, as there are many design options available. They can be designed to improve amenity and biodiversity in developed areas. For instance, ponds can be designed as a local feature in large sites for recreational purposes.
and to provide valuable local wildlife habitat nodes and corridors. This variety of options allows designers to consider local land use and the needs of local people when undertaking the drainage design, as well as considering the traditional engineering components of the design, such as peak flow and capacity in the system. The SUDS management train is a useful concept in the development of a drainage system and illustrates the methodology of operation of SUDS as given in Figure 25.1. Just as in a natural catchment, a combination of drainage techniques can be used in series to change the flow and the quality of the runoff in stages.

Figure 25.1: SUDS Management train-adapted from www.ciria.org

This concept is fundamental to designing a successful SUDS scheme – it uses drainage techniques in series to incrementally reduce pollution, flow rates and volumes. The hierarchy of techniques that should be considered in developing the management train are as follows:

**Prevention**– The use of good site design and site housekeeping measures to prevent runoff and pollution (eg: sweeping to remove surface dust and detritus from car parks) and rainwater reuse/ harvesting. Prevention policies should generally be included within the site management plan

**Source control**- Control of runoff at or very near its source (eg. Soakaways, other infiltration methods, green roofs, pervious pavements)

**Site control**- Management of water in a local area or site (eg. Routing water from building roofs and car parks to a large soakaway, infiltration or detention basin)
Regional control- Management of runoff from a site or several sites, typically in a balancing pond or wetland

‘Best Management Practices’ or BMPs, which form a part of this management strategy are the application tools of SUDS and categorised under the following heads based on their utilitarian efficiency:

- Source Control & prevention techniques
  - Permeable pavement surfaces
  - Green Roofs
  - Rain water collection

- Infiltration devices
  - Infiltration trenches and basins

- Permeable conveyance systems
  - Filter strips and drains
  - Swales

- Passive treatment systems
  - Constructed wetland e.g. reedbeds
  - Detention and retention ponds

Figure 25.2: Pervious Pavements
Permeable pavement is an alternative to conventional paving in which water permeates through the paved structure rather than draining off it. Both the surface and the sub-grade need to be designed with this function in mind. Where the conditions are suitable the water may be allowed to infiltrate directly into the subsoil. Alternatively, it can be held in a reservoir structure under the paving for subsequent reuse, infiltration or delayed discharge, as shown in adjacent figure (Figure adapted from www.ciria.org). The permeable paving can be materials such as gravel, grasscrete, concrete blocks designed for the purpose or porous asphalt.

Overflows can be constructed on all these systems where a surface must be kept free of water in all conditions or where the base needs to be sealed to protect the aquifer.

**Green Roofs**

The system offers significant benefits in terms of reduction in the amount of water running off the roof, the rate of runoff and quality improvements. Many conventional flat roof systems used in industrial buildings could be converted to green roofs without exceeding design loadings and with the additional benefit of improving insulation and extending roof life. Green roofs built with the most appropriate base and vegetation has the potential to absorb 15 – 90% of roof runoff. Figure 25.3 shows a green roof section with its typical components.

![Green Roof Section](image)

**Figure 25.3: Green roof (Source: Karen Liu, PhD, from Proceedings of the Green Rooftops for Sustainable Communities Conference, Chicago, 2003, p.279)**
**Infiltration Trenches**

An infiltration trench is a shallow, excavated trench that has been backfilled with stone to create an underground reservoir. Stormwater runoff flowing into the trench gradually infiltrates into subsoil. An overflow may be required for extreme rainfalls that exceed the capacity of the reservoir. The working mechanism of an Infiltration trench is illustrated in the adjacent Figure 25.4. The performance of the trench depends largely on the permeability of the soil and the depth to the water table. In common with other source control techniques, infiltration trenches usually serve small catchment areas, perhaps up to 2-3 hectares. The closer they are to the source of the run-off the more effective they will be. The operational life of the trench may be enhanced by providing pre-treatment for the inflow, such as a filter strip, gully or sump pit, to remove excessive solids. Regular maintenance will be required for most pre-treatment designs. Pollutant removal mechanisms include adsorption, filtering and microbial decomposition in the fill media and the soil below the trench and trapping of particulate matter within pre-treatment areas. Properly constructed and maintained, infiltration trenches can significantly reduce levels of solids, coliforms, trace metals and organic matter. Levels of phosphate and nitrate can also be reduced.

![Infiltration Trench](image)

**Figure 25.4: Infiltration trench**

**Infiltration Basins**

Infiltration basins are shallow, surface impoundments where storm water runoff is stored until it gradually infiltrates through the soil of the basin floor as given in the adjacent schematic layout. An overflow may be required for extreme rainfall events which exceed the capacity of the reservoir. The performance of the basin depends largely on the permeability of the soil and the depth to the water table. Infiltration basins can serve larger catchment areas than infiltration trenches because a larger volume of water can be stored on the surface. They can typically serve catchments of up to 10 hectares. All other features are similar to the Infiltration Trenches.
Permeable Conveyance Systems

These move runoff water slowly towards a receiving watercourse, allowing storage, filtering and some loss of runoff water through evaporation and infiltration before the discharge point. There are two main types: underground systems, such as filter drains (or French drains) and surface water swales.

Filter Drains

The underground systems are known as filter (or French) drains. They comprise a trench, filled with gravel wrapped in a geo-textile membrane into which runoff water is led, either directly from the drained surface or via a pipe system. The gravel in the filter drain provides some filtering of the runoff, trapping sediment, organic matter and oil residues that can be broken down by bacterial action through time. Runoff velocity is slowed, and storage of runoff is also provided. Infiltration of stored water through the membrane can also occur and some filter drains need not lead to a watercourse at all. Filter drain systems have been widely used by the highway authorities for roads drainage.

Swales

Swales are grassed depressions which lead surface water overland from the drained surface to a storage or discharge system, typical using the green space of roadside margins. When compared to a conventional ditch, a swale is shallow and relatively wide, providing temporary storage for storm water and reducing peak flows. They are appropriate close to source and can form a network within a development scheme, linking storage ponds and wetlands. A swale is dry during dry weather but during a rainfall event water flows over the edge and slowly moves through the grassed area. The flow of surface water is retarded.
and filtered by the grass. Sediment is deposited and oily residues and organic matter retained and broken down in the top layer of soil and vegetation. Swales can be lined below the soil zone where necessary, to protect the underlying aquifer. During a rainfall event a proportion of the runoff can be lost from the swale by infiltration, and by evaporation and transpiration. If necessary, overflows can be placed at high level to provide conveyance in times of exceptionally heavy rainfall. Swales should be designed to be dry between storm events to enhance their pollutant removal capability.

**Passive Treatment Systems**

Passive treatment systems use natural processes to remove and break down pollutants from surface water runoff. Small scale systems such as filter strips, can be designed into landscaped area, and are sited upstream of other SUDS. Larger, "end of pipe" systems usually involve storage of water in constructed ponds where natural purification processes can be encouraged. Constructed wetlands and ponds also provide the opportunity to improve wildlife habitat in urban areas. Additionally, ponds can be made into amenity features for the local community.

**Filter Strips**

Filter strips are vegetated sections of land designed to accept runoff as overland sheet flow. In order to be effective they should be 5 – 15 metres wide and they may adopt any natural vegetated form, from grassy meadow to small wood. The wider the strip and the more dense the vegetative cover the better the pollutant removal.

**Detention Basins**

Detention basins are designed to hold back storm runoff for a few hours to allow the settlement of solids. Bypasses may be included to ensure the "first flush" is detained. Detention basins drain via an orifice or similar hydraulic structure into a watercourse or surface water drainage system. Detention basins are dry outside of storm periods. They are designed to retain flood events, reducing peak flows and limiting the risk of flooding. Solids removal is the chief feature of detention basins, and high removal rates are possible. Nutrient and trace metals removal is more modest. Extended detention basins incorporate a small permanent pond or wetland which can enhance the appearance of the basin.

Pollutant removal can be maximised by allowing up to 24 hours detention and seeking to treat a modest volume of runoff. It may be better to treat the "first flush" of runoff from the catchment and by-pass the rest, rather than to scour out
settled silt by passing the full storm flow through the basin. Performance is further enhanced with retention ponds and wetland pond systems.

**Retention Ponds**

Retention Ponds retain a certain volume of water at all times. This can avoid possibly unsightly exposure of banks of collected sediment and enhance performance in removing nutrients, trace metals, coli forms and organic matter. Allowance for a considerable variation in water level during storms should be incorporated in the design, so that a significant storage volume can still be provided. The permanent water may be visually more attractive, although elevated nutrient concentrations may result in algal blooms. To be successful as an amenity, a retention pond should have a catchment of at least 5 hectares and/or a reliable source of base flow.

**Wetlands**

These are a further enhancement of retention ponds, and incorporate shallow areas planted with marsh or wetland vegetation. These provide a much greater degree of filtering and removal of nutrients by algae and, to a lesser extent, by incorporation into plant material.

Inlet and outlet sumps, as with detention basins and retention ponds, will enhance performance and might be considered almost obligatory, since excessive sediment can quickly overwhelm the shallow area. Only specially constructed wetlands should be used to treat surface water. It is not normally an acceptable practice to lead surface water into an existing, natural, wetland area.

**Table 25.1: Summary of SUDS Components**

<table>
<thead>
<tr>
<th>Pervious pavings</th>
<th>Surfaces that allow inflow of rainwater into the underlying construction or soil</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Green roofs</strong></td>
<td>Vegetated roofs that reduce the volume and rate of runoff and remove pollution.</td>
</tr>
<tr>
<td><strong>Filter drains</strong></td>
<td>Linear drains consisting of trenches filled with a permeable material, often with a perforated pipe in the base of the trench to assist drainage, to store and conduct water; they may also permit infiltration.</td>
</tr>
<tr>
<td><strong>Filter strips</strong></td>
<td>Vegetated areas of gently sloping ground designed to drain</td>
</tr>
<tr>
<td>Pervious pavings</td>
<td>Surfaces that allow inflow of rainwater into the underlying construction or soil</td>
</tr>
<tr>
<td>-----------------</td>
<td>--------------------------------------------------------------------------------</td>
</tr>
<tr>
<td></td>
<td>water evenly off impermeable areas and to filter out silt and other particulates.</td>
</tr>
</tbody>
</table>

| Swales          | Shallow vegetated channels that conduct and retain water and may also permit infiltration; the vegetation filters particulate matte |

| Detention Basins and Retention ponds | Areas that may be utilised for surface runoff storage as well as to provide water quality Treatment |

| Infiltration devices | Sub-surface structures to promote the infiltration of surface water to ground. They can be trenches, basins or soak-aways. |

| Pipes and accessories | A series of conduits and their accessories normally laid underground that convey surface water to a suitable location or treatment and/or disposal. (Although sustainable, these techniques should be considered where other SUDS techniques are not practicable). |

| Constructed wetlands | Constructed Wetlands are ponds with shallow areas and wetland vegetation to improve pollutant removal and enhance wild life habitat |

Source: Modified from the ‘Interim Code of practice for SUDS’ - National SUDS Working Group

**Maintenance**

All drainage systems require management and maintenance. Maintenance costs are reduced as SUDS schemes can be managed as part of normal landscape care and avoids the need for expensive specialist contractors.
Conventional site drainage which uses gullies, pipes, inspection chambers, and oil interceptors, requires regular specialist maintenance which is often neglected until pollution occurs.

Source Control elements require maintenance which can be accommodated by normal landscape management practice. The inherent design tolerances of BMP techniques prevent catastrophic failure as well as background pollution of the environment.

Guidance notes on Storm water management in Basements

Storm water management in Basements is a very vital part of the entire gamut of sustainable runoff control. Often this aspect of drainage control is viewed more from the perspective of giving an immediate solution to a risky disturbance, than trying to integrate the same into the entire site’s storm water drainage management regime. Since basements in India are generally used for vehicular parking, the storm water running through these spaces are highly polluted with vehicular spills such as oils, fuel, sand and silt, etc. Basement storm water management hence becomes an area of concern that requires additional focus on pollutant-load reduction also.

It is an accepted practice in most of the Indian cities that storm water entering into basements is generally drained into a collection tank and is pumped out of the same onto the adjoining roads or into the sewage/storm water drains, only adding to the flooding problems in the city. Nevertheless, in a few places in like Bangalore and Chennai, this practice has been integrated with Rain water harvesting to achieve greater benefits than envisaged. Apart from following the current practice of allowing the storm water to be drained into collection tanks that immediately solve the flooding issue in basements, the integration of the collection tank into an Infiltration device shall also allow the collected water to recharge the aquifer and remove the need to empty the tank by pumping it out. This shall not only efficiently take care of the storm water by recharging the aquifer, it shall bring down the load on the motor pump considerably by reducing the need for its use.

It is however equally important that the storm water that drains through the basements and into the collection tank is adequately filtered to avoid the contamination of ground water from vehicular spills in parking areas. Water runoff from vehicles should be dealt with in basement parking spaces by installing trench drains with cast iron covers at all vehicle entrance/exit points, sand and oil traps at all storm drain discharge points, and floor area drains at every low point. The tank itself should have filtration beds, similar to a RWH pit to ensure that clean water only recharges the aquifer.
Overflow management measures shall also be installed either in the form of overflow into another tank that holds water being reused for various purposes or a water-level sensor-fitted motor that shall pump the water into a drain.

A case study of a successful Basement RWH initiative taken up in Mysore, has been presented at http://www.indiatogether.org/2008/jun/env-borewell.htm
Guidelines on watershed management

Guideline 26a: Ensure that the rainwater falling on the site (excluding the rainwater being stored) and provided site conditions permit is recharged through adequate measures.

Guideline 26b: Ensure a Monitoring plan to maintain the level of ground water (pre and post monsoon).

Benefits

Soil, water and vegetation are the three most vital natural resources for the survival of human, therefore watershed is considered the ideal unit for managing these three vital resources.

The main objectives of watershed management is to restore the ecological balance by harnessing, conserving and developing degraded natural resources such as soil, vegetative cover and water. The outcomes are prevention of soil run-off, regeneration of natural vegetation, rain water harvesting and recharging of the ground water table.

Urban Watershed Management is the technological approach of managing the storm water runoff generated from rainfall in an urban environment. In undeveloped and undisturbed environment, rainfall is naturally filtered and absorbed by its environment. In an urban setting, with typical development of many impervious surfaces, storm water transports pollutants to receiving waters. Therefore, under watershed management programme attempts are made to catch every drop of rainwater to avoid runoff and transportation of pollutants.

It is particularly recommended in areas where groundwater is polluted and where run-off from rivers and watercourses is minimal. In general, the lack of precipitation during the dry season makes this the most attractive solution.

In isolated areas with high precipitation, it should be promoted for the purpose of obtaining higher quality water and avoiding high water transportation costs.
Guidance notes

Artificial Recharge and recommended Rainwater harvesting strategies

Groundwater recharge is simply collection of rainwater and diversion into underground after filtration. It is also called “artificial recharge” of groundwater when done through man made structures. It is necessary to maintain the groundwater levels and helps in improving quality of groundwater through dilution process apart from minimising urban flooding. Artificial recharge is the need of the hour because:

1. Much of the precipitation never reaches aquifers but evaporates, what reaches land is variable in time, aerial extent and intensity.

2. Earlier, natural recharge took place from unpaved surfaces during the monsoon in cities and was sufficient to recharge the aquifers so that it can be used to meet the water requirements of the year.

3. But, due to rapid urbanization, the recharge area has shrunk to almost negligible in all cities, water bodies lost & groundwater over exploited. Now efforts have to be done to ease this process of recharging – through manmade structures, artificially.

Types of Recharge structures

- Recharge well
- Recharge troughs
- Percolation Pits
- Conversion of dried up/ abandoned tube well into a recharge structure
- Use of open well for ground water recharge

1. **Recharge well**

   - A recharge well is one that is used for the purpose of increasing the groundwater supply by feeding surface water into an aquifer.

   - A recharge well may also be called as an inverted well because the movement of water in a recharge well is in the reverse direction to that of ordinary well (Meinzer, 1923).
The depth of the recharge bore is dependent on:

- Depth of water level: it should be minimum 5-8 m above the water level in the homogenous aquifers.
- Depth of porous strata: It should reach a good porous and permeable strata and should be ensured that it penetrates impermeable formation, if any.
- Rainfall intensity: If the intensity is low, even shallow bores could handle the runoff from the catchment slowly. If the intensity is high and a huge runoff comes to structure suddenly, it needs a deeper bore to create good head & deliver it at faster rate.
- Quality of runoff: If the quality of water to be recharged meets all drinking water quality standards, it can be kept closer to water table otherwise, a good distance should be maintained to ensure natural filtration of minor contaminants through sub-soil strata.

**Figure 26b 1:** Cross section view of recharge well

### 2. Percolation Pit

- It has a small pit filled with filtering material (pebbles only)
- A recharge bore of shallow depth, encountering first permeable strata
- No inlet and over flow pipe
- Located in low lying area
- Perforated RCC slab on top.
Applicable for

- Smaller catchment areas
- Non availability of space for larger structures such as recharge wells or recharge trenches.
- Specially suitable for surface runoff and unpaved areas.

Figure 26b 2: View of percolation pit
Source: Centre for Science and Environment

3. Recharge trench

Figure 26b 3: Cross section view of recharge trench

- It has a longer rectangular pit (normally across the length of main gate)
- Provided with one/two/more shallow recharge bores encountering first permeable permeable strata
- Pits may or may not be constructed around the bore.
- No inlet and over flow pipe pipes
- Metal grill cover or perforated RCC slab on top.
Figure 26b 4: View of recharge trench

Applicable where

- No drain, channel or rainwater pipe to collect runoff
- Where water is wasted without being trapped and creates water logging on the road.
- Specially suitable for surface runoff from paved areas.

4. Use of abandoned/dry wells

- A pit of desired size is constructed around the existing casing pipe of dry tube well.
- The pit can also be away from it if there is no space.
- Filled with filtering material
- Inlet and over flow pipe arrangements
- RCC slab or metal grill cover top.

Applicable where

- Dry or abandoned bores available
- Quality of water is ensured to be free of contaminants as abandoned tube wells may put water directly into aquifer and there may not be any chances of natural filtration.
- Specially suitable for rooftop rainwater

5. Use of dug well

- A filtering tank of desilting chamber is provided before it for filtering the runoff.
The well acts as a large diameter recharge bore because its bottom is always connected to some aquifer.

Inlet but no overflow arrangements required due to its high capacity.

Covered with a RCC slab or metal grill on top.

Its very low cost technology of recharging.

Applicable where:

- Dry or abandoned dug wells available
- A huge quantity of runoff is available
- Suitable for all types of runoff

Figure 26b 5: Use of common recharge well (Source: Centre for Science and Environment)
Quality control and Maintenance

For effective functioning of recharge structures, maintenance is a very important part. Q & M related measures for recharging are as follows:

- Clean catchment (rooftop, etc) and recharge structures before monsoon
- Cover roof outlet on terraces with mesh to prevent leaves & debris entering the system
- Replace or wash filter materials before the monsoon
- Annually replace jute coir and top sand layer in the recharge wells. Wash filtering materials (pebbles & boulders) with water
- Keep diversion valves open for the first 5 to 10 minutes (First flush) to drain away pollutants from first rains
- Avoid using pesticides & insecticides in lawns (catchment)

Selection of Rainwater Harvesting strategies

All over India, availability of adequate quantity and quality of potable water has increasingly become critical. Traditionally, Indian society has been a water conserving society but over the years somehow this practise has lost.

In India climatological and meteorological factors varies from state to state, so to find out the best rain water harvesting technique, the entire country is divided into six zones/regions i.e cold region, dry region, north-east region, coastal region, mid lower region/zone-3 and mid upper region/zone-4. The factors considered in Table-XX to classify the different zones/region are soil/terrain type, average annual rainfall, stage of ground water development, level of ground water table, flood-proneness and LPCD in class-I and class-II cities in a particular region. Every region/ state consists of different areas like forest/hilly, plain, coastal/desert and built-up areas; hence some common RWH techniques are recommended, which could be applicable to a particular area within a region/state. For e.g. Himachal Pradesh, a hilly area can have plain area, forest area and built-up area too; so as per the location of large developmental project in Himachal Pradesh correspondingly RWH technique is applied or if site terrain has mixed characteristics say sloping and plain ground than combination of RWH techniques will be applicable.

Further in Tables 26b1 - 26b1 various zones/regions are classified on the basis of pollutant responsible for ground water contamination. A single state can be
polluted with all pollutants or a particular pollutant. For all regions RWH method and RWH techniques are suggested which could be similar for most of the states for e.g. storage as well as recharge options are applicable for west coastal zone. Some soil conservation measures are also recommended especially for hilly regions.
### Table 26b 1: Region wise recommended rain water harvesting strategies

<table>
<thead>
<tr>
<th>Region</th>
<th>States covered</th>
<th>Soil/terrain type</th>
<th>Average annual rainfall (mm)</th>
<th>Stage of ground water development (%)</th>
<th>GW table (m)</th>
<th>Flood prone area</th>
<th>Class-I cities lpcd</th>
<th>Class-II cities lpcd</th>
<th>Recommended RW harvesting strategies</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2. Plain Areas: percolation ponds, furrow ditches, recreational ponds.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3. Coastal and Desert areas: infiltration galleries, subsurface check dams, percolation ponds.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4. Built up areas: artificial /recreational water body, rooftop harvesting / groundwater recharge.</td>
</tr>
<tr>
<td>Dry region</td>
<td>Rajasthan, Punjab, Har, Del, Saurashtra/Kutch</td>
<td>desert soil/alluvial soil/ grey &amp; brown soil</td>
<td>297-678</td>
<td>125-170</td>
<td>10.0-40.0</td>
<td>all</td>
<td>143-180</td>
<td>115-130</td>
<td></td>
</tr>
<tr>
<td>North East</td>
<td>all 8 states</td>
<td>alluvial/mixed red &amp; black/red loamy / mountain soil/ laterite soil</td>
<td>1920-2935</td>
<td>0.04-22</td>
<td>2.0-10.0</td>
<td>only Assam</td>
<td>139-301</td>
<td>130-172</td>
<td></td>
</tr>
<tr>
<td>Region</td>
<td>States covered</td>
<td>Soil/terrain type</td>
<td>Average annual rainfall (mm)</td>
<td>Stage of ground water development (%)</td>
<td>GW table (m)</td>
<td>Flood prone area</td>
<td>Class-I cities lpcd</td>
<td>Class-II cities lpcd</td>
<td>Recommended RW harvesting strategies</td>
</tr>
<tr>
<td>------------</td>
<td>-------------------------------------</td>
<td>-------------------------------------------------</td>
<td>-------------------------------</td>
<td>--------------------------------------</td>
<td>--------------</td>
<td>------------------</td>
<td>---------------------</td>
<td>----------------------</td>
<td>-----------------------------------</td>
</tr>
<tr>
<td>Coastal</td>
<td>Konkan &amp; Goa, coastal Karnata, Kerela</td>
<td>red loamy/ black soil</td>
<td>2978-3613</td>
<td>27-70</td>
<td>2.0-10.0</td>
<td>only Kerela</td>
<td>100-190</td>
<td>97-162</td>
<td></td>
</tr>
<tr>
<td>Zone 3</td>
<td>West MP, Maharashtra, Karnata, TN, AP</td>
<td>black soil/ red sandy soil/ alluvial/ mixed red &amp; black soil</td>
<td>677-1104</td>
<td>45-85</td>
<td>2.0-20.0</td>
<td>only AP</td>
<td>79-310</td>
<td>70-162</td>
<td></td>
</tr>
<tr>
<td>Zone 4</td>
<td>UP, Bihar, Jharkand, part of MP, Orissa, West Bengal</td>
<td>alluvial/ red &amp; yellow soil/ red sandy soil/ black soil/ red loamy soil/ laterite soil.</td>
<td>888-1472</td>
<td>18-70</td>
<td>2.0-10.0</td>
<td>UP, Bihar, West Bengal, Orissa</td>
<td>170-247</td>
<td>93-127</td>
<td></td>
</tr>
</tbody>
</table>

**Table 26b 2: Region wise recommended rain water harvesting techniques**

<table>
<thead>
<tr>
<th>S. No</th>
<th>Zone/Region</th>
<th>States covered</th>
<th>Pollutants responsible for Ground Water Contamination in state</th>
<th>RWH Method</th>
<th>RWH Technique</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>S. No</td>
<td>Zone/ Region</td>
<td>States covered</td>
<td>Pollutants responsible for Ground Water Contamination in state</td>
<td>RWH Method</td>
<td>RWH Technique</td>
<td>Remarks</td>
</tr>
<tr>
<td>-------</td>
<td>-----------------------</td>
<td>-------------------------------------------------------------------------------</td>
<td>---------------------------------------------------------------</td>
<td>------------</td>
<td>-----------------------------------</td>
<td>------------------------------------------------------------------------</td>
</tr>
<tr>
<td>1</td>
<td>North-east region</td>
<td>Arunachal Pradesh, Assam, Assam, Meghalaya, Tripura, Mizoram, Nagaland, Manipur, Sikkim</td>
<td>Arsenic contamination, Flouride contamination, Iron contamination, Nitrate contamination</td>
<td>Storage/ Recharge</td>
<td>Artificial ponds/ Rooftop Rainwater Harvesting/ Embankment type ponds/ dugout ponds/ dugout-cum-embankment type ponds.</td>
<td>Assam state is highly contaminated with almost all pollutants hence it is suggested to avoid recharge option in the state. Other than assam, remaining state can opt for recharge option (after close examination of topography and hydrogeology of the area) for safe disposal of excess quantity/volume of collected rainwater. Attention need to paid on natural water body survival, if it is nearby the developmental area.</td>
</tr>
<tr>
<td>2</td>
<td>Cold region</td>
<td>J&amp;K, Himachal Pradesh</td>
<td>-</td>
<td>Storage/ Recharge</td>
<td>Contour bundling/ trenching, Gully plugging, check</td>
<td>Kashmir and Himachal Pradesh are almost/ entirely hilly regions, hence measures to be taken to</td>
</tr>
</tbody>
</table>


### Guidelines and benchmarks for Green Large Area Developments Final report

<table>
<thead>
<tr>
<th>S. No</th>
<th>Zone/Region</th>
<th>States covered</th>
<th>Pollutants responsible for Ground Water Contamination in state</th>
<th>RWH Method</th>
<th>RWH Technique</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Dry region</td>
<td>Rajasthan, Punjab, Haryana, Delhi, Saurashtra/ Kutch</td>
<td>- All Rajasthan, Punjab, Haryana, Saurashtra/ Kutch</td>
<td>Storage/ Recharge</td>
<td>Artificial ponds/ Rooftop Rainwater Harvesting/</td>
<td>control runoff on slopes by considering appropriate techniques like trenching. The state of Rajasthan and part of Gujarat is characterized by drought prone as well as flood prone states, hence to overcome the problem of water shortage and mitigate the risk of short term flood by considering soil characteristics, storage option seems to be most preferable. In states like Delhi, Haryana, Punjab storage option is suitable where there municipal supply is very fluctuating throughout the year. Areas with regular and good municipal water supply can opt for recharge option or vice-versa.</td>
</tr>
<tr>
<td>S. No</td>
<td>Zone/ Region</td>
<td>States covered</td>
<td>Pollutants responsible for Ground Water Contamination in state</td>
<td>RWH Method</td>
<td>RWH Technique</td>
<td>Remarks</td>
</tr>
<tr>
<td>-------</td>
<td>---------------------------</td>
<td>---------------------------------</td>
<td>---------------------------------------------------------------</td>
<td>-------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>4</td>
<td>West Coastal region</td>
<td>Konkan, Goa, Coastal Karnataka, Kerela</td>
<td>-</td>
<td>All</td>
<td>All</td>
<td>Storage/ Recharge</td>
</tr>
<tr>
<td>5</td>
<td>Mid bottom region (Zone 3)</td>
<td>West MP, Maharashtra, Tamilnadu, Andra Pradesh</td>
<td>-</td>
<td>All</td>
<td>All</td>
<td>Storage/ Recharge</td>
</tr>
<tr>
<td>6</td>
<td>Mid upper region (Zone 4)</td>
<td>Uttar Pradesh, Bihar, Jharkhand, Part of MP, Orissa, West Bengal</td>
<td>Bihar, Chattisgarh, West Bengal, Uttar Pradesh</td>
<td>All</td>
<td>All</td>
<td>Storage/ Recharge</td>
</tr>
<tr>
<td>S. No</td>
<td>Zone/Region</td>
<td>States covered</td>
<td>Pollutants responsible for Ground Water Contamination in state</td>
<td>RWH Method</td>
<td>RWH Technique</td>
<td>Remarks</td>
</tr>
<tr>
<td>-------</td>
<td>-------------</td>
<td>----------------</td>
<td>---------------------------------------------------------------</td>
<td>------------</td>
<td>---------------</td>
<td>---------</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>West Bengal.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NOTE:

A. Ideal Conditions for Artificial Recharge to Ground Water:

1. Most suitable for the urban areas where adequate space for surface storage is not available.
2. Water level is deep enough (greater than 8m.) an adequate surface storage is not available.
3. Permeable strata is available at shallow / moderate depth.
4. Where adequate quantity of surface water is available for recharge to ground water.
5. Where there is possibility of intrusion of saline water especially in coastal areas.
6. Where the evaporation rate is very high from surface water bodies.
7. Where the ground water quality is bad.

B. RWH Techniques in Urban areas

- Recharge Pit
- Recharge Trench
- Tubewell
- Recharge Well
The prime objective of these guidelines is to close the waste cycle loop and to follow a more systematic, integrated approach to waste management. Solid Waste Management covers all activities pertaining to the control, transfer, transport, processing and disposal of solid waste in accordance with best principles and practices of public health, economics, engineering, conservation and aesthetics.

The best method to deal with waste is centered on a broadly accepted “Hierarchy of waste management” which gives a priority listing of the technical and sociological options of waste management. The hierarchy gives general guidelines on relative desirability of the different management options.

![Hierarchy of integrated solid waste management](image)

**Figure : Hierarchy of integrated solid waste management**

The highest and most preferred rank of this integrated management hierarchy is waste prevention or waste minimization at source, which aims at reducing the amount of the waste produced. It is the most effective way to reduce the quantity of disposable waste, the cost associated with its handling and its adverse environmental impacts.

Reuse, recycling and energy recovery technologies then come as moderately suitable technologies. Land-filling is the last option of the hierarchy that involves controlled interment of the residual waste which has no further use on or in the earth’s mantle.
Guideline 27: Organic /Biodegradable and Recyclables waste management

All large development should ensure that the collection, storage, treatment and disposal of organic/biodegradable, recyclables(such as paper, plastics, can, glass, etc.) and non degradable waste (inert material such as dust) generated within the premises is as per the Municipal Solid Waste (Management and Handling) Rules 2000.

1. Ensure that organic waste and recyclables must be collected and stored separately in multi coloured containers/bins at both decentralized and centralized level.

2. Arrangements for secondary collection of segregated biodegradable waste for treatment. Employ a suitable technology on site to treat the biodegradable waste at centralized level.

3. After treatment organic waste should be disposed off or utilized in a safe manner within the developmental area.

4. Arrangements for secondary collection and communal storage for recyclables should be made to be taken up on a frequent basis by registered recycling agency or informal waste recycling dealer. Enclosure for the communal storage has to be at least 2 m high.

5. Arrangements for secondary collection of inert material and communal storage to be later taken by the municipality/local government for disposal.

Per capita waste generation varies widely across the country. As per the MoEF’s, Report of the Committee to Evolve Road Map on Management of Wastes in India26, the highest per capita waste generation was in the city of Kochi (0.67 kg/capita/day) and the lowest was (0.17-0.19 kg/c/day) in Kohima, Imphal and Nashik. Typical waste characterization in the report states that municipal solid wastes typically contains 51 % of organic waste, 17% recyclables, 11% hazardous and 21% inert. However, about 40% of all MSW is not collected at all and hence lies littered in the city/town and finds its way to nearby drains and water bodies, causing choking of drains and pollution of surface water. Large developments have the advantage of a well defined boundary and can devise mechanisms to

26 MoEF, 2010, Report of the Committee to Evolve Road Map on Management of Wastes in India, Govt. of India.
completely treat the organic waste generated within the site premises; facilitate better recovery of recyclables by preferably engaging informal waste recycling sector; and sending the remaining segregated hazardous and inert waste to disposal sites/engineered landfills. This directly implies that only 32% of the total waste generated leaves the site and find its way to landfills.

Some strategies to achieve the above guideline are:

1. Ensure/Initiate door to door waste collection of biodegradable, recyclables and inert waste separately.

2. To achieve the above goal as mentioned under A, multi-coloured bins must be placed at both primary and secondary level within the development area.

3. Providing information to all occupants in developmental area on what type of waste goes into which bin.

4. Provide separate bins of adequate capacity for different types of waste in all common areas along with instructions on what type of waste goes where.

5. Provide separate community bins for recyclable waste such as Paper, Plastic, Glass and Cans. These should be covered and located in an easily accessible, secure location.

6. Capacity of all waste containers should be large enough to hold minimum two days or more garbage/waste (depending on the frequency of collection, transfer from the secondary collection points for treatment and/or disposal) at both primary and secondary level.

7. For the effective collection of both wet and dry waste separately, separate space must be provided within developmental facility/area at both primary and secondary level.

8. Location of waste container at secondary level should be decided in such a way that it should be accessible to all nearby blocks within the developmental area.

9. Distance between two waste containers at secondary level should be decided judiciously to cover all buildings in developmental premises.

10. Waste transfer or transport route to transfer waste from all secondary level containers to a common centralized location should be fixed.
Guidance Notes:

Functional Elements of Solid Waste Management

The activities associated with the management of solid wastes from the point of generation to final disposal can be grouped into six functional elements:

1. Waste generation;
2. Waste handling and sorting, storage, and processing at the source;
3. Collection;
4. Sorting, processing and transformation;
5. Transfer and transport; and
6. Disposal.

Waste Generation: Waste generation encompasses activities in which materials are identified as no longer being of value (in their present form) and are either thrown away or gathered together for disposal. Waste generation is, at present, an activity that is not very controllable. In the future, however, more control is likely to be exercised over the generation of wastes. Reduction of waste at source, although not controlled by solid waste managers, is now included in system evaluations as a method of limiting the quantity of waste generated.

Waste Handling, Sorting, Storage, and Processing at the Source: The second of the six functional elements in the solid waste management system is waste handling, sorting, storage, and processing at the source. Waste handling and sorting involves the activities associated with management of wastes until they are placed in storage containers for collection. Handling also encompasses the movement of loaded containers to the point of collection. Sorting of waste components is an important step in the handling and storage of solid waste at the source. For example, the best place to separate waste materials for reuse and recycling is at the source of generation. Households are becoming more aware of the importance of separating newspaper and cardboard, bottles/glass, kitchen wastes and ferrous and non-ferrous materials.

On-site storage is of primary importance because of public health concerns and aesthetic consideration. Unsightly makeshift containers and even open ground storage, both of which are undesirable, are often seen at many residential and commercial sites. The cost of providing storage for solid wastes at the source is normally borne by the household in the case of individuals, or by the
management of commercial and industrial properties. Processing at the source involves activities such as backyard waste composting.

**Collection:** The functional element of collection includes not only the gathering of solid wastes and recyclable materials, but also the transport of these materials, after collection, to the location where the collection vehicle is emptied. This location may be a material processing facility, a transfer station, or a landfill disposal site.

**Sorting, Processing and Transformation of Solid Waste:** The sorting, processing and transformation of solid waste materials is the fourth of the functional elements. The recovery of sorted materials, processing of solid waste and transformation of solid waste that occurs primarily in locations away from the source of waste generation are encompassed by this functional element. Sorting of commingled (mixed) wastes usually occurs at a materials recovery facility, transfer stations, combustion facilities, and disposal sites. Sorting often includes the separation of bulky items, separation of waste components by size using screens, manual separation of waste components, and separation of ferrous and non-ferrous metals.

Waste processing is undertaken to recover conversion products and energy. The organic fraction of Municipal Solid Waste (MSW) can be transformed by a variety of biological and thermal processes. The most commonly used biological transformation process is aerobic composting. The most commonly used thermal transformation process is incineration.

Waste transformation is undertaken to reduce the volume, weight, size or toxicity of waste without resource recovery. Transformation may be done by a variety of mechanical (e.g. shredding), thermal (e.g. incineration without energy recovery) or chemical (e.g. encapsulation) techniques.

**Transfer and Transport:** The functional element of transfer and transport involves two steps: (i) the transfer of wastes from the smaller collection vehicle to the larger transport equipment and (ii) the subsequent transport of the wastes, usually over long distances, to a processing or disposal site. The transfer usually takes place at a transfer station.

**Disposal:** The final functional element in the solid waste management system is disposal. Today the disposal of wastes by land-filling or uncontrolled dumping is the ultimate fate of all solid wastes, whether they are residential wastes collected and transported directly to a landfill site, residual materials from Materials Recovery Facilities (MRFs), residue from the combustion of solid waste, rejects of composting, or other substances from various solid waste-processing facilities. A
municipal solid waste landfill plant is an engineered facility used for disposing of solid wastes on land or within the earth’s mantle without creating nuisance or hazard to public health or safety, such as breeding of rodents and insects and contamination of groundwater.

**Technology for treatment of organic/biodegradable waste**

Technology selection is primarily guided by the kind and type of waste composition. The solid waste generated in and around developmental project comprise of almost 50 per cent of biodegradable waste. Such waste can be biologically or thermally treated. Various kind of technology options available for the processing of biodegradable waste and the parameters which should be considered for selection of the treatment option are given in the adjoining figure.

**Biological Processes**

Biological treatment involves using micro-organisms to decompose the biodegradable components of waste. Two types of processes are used, namely:

1. Aerobic processes: Windrow composting, aerated static pile composting and in-vessel composting; vermi-composting, composting with bioculture method etc.

2. Anaerobic processes: Low-solids anaerobic digestion (wet process), high-solids anaerobic digestion (dry process) and combined processes.

In the aerobic process the utilizable product is compost. In the anaerobic process the utilizable product is methane gas (for energy recovery). Both processes have been used for waste processing in different countries – a majority of the biological treatment process adopted world-wide are aerobic composting; the use of anaerobic treatment has been more limited. In India, aerobic composting plants have been used to process up to 500 tons per day of waste.

**Thermal Processes**

Thermal treatment involves conversion of waste into gaseous, liquid and solid conversion products with concurrent or subsequent release of heat energy. Three types of systems can be adopted, namely:
1. Combustion systems (Incinerators): Thermal processing with excess amounts of air.

2. Pyrolysis systems: Thermal processing in complete absence of oxygen (low temperature).

3. Gasification systems: Thermal processing with less amount of air (high temperature).

Combustion system is the most widely adopted thermal treatment process world-wide for MSW. Though pyrolysis is a widely used industrial process, the pyrolysis of municipal solid waste has not been very successful. Similarly, successful results with mass fired gasifiers have not been achieved.

Three types of combustion systems have been extensively used for energy recovery in different countries namely:

1. Mass-fired combustion systems (MASS),

2. Refuse Derived Fuel (RDF),

3. Fired combustion systems and Fluidized Bed (FB) combustion systems

To be viable for energy recovery through thermal processing, the organic waste must possess a relatively high calorific value. In the MSW generated in developed countries, presence of significant quantity of paper and plastics yields a high calorific value of the MSW (typically above 2000 kcal/kg) which makes it suitable for thermal processing. In Indian MSW, the near absence of paper and plastics as well as the presence of high quantities of inert material, all combine to yield a low calorific value of the MSW (typically less than 1000 kcal/kg). In its mixed form, such waste may not be suitable for thermal processing.

Parameters to be considered for selection of the treatment option for biodegradable waste

Some of the parameters which should be considered for selecting the treatment type are listed as under:

- Capital cost
- Operation & Maintenance cost
- Composition of the waste, it’s calorific value
- Land requirements
- Sensitivity of the treatment technology to external parameters like temperature, humidity, oxygen level, etc
- By-products
- Social acceptability
- Pay-back period
- Finances
- Viability of the scale of operation
Guideline 28: E-waste Management in large development

All large development should ensure a facility/system for effective and efficient management of electronic waste in developmental area as per the e-waste (Management and Handling) Rules, 2011 applicable from May 2012.

1. Provision for a collection centre within the premises in case producers (of electronics and electrical equipments and as defined by the Rules) have not provided for one in the area. Collection centres should follow the responsibilities as prescribed under the Rules.

2. Provision for taking away the collected e-waste within the prescribed time limits by registered dismantlers or recyclers (registered with the State Pollution Control Board or the Pollution Control Committee of the Union Territories as the case may be).

3. Collection centers should maintain records of the e-waste in the prescribed form of the e-waste (Management and Handling) Rules, 2011 and submit to the State Pollution Control Board or the Pollution Control Committee of the Union Territories as the case may be.

Benefits

Electrical and electronic waste (E-waste) is one of the fastest growing waste streams in the world. Developing countries face a greater challenge in terms of e-waste due to increasing “market penetration”, and “high obsolescence rate” and legal/illegal ways of e-waste being dumped by developed countries in developing countries. As per the MoEF’s, Report of the Committee to Evolve Road Map on Management of Wastes in India, the E-waste inventory based on the obsolescence rate in India for the year 2005 was estimated to be 1,46,000 tonnes, which is expected to exceed 8,00,000 tonnes by 2012. Management of such waste is a big challenge. E-waste contains high levels of heavy metals such as mercury, lead, Antimony, Chromium, cadmium, etc which could cause cancer, affect the Central nervous system and other respiratory problems. When dumped in open landfills, they also pollute the underground water and cause serious environmental damage.

---

MoEF, 2010, Report of the Committee to Evolve Road Map on Management of Wastes in India, Govt. of India.
Guidance Notes

Composition of E-Waste

Composition of e-waste is very diverse and differs in products across different categories. It contains more than 1000 different substances, which fall under “hazardous” and “non-hazardous” categories. Broadly, it consists of ferrous and non-ferrous metals, plastics, glass, wood & plywood, printed circuit boards, concrete and ceramics, rubber and other items. Iron and steel constitutes about 50% of the e-waste followed by plastics (21%), non ferrous metals (13%) and other constituents. Non-ferrous metals consist of metals like copper, aluminium and precious metals ex. silver, gold, platinum, palladium etc. The presence of elements like lead, mercury, arsenic, cadmium, selenium, and hexavalent chromium and flame retardants beyond threshold quantities in e-waste classifies them as hazardous waste. It includes all the items as listed in Schedule I of the e-waste (Management and Handling) Rules, 2011.

Components of E-Waste

E-waste has been categorized into three main categories, Viz. Large Household Appliances, IT and Telecom and Consumer Equipment. Refrigerator and Washing Machine represent large household appliances, Personal Computer, Monitor and Laptop represent IT and Telecom, while Television represents Consumer Equipment. Each of these E-waste items has been classified with respect to twenty six common components, which could be found in them. These components form the “Building Blocks” of each item and therefore they are readily “identifiable” and “removable”. These components are metal, motor/compressor, cooling, plastic, insulation, glass, LCD, rubber, wiring/electrical, concrete, transformer, magnetron, textile, circuit board, fluorescent lamp, incandescent lamp, heating element, thermostat, BFR-containing plastic, batteries, CFC/HCFC/HFC/HC, external electric cables, refractory ceramic fibers, radio active substances and electrolyte capacitors (over L/D 25 mm).

Large household appliance (refrigerator) may consist of electric motor, a circuit board, a transformer, capacitor, thermal insulation, switches, wiring, plastic casing that contain flame retardants etc. A typical washing machine may consist of the metal casing, concrete ballast, inner and outer drums, a motor, a pump, washing cycle controller unit, switches and other components. The latest trends in these appliances is the phase out of the use of ODS and improvement of energy efficiency. Old washing machines are likely to contain large capacitors, while in relatively new machines, variable speed motors are controlled from the circuit board. IT and Telecom equipments sector is observing a trend of “micro
miniaturization”, while CRTs (cathode ray tube) are being replaced by LCD screens.

**E-Waste Management strategies**

E-waste management requires participation of manufactures, consumers, regulators, municipal authorities, state governments, and policy makers. The critical elements of an e-waste management system in India is presented in Figure 28.1.

![Figure 28.1: Elements of E-waste management system for India](image)

*Source: Joseph Kurian, paper on “Electronic waste management in India-Issues and Strategies”, Centre for Environmental Studies, Anna University, Chennai*

**E-waste Recycling/Treatment technologies in India**

The assessment of e-waste recycling sector in India indicates that e-waste trade starts from formal dismantling sector and moves to informal recycling sector. E-waste movement from formal to informal sector is driven by trade and can be tracked by trade value chain. This e-waste trade value chain can be mapped based on material flow from formal sector to informal sector.
The three levels of e-waste generation hierarchy give rise to three types of stakeholders involved in e-waste trade as described below.

1. 1st Level – Preliminary e-waste Generators.
2. 2nd Level – Secondary e-waste Generators.
3. 3rd Level – Tertiary e-waste Generators.

The input to “Preliminary E-waste Generator” comes from formal organized market like manufacturers, importers, offices and organized markets, where e-waste from domestic consumers comes either in exchange schemes or as a discarded item. Therefore, the major stakeholders are scrap dealers/ dismantlers who purchase e-waste from the first level in bulk quantities. These stakeholders have limited capacity of dismantling and are involved in trading of e-waste with “Secondary e-waste Generators”. The market between first and second level is semi formal i.e. part formal, while the market between second and third level is completely informal. Stakeholders falling under “Secondary e-waste Generators” have limited financial capacity and are involved in item/ component wise dismantling process and segregation ex. Dismantling of CRT, PCB, plastic and glass from e-waste. “Tertiary Level Stakeholders” are the major stakeholders
between second and third level and are metal extractors, plastic extractors and electronic item extractors. They use extraction process, which are hazardous in nature. The characteristics of emissions from e-waste treatment in semi formal and informal sector in India are as follows:

1. Generation of mixed e-waste fractions along with hazardous waste after dismantling
2. Generation of effluents during metal extraction e.g. Acid bath process for copper extraction from printed circuit board
3. Air emissions due to burning of printed circuit board
4. Inefficient secondary raw material generation

The entire e-waste treatment is being carried out in an unregulated environment, where there is no control on emissions. Almost 90% of the estimated 4 lakh tones of e-waste get recycled in informal sector. There are 17 organized recyclers/dismantlers in India. Things may change when the e-waste (Management and Handling) Rules, 2011 are enforced and the producers and bulk consumers participate in the process. However, currently there is no business model to integrate the informal recycling sector within the current framework. Waste from the collection centers should therefore go to the registered dismantlers and recyclers.

Guideline 29: Hospital/Health Care Unit waste Management

Large development such as medical college campuses, hospital complexes and neighbourhoods where some level of health facilities exist should provide for handling, segregation, mutilation, disinfection, storage, transportation and final disposal of biomedical waste as per Bio-medical Waste (Management and Handling) Rules, 1998. And ensure that waste generated is handled without any adverse effect to human health and environment.

To achieve the above, it is recommended that:

1. All health care facilities have a healthcare waste management committee in all health care units to manage the generated waste in a systematic manner and as prescribed by the Rules.

2. To regularly impart training to hospital staff and healthcare staff (HCUs with less than 20 beds; pathological labs, clinics and day care units)

3. To have an adequate monitoring plan to ensure the above.

Guidance Notes

What is biomedical waste?

As per Bio-medical Waste (Management and Handling) Rules, 1998, ‘Bio-medical waste’ means any solid and/or liquid waste including its container and any intermediate product, which is generated during the diagnosis, treatment or immunization of human beings or animals or in research pertaining thereto or in the production or testing thereof.

Health hazards associated with biomedical waste

1. Injury from sharps to staff and waste handlers associated with the health care establishment.

2. Hospital Acquired Infection (HAI) (Nosocomial) of patients due to spread of infection.

3. Risk of infection outside the hospital for waste handlers/scavengers and eventually general public.

4. Occupational risk associated with hazardous chemicals, drugs etc.
5. Environmental Hazards: The following are the main environmental hazards with respect to improper disposal of bio-medical waste management:

- Spread of infection and disease through vectors (fly, mosquito, insects etc.) which affect the in-house as well as surrounding population.

- Spread of infection through contact/injury among medical/non-medical personnel and sweepers/rag pickers, especially from the sharps (needles, blades etc.).

- Spread of infection through unauthorised recycling of disposable items such as hypodermic needles, tubes, blades, bottles etc.

- Reaction due to use of discarded medicines.

- Toxic emissions from defective/inefficient incinerators.

- Indiscriminate disposal of incinerator ash / residues.

Biomedical Waste Storage

Storage of waste is necessary at two points:

1. At the point of generation and

2. Common storage for the total waste inside a health care organisation.

Systematic segregated storage is the most important step in the biomedical waste control programme of the health care establishment. For ease of identification and handling it is necessary to use colour coding, i.e., use of specific coloured container with liner / sealed container (for sharps) for particular wastes. It must be remembered that according to the Rules, untreated waste should not be stored beyond a period of 48 hours.

Segregated Storage in Separate Containers (at the Point of Generation)

Each category of waste (according to treatment options mentioned in Schedule I of the “Biomedical waste (management and handling) rule 1998” has to be kept segregated in a proper container or bag as the case may be. Such container / bag should have the following property:

- It must be sturdy enough to contain the designed maximum volume and weight of the waste without any damage.

- It should be without any puncture/leakage.
- The container should have a cover, preferably operated by foot. If plastic bags are to be used, they have to be securely fitted within a container in such a manner that they stay in place during opening and closing of the lid and can also be removed without difficulty.

- The sharps must be stored in puncture proof sharps containers. But before putting them in the containers, they must be mutilated by a needle cutter.

The bags/containers should not be filled more than 3/4th capacity. Attempts should be made to designate fixed places for each container so that it becomes a part of regular scenario and practice for the concerned medical as well as nursing staff.

**Table 29.1: Schedule I of the Bio-Medical Waste Rules**

<table>
<thead>
<tr>
<th>Option</th>
<th>Treatment &amp; Disposal</th>
<th>Waste Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cat. No. 1</td>
<td>Incineration /deep burial</td>
<td>Human Anatomical Waste (human tissues, organs, body parts)</td>
</tr>
<tr>
<td>Cat. No. 2</td>
<td>Incineration /deep burial</td>
<td>Animal Waste Animal tissues, organs, Body parts carcasses, bleeding parts, fluid, blood and experimental animals used in research, waste generated by veterinary hospitals/ colleges, discharge from hospitals, animal houses)</td>
</tr>
<tr>
<td>Cat. No. 3</td>
<td>Local autoclaving/ micro waving/ incineration</td>
<td>Microbiology &amp; Biotechnology waste (wastes from laboratory cultures, stocks or specimens of micro-organisms live or attenuated vaccines, human and animal cell culture used in research and infectious agents from research and industrial laboratories, wastes from production of biological, toxins, dishes and devices used for transfer of cultures)</td>
</tr>
<tr>
<td>Cat. No. 4</td>
<td>Disinfections (chemical treatment /autoclaving/micro waving and mutilation shredding</td>
<td>Waste Sharps (needles, syringes, scalpels blades, glass etc. that may cause puncture and cuts. This includes both used &amp; unused sharps)</td>
</tr>
<tr>
<td>Cat. No. 5</td>
<td>Incineration / destruction &amp; drugs disposal in secured</td>
<td>Discarded Medicines and Cytotoxic drugs (wastes comprising of outdated, contaminated and</td>
</tr>
</tbody>
</table>
landfills
discarded medicines)

Cat. No. 6  
Incineration, autoclaving/micro waving  
Solid Waste (Items contaminated with blood and body fluids including cotton, dressings, soiled plaster casts, line beddings, other material contaminated with blood)

Cat. No. 7  
Disinfections by chemical treatment autoclaving/micro waving & mutilation shredding.  
Solid Waste (waste generated from disposable items other than the waste sharps such as tubing, catheters, intravenous sets etc.)

Cat. No. 8  
Disinfections by chemical treatment and discharge into drain  
Liquid Waste (waste generated from laboratory & washing, cleaning, house-keeping and disinfecting activities)

Cat. No. 9  
Disposal in municipal landfill  
Incineration Ash (ash from incineration of any bio-medical waste)

Cat. No. 10  
Chemical treatment & discharge into drain for liquid & secured landfill for solids  
Chemical Waste (chemicals used in production of biological, chemicals, used in disinfection, as insecticides, etc)

Recommended Labelling and Colour Coding
These have to be in accordance with Schedule II of the “Biomedical waste (management and handling) rule 1998”. A simple and clear notice, describing which waste should go to which container and how frequently it has to be routinely removed and to where, is to be pasted on the wall or at a conspicuous place nearest to the container. The notice should be in English, Hindi and the predominant local language. Preferably, it should have drawings correlating the container in appropriate colour with the kind of waste it should contain.

Table 29.2: Schedule II of the Bio-Medical Waste Rules

<table>
<thead>
<tr>
<th>Colour Coding</th>
<th>Type of Containers</th>
<th>Waste Category</th>
<th>Treatment Options as per Schedule 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yellow</td>
<td>Plastic bag</td>
<td>1,2,3,6</td>
<td>Incineration/deep burial</td>
</tr>
<tr>
<td>Red</td>
<td>Disinfected Container/ Plastic bag</td>
<td>3,6,7</td>
<td>Autoclaving/Micro waving/ Chemical Treatment</td>
</tr>
</tbody>
</table>
When a bag or container is sealed, appropriate label(s) clearly indicating the following information (as per Schedule IV of the “Biomedical waste (management and handling) rule 1998”) has to be attached. A water-proof marker pen should be used for writing.

They should be labelled with the ‘Biohazard’ or ‘cyto-toxic’ symbol as the case may be according to Schedule III of the rules.

- The containers should bear the name of the department/laboratory from where the waste has been generated so that in case of a problem or accident, the nature of the waste can be traced back quickly and correctly for proper remediation and if necessary, the responsibility can be fixed.

- The containers should also be labelled with the date, name and signature of the person responsible. This would generate greater accountability.

- The label should contain the name, address, phone/fax nos. of the sender as well as the receiver.

- It should also contain name, address and phone/fax nos. of the person who is to be contacted in case of an emergency.

**Common/Intermediate Storage Area**

Collection room(s)/intermediate storage area where the waste packets/bags are collected before they are finally taken/transported to the treatment/disposal site are necessary for large hospitals having a number of departments, laboratories, OTs, wards etc. This is all the more important when the waste is to be taken outside the premises. Arrangement for separate receptacles in the storage area with prominent display of colour code on the wall nearest to the receptacles has to be made. When waste carrying carts/containers arrive at this area, they have to be systematically put in the relevant receptacle/designated area.

**Handling and transportation**

This activity has three components:
1. Collection of different kinds of waste (from waste storage bags/containers) inside the hospital/medical college,

2. Transportation and intermediate storage of segregated waste inside the premises

3. Transportation of the waste outside the premises (to the treatment/disposal facility).

**Collection of Waste inside the Hospital/Health Care Establishment/medical collage**

The collection containers for bio-medical waste have to be sturdy, leak proof, of adequate size and wheeled. For convenience as well as for avoiding any confusion, the colour code applicable for the bags / containers should also be used for the bins.

Collection timings and duty chart should be put in a prominent place with copies given to the concerned waste collectors and supervisors. For general waste from the office, kitchen, garden etc., normal wheel-barrows may be used.

**Transportation of Segregated Waste inside the Premises**

All attempts should be made to provide separate service corridors for taking waste matter from the storage area to the collection room. Preferably these corridors should not cross the paths used by patients and visitors. The waste has to be taken to the common storage area first, from where it is to be taken to the treatment/disposal facility, either within or outside the premises as the case may be.

**Transportation of Waste Outside**

In case of off-site treatment, the waste has to be transported to the treatment/disposal facility site in a safe manner. The vehicle, which may be a specially designed van, should have the following specifications:

- It should be covered and secured against accidental opening of door, leakage/spillage etc.

- The interior of the container should be lined with smooth finish of aluminium or stainless steel, without sharp edges/corners or dead spaces, which can be conveniently washed and disinfected.
- There should be adequate arrangement for drainage and collection of any run off/leachate, which may accidentally come out of the waste bags/containers. The floor should have suitable gradient, flow trap and collection container.

- The size of the van would depend on the waste to be carried per trip.

- In case, the waste quantity per trip is small, covered container of 1-2 cu. m., mounted on 3 wheeled chassis and fitted with a tipping arrangement can be used.

Waste treatment and disposal

Different methods have been developed for rendering bio-medical waste environmentally innocuous and aesthetically acceptable but all of them are not suitable for our condition. The ‘Bio-Medical Waste (Management & Handling) Rules, 1998’ has elaborately mentioned the recommended treatment and disposal options according to the 10 different categories of waste generated in health care establishments in Schedule I of the rules. Standards for the treatment technologies are given in Schedule V of the Rules, which must be complied with.
**Guideline 30: Construction & Demolition (C & D) waste management**

All large development should provide an onsite system for the segregation, storage, reuse and recovery of C & D waste.

In order to achieve the above:

1. Ensure that C & D waste must be segregated and stored separately on the site.

2. Provide separate space centrally for the recovery and processing of C & D waste during construction phase.

3. Provision of selling C & D waste to a registered C & D waste recycler can be considered if the waste cannot be reused or utilized during construction phase within the developmental area.

**Benefits**

Given the enormous scale of construction and demolition happening in the country and lack of any mechanism and system for proper management and disposal of such waste, it is important to prevent the ill effects of such waste.

Some of the benefits of properly managing such waste are:

Construction and demolition waste management plan creates opportunities such that a significant portion of the solid waste stream is diverted from landfills/open dumps, thus reducing the environmental impacts of waste in dumps/landfills. Land, water and air pollution impacts are reduced, less pollution from manufacturing and transportation related emissions and lower greenhouse gas emissions. Reuse and recycling of the restored material further reduces the need to extract virgin natural resources.

**Health issues:** Proper handling and management of construction and demolition wastes ensures that the ill effects of pollution arising out of such wastes are minimized including health impacts.

**Economic benefits:** Waste minimization and reuse of salvaged construction and demolition waste brings in monetary benefits as well.
Guidance Notes:

Construction and demolition waste is generated whenever any construction/demolition activity takes place, such as, building roads, bridges; flyover, subway, remodelling etc. It consists mostly of inert and non-biodegradable material such as debris, concrete, steel, plaster, metal, wood, plastics, packaging and paper products, fluorescent tubes, light fixtures, tiles, paints, etc.

These wastes are heavy, having high density, often bulky and occupy considerable storage space either on the road or communal waste bin/container. It is not uncommon to see huge piles of such waste, which is heavy as well, stacked on roads especially in large projects, resulting in traffic congestion and disruption. Waste from small generators like individual house construction or demolition, find its way into the nearby municipal bin/vat/waste storage depots, making the municipal waste heavy and degrading its quality for further treatment like composting or energy recovery. Often it finds its way into surface drains, choking them. It constitutes about 10-20 % of the municipal solid waste (excluding large construction projects).

It is estimated that the construction industry in India generates about 10-12 million tons of waste annually. Projections for building material requirement of the housing sector indicate a shortage of aggregates to the extent of about 55,000 million cu.m. An additional 750 million cu.m aggregates would be required for achieving the targets of the road sector. Recycling of aggregate material from construction and demolition waste may reduce the demand-supply gap in both these sectors.

Concrete and masonry waste can be recycled by sorting, crushing and sieving into recycled aggregate. This recycled aggregate can be used to make concrete for road construction and building material. Work on recycling of aggregates has been done at Central Building Research Institute (CBRI), Roorkee, and Central Road Research Institute (CRRI), New Delhi.

According to a study commissioned by Technology Information, Forecasting and Assessment Council (TIFAC), 70% of the construction industry is not aware of recycling techniques.

Characteristics of C & D waste

This category of waste is complex due to the different types of building materials being used but in general may comprise of the following materials:
Major components

- Cement concrete
- Bricks
- Cement plaster
- Steel (from RCC, door/window frames, roofing support, railings of staircase etc.)
- Rubble
- Stone (marble, granite, sand stone)
- Timber/wood (especially demolition of old buildings)

Minor components

- Conduits (iron, plastic)
- Pipes (GI, iron, plastic)
- Electrical fixtures (copper/aluminium wiring, wooden baton, bakelite/plastic
- switches, wire insulation)
- Panels (wooden, laminated)
- Others (glazed tiles, glass panes)

Steps for Integrated management of C & D waste.

Storage of construction and demolition waste

These wastes are best stored at source, i.e., at the point of generation. If they are scattered around or thrown on the road, they not only cause obstruction to traffic but also add to the workload of the local body. For large developmental projects special provision should be made for storage and handling of waste material. All attempts should be made to stick to the following measures:

1. All construction/demolition waste should be stored within the site itself. A proper screen should be provided so that the waste does not get scattered and does not become an eyesore.
2. Attempts should be made to keep the waste segregated into different heaps as far as possible so that their further gradation and reuse is facilitated.

3. Material, which can be reused at the same site for the purpose of construction, levelling, making road/pavement etc. should also be kept in separate heaps from those, which are to be sold for landfilled or processing.

4. The client may arrange to provide appropriate number of skip containers/trolleys on hire which may be parked at the site and removed with skip lifters or tractors as the case may be.

Collection and transportation
If the construction debris is stored in skips, then skip lifters fitted with hydraulic hoist system should be used for efficient and prompt removal. In case, trailers are used, then tractors may remove these. For handling very large volumes, front-end loaders in combination with sturdy tipper trucks may be used so that the time taken for loading and unloading is kept to the minimum.

For small generators of construction debris, e.g., petty repair/maintenance job, there may be two options – (i) specific places for such dumping by the local body and (ii) removal on payment basis.

In case of small towns where skips and tipping trailers are not available, manual loading and unloading should be permitted.

In case of large generators C & D waste should be reused for construction activities or must be sold to registered C & D waste recyclers.

Recycling and reuse
The use of these materials basically depends on their separation and condition of the separated material. A majority of these materials are durable and therefore, have a high potential of reuse. It would, however, be desirable to have quality standards for the recycled materials.

Construction and demolition waste can be used in the following manner:

1. Reuse (on site) of bricks, stone slabs, timber, conduits, piping railings etc. to the extent possible and depending upon their condition.

2. Sale / auction of material which can not be used at the site due to design constraint or change in design.
3. Plastics, broken glass, scrap metal etc. can be used by recycling industries.

4. Rubble, brick bats, broken plaster/concrete pieces etc. can be used for building activity, such as, levelling, under coat of lanes where the traffic does not constitute of heavy moving loads.

5. Larger unusable pieces can be sent for filling up low-lying areas.

6. Fine material, such as, sand, dust etc. can be used as cover material.

**Disposal**

Being predominantly inert in nature, construction and demolition waste does not create chemical or biochemical pollution. Hence maximum effort should be made to reuse and recycle them as indicated above. The material can be used for filling/levelling of low-lying areas. However, proper sampling of the material for its physical and chemical characteristics has to be done for evaluating its use under the given circumstances.

**Stages of Waste Minimization**

There are three key stages where waste minimisation and reuse initiatives should be introduced:

1. Contractual stage
2. Design stage
3. Site operation stage

At the contractual stage, the legal responsibility of project partners for minimizing waste during construction and properly managing waste is established by including clauses in the contract agreement.

At the design stage, firstly the client should clearly communicate the commitment to reducing environmental impact in design briefs and accordingly select a design team. The architect/designer should consider the following:

- Materials specification: Avoidance of the following where possible
- Designs that require more material than necessary. E.g., over specification of the material quantities for beams or columns;
- Designs that restrict the use of reclaimed and recycled materials;
- Use of high embodied energy materials
- Sizing of members and components which involve a lot of wastage from cuts

**Site operation stage** is primarily done by the contractors and involves a structured methodology of three distinct phases.

**Phase 1-Analysis and evaluation of waste management opportunities**
This phase involves identifying the waste streams and causes of waste generation; evaluating the various options for waste segregation (on-site or off-site), options for recycling and reusing materials; deciding the final destination of waste material; designing spaces for storage of waste on-site, etc and drawing the final waste management plan.

**Phase 2- Implementation**
For successful implementation of the waste management plan, staff training and communication plays a very important role and is done at this phase.

**Phase 3-monitoring**
At this phase, the success of the waste management plan is determined by conducting survey at regular intervals.

**List of hazardous wastes present in C & D waste:**
1. Asbestos products-insulation, tiles, etc.
2. Fuels and heating oils and other volatile/flammable liquids such as coolants, grease, etc.
3. Tar and Tar products (bitumen, felt, water proofing compounds, etc.)
4. Centering oil, formwork oil
5. Wood dust
6. Lead
7. Plastics, Acrylics, Silica, PVC
8. Chemical admixtures, sealants, adhesives solvents etc.
9. Paints, pigments, dyes and primers
10. Pesticides
11. Tarpaulin

12. Explosives and related products and equipment used in excavations

13. Product packaging (cement bags, cartons, containers, plastic covers, etc.)

14. Compressed gas/cylinders

15. Mercury containing lamps and tubes-Fluorescent lamps intact and crushed, halogen lamps, arc lamps, UV lamps, high pressure sodium lamps, mercury vapour lamps, neon lamps, incandescent lamps.

16. Mercury containing devices-mercury switches, relays, regulators, thermostats, etc.

17. All types of batteries

18. Electronic ballast, PCBs, transformers, capacitors, switchgear, lead cable, oil filled/gel filled cables.

19. Electronic waste-computer products, circuit boards, CRTs, electronic parts, solder dross, weld waste
Section G: Risk Mitigation / Adaptation and Climate Change

Guideline 31: Guideline for planning for climate change adaptation in large developments

This section gives an introduction to climate change impacts to Indian cities and responses to these threats in the form of adaptation and mitigation. It underlines the need for cities to plan for climate change impacts at neighbourhood levels not only to prepare and withstand these impacts but also to enjoy the fruits of sustainable, climate and environment friendly development. Factoring climate change adaptation and mitigation into large developments would equip them to withstand shocks and threats that are yet unforeseen and sometimes unpredictable.

Introduction:

Climate change is a potential threat that needs to be addressed at all levels. As concentrations of large populations, cities are at risk of the impacts of climate change on infrastructure, human lives, human health, personal property, environmental quality and future prosperity. Cities should not be seen only as centers of GHG emissions, as they also play a key role in strategies to reduce these. Two broad categories of response mechanism are identified by UNFCCC to deal with climate change, namely mitigation and adaptation.

‘Mitigation’ involves reducing the sources or enhancing the sinks of greenhouse gases. Adaptation refers to the ability of a system to adjust to climate change (including climate variability and extremes), to moderate potential damage, to take advantage of opportunities, or to cope with the consequences. Both responses are equally important and can help reduce the risks of climate change to natural and human systems.

Climate change not only increases the incidence of extreme events and disasters but also induces gradual changes such as temperature and precipitation changes, thus variability of climate is another important impact that makes resource management and infrastructure planning more challenging, and increases the urgency of the need to adapt city level operations to both current climate

---

30 Lankao, P R (2007), "Are we missing the point? Particularities of urbanization, sustainability and carbon emissions in Latin American Cities", Environment and Urbanization Vol 19, No 1, April, pages 159–175
variability and future climate change. There is strong need therefore to plan for adaptation and mitigation actions at all levels within cities by identifying prime sectors for intervention depending on projected impact of the climate for particular region.

**Climate-Related Risks and the Vulnerability Of Indian Cities**

Changes in precipitation patterns, temperatures, and frequency and intensity of extreme events are already taking place across the Indian subcontinent. Not only the projected impacts of climate change on the Indian subcontinent are significant but are multidimensional in nature.

**Change in Temperature:**

Warming is predicted all over the country and extremes in maximum and minimum temperature are expected to increase into the future. It is observed that the night time temperatures are increasing faster than day time temperatures in India (Rupa Kumar et al, 2006).31

Warming is characterized by increase in temperatures in winters (0.82° C per 100 years) and post monsoon seasons (0.82° C per 100 years). Where all India maximum temperature show an increase in temperature of 0.71° C per 100 years, the minimum temperatures have shown an increase of 0.27° C per 100 years for the duration 1907-2007 (Kothawala et al, 2010).32 The following figure shows Spatial patterns of linear trends of (a) maximum and (b) minimum temperature over India.

![Spatial patterns of linear trends of maximum and minimum temperature over India](image)

**Figure 31.1: Spatial patterns of maximum and minimum temperature over India**


Legend: Red shows warming trend at 5%; Blue shows cooling trend at 5%; Green shows cooling trend; yellow- shows warming. Source: (Kothawale et al 2010)

**Change in rainfall**

There would be a shift in the monsoon system leading to an increase of 7 to 20% in mean annual precipitation due to the predicted regional temperature rise along with the changes in the global climatic system. Apart from this the following impacts are also foreseen:

- A 10 to 15% increase in monsoon precipitation,
- A decline of 5 to 25% in semiarid and drought prone central India and
- A decline in winter rainfall in northern India

Besides this, a decrease in the number of rainy days is expected over much of India, along with frequency of heavy rainfall in the monsoon season. The frequency of extreme precipitation events (like that of Mumbai in July 2005), are expected to increase substantially over the west coast and central India. The following figure shows the trends in annual extreme rainfall. Dark green colour indicates increasing trends and red denotes decreasing trends

![Trends in annual extreme rainfall over India](image)

*Figure 31.2: Trends in annual extreme rain fall over India*

Source: (Kothawale et al 2010)

Expected increase in incidences of drought in the semi-arid peninsular and Western parts of the country will lead to increased seasonal migration from rural to urban areas. These migrants in turn form the most marginalized and highly vulnerable groups in cities, generally having limited skills, education, capital and social and economic mobility. Gujarat has faced 3 consecutive floods since 2004, causing large economic losses to its cities due to extreme precipitation events. The devastating Mumbai floods of 2005 were likewise caused by an extreme precipitation event.

---

weather event. The bulk of the city services and also all transportation networks were shut down for almost 5 days. Over 1000 people lost their lives and economic life in city came to a halt. Similar devastation occurred in 1999 in Orissa when a super cyclone killed over 10,000 people, devastated buildings, lifeline infrastructure and economic assets across 10 coastal and 6 inland districts, including a number of towns and cities.34

Cyclone and storm surges could have a devastating impact on large coastal urban centers including the mega cities of Mumbai, and Chennai, the million plus cities of Vishakhapatnam, Surat, Bharuch, Bhavnagar and Jamnagar apart from affecting the important ports like Kandla.

**Sea level rise (SLR):**

Studies show that SLR could be as much as 0.8 m over the current century. The most vulnerable stretches to sea level rise along the western Indian coast are Khambhat and Kuchh in Gujarat, Mumbai and parts of the Konkan Coast, and South Kerala. Significant settlement area is expected to be lost in the deltas of the Ganga, Krishna, Godavari, Cauvery and Mahanadi on the east coast.35

**The need for climate change adaptation and mitigation**

India’s present urban challenges make the cities more vulnerable to losses that might result from the impacts of climate change. India has 4,378 urban agglomerations/cities and towns. Thirty-five of these have populations of more than a million and 393 have populations of more than 100,000. India contributes to 12 per cent of global population growth, and three of India’s cities, namely Mumbai, Delhi and Kolkata, are among the world’s eighth largest cities.

However, the cities in India, irrespective of their size and contribution to the GDP, are already grappling with inadequate provision for water, sewerage systems, drainage and solid waste management facilities. Many cities lack proper road infrastructure and efficient public transport facilities. Above all, the housing scenario is grossly inadequate, with almost 50 per cent of the people living in slums in some of the metro cities. These factors make the cities even more vulnerable to climate related disasters and events. There is a strong need, therefore, for integration of climate change risk mitigation and adaptation in the urban planning initiatives, and before that there is a strong need to view,

---


recognize and acknowledge climate change as a major theme to be worked upon and integrated within the whole urban planning agenda and process.

Adaptation Planning Interventions thus far In India:
The Ministry of Urban Development’s National Mission for Sustainable Habitat, one of eight missions under the National Action Plan for Climate Change, provides a broad institutional strategy for integrating adaptation into urban planning processes at national, regional and city levels. This ministry is the nodal agency to take this mission forward. Besides this, many States in India are drawing their State climate Change Action Plan. Urban habitats are part of these and envisage adaptation and mitigation as necessary responses to help cities withstand the impacts of climate change. The cities of Surat, Indore and Gorakhpur are foremost in India to have built their Climate change resilience strategies under the Asian Cities Climate Change Resilience Network- A Program funded by Rockefeller Foundation covering 10 cities in Asia(3 of which mentioned here in India).

Adaptation at Neighbourhood level:
Although above mentioned programs hold promise for planning for climate change impacts, adaptation planning at city level, let alone neighbourhood level is still a distant dream in India. However, it is an established fact that adaptation and mitigation are operational on much smaller scales and their cumulative results would benefit at a larger scale. For example, energy efficient buildings that are less dependent on mechanical means for thermal comfort would help reduce considerable amount of energy use, thus indirectly leading to mitigation effort. Similarly, a colony with a storm water drainage network with a designed capacity to withstand flash floods during monsoon periods or any unforeseen heavy precipitation event as an outcome of climate change would make the area resilient to that particular climate impact or threat.

Also various elements of adaptation planning and mitigation activities are better designed at the level of the individual buildings, or colony, or a large campus or neighbourhood. For example, while water conservation as an adaptation activity could be mandated by law in a city, but actual conservation would take place when the facility is built at the level of the building/ a community/ a colony or a campus.

Why is the guideline required?
The National Mission on Sustainable Habitat suggests and asks cities to adopt adaptation and mitigation measures to help cities withstand impacts of climate change, while also enjoying the co benefits of sustainable planning practices that
become part of adaptation and mitigation. As one of the requirements under the NMSH, sustainable habitats parameters are to be constituted that guide future development of cities, large developments, and individual buildings. This guideline falls in line with the objective of the sustainable habitat parameters and is a detailed out version of the various parameters suggested under NMSH. This guideline would help in development of an understanding of variety of actions possible towards climate proofing large developments.

**Guideline:**

There are no generic or tailor-made solutions available to help any development to be climate proof – one that encompasses adaptation and mitigation actions at the planning stage itself. However, different studies are available (Eckert et al, 200936),(EU,200937) where such attempts have been made. This section draws from such studies and attempts categorization of adaptation and mitigation actions on the basis of the relevant climate impact. The last column in the following table (at the extreme right) gives an account of tentative locations where the suggested measures may be relevant. This is based on predicted climate change impacts on various regions in India. However, impacts may vary from region to region and city to city and it is strongly recommended that cities should allow for a city level risk assessment and vulnerability analysis to understand and plan city specific adaptation needs.

**Table 31.1:** Recommended adaptation measures on the basis of climate impact

<table>
<thead>
<tr>
<th>Cause</th>
<th>Urban Impact</th>
<th>Sectoral Response</th>
<th>Adaptation Measure</th>
<th>Relevant regions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sea level Rise</td>
<td>Urban flooding</td>
<td>Land use planning</td>
<td>Conduct natural drainage pattern of the site analysis and place the built-up such that it allows for excess water to stream out rather than collect at various locations within</td>
<td>All cities with undulating topography, coastal cities and cities at the bank of major rivers.</td>
</tr>
<tr>
<td>Change in precipitation – heavy rain, ground water</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

37 2009. European Union. ‘Adaptation to climate change-Policy instruments for adaptation to climate change in big European cities and metropolitan areas’.
38 The impact considered here are with reference to the scale in question i.e large campus or neighbourhood level development. There might be other urban impacts of the same climate event but not relevant here at this stage, and hence is not included here.
<table>
<thead>
<tr>
<th>level rise</th>
<th>site.</th>
<th>Western Indian Coast, Mumbai and parts of Konkan Coast, South Kerala. Low lying areas of part of deltas of the river Ganges, Krishna, Godavari, Cauvery and Mahanadi on the east coast</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drainage systems</td>
<td>Managing flood pathways within site</td>
<td>Providing for a well developed drainage system within site</td>
</tr>
<tr>
<td>Water resource conservation-quality and quantity</td>
<td>Management of quantity of run off water</td>
<td>Providing for collection of excess runoff on site and directing it to ground water recharge/sump-well for future use</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Drains cleaning mechanisms to ensure unhindered water flow in flood prone areas of the site.</td>
</tr>
<tr>
<td>Health</td>
<td>Primary health care facilities available on site</td>
<td>Mechanisms at place for prevention of water borne diseases</td>
</tr>
<tr>
<td>Flood defenses</td>
<td>Building outfalls and storage reservoirs, sluices</td>
<td></td>
</tr>
<tr>
<td>Temperature rise</td>
<td>Heat wave</td>
<td>Increase proportion of green space</td>
</tr>
<tr>
<td>------------------</td>
<td>----------</td>
<td>-----------------------------------</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Reduction of sealed surface</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Increase water bodies</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Solar control</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ventilation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cooling</td>
</tr>
<tr>
<td>Heat Island effect</td>
<td>Network of cool roofs</td>
<td>Light colored, material to prevent solar gain</td>
</tr>
<tr>
<td>-------------------</td>
<td>----------------------</td>
<td>---------------------------------------------</td>
</tr>
<tr>
<td>Increase tree canopy</td>
<td>Providing for lot of green shady areas on site</td>
<td></td>
</tr>
<tr>
<td>Conserving old trees</td>
<td>Restoring large trees and green patches</td>
<td></td>
</tr>
<tr>
<td>Planting new shady trees</td>
<td>Northern India</td>
<td></td>
</tr>
<tr>
<td>Green roofs</td>
<td>Planning, designing green roofs</td>
<td></td>
</tr>
<tr>
<td>District cooling</td>
<td>Providing for energy efficiency in buildings to decrease use of mechanical means for thermal comfort</td>
<td></td>
</tr>
<tr>
<td>Material use outside and inside buildings</td>
<td>To reduce heat gain by buildings</td>
<td></td>
</tr>
<tr>
<td>Extensive rain water harvesting</td>
<td>Central India, Semi Arid peninsula, Western parts of the country, northern India (Rajasthan, parts of Gujarat)</td>
<td></td>
</tr>
<tr>
<td>Drought and water shortage</td>
<td>Allow for compulsory rain water harvesting</td>
<td></td>
</tr>
<tr>
<td>Water storage</td>
<td>Recharging and storing rain water to be used in summer season</td>
<td></td>
</tr>
<tr>
<td>Water Recycling systems installed in buildings</td>
<td>Fittings</td>
<td>Developers provide for efficient fittings/faucets</td>
</tr>
</tbody>
</table>
Mitigation Measures

Site level facilities for pedestrian movements

Restriction on car use for demarcated area within

Ensuring markets and utility areas within walking distance to discourage use of car and two-wheelers, provision of public transport outside/within campus

Promote design and orientation of buildings such that less need for mechanical means for thermal comfort. Solar passive design features and shading devices could be used.

Provision of Green Areas/Plantation /green cover to improve air quality on site

Besides host of adaptation measures enlisted above the mitigation measures would not only help reduce GHG emissions but also help enhance the air quality of the site in question. The mitigation measures, however, not related to specific impacts of climate change are equally important to discourage excessive use of conventional energy and non-renewable resources.
Annexure 1: Literature Review

Extensive literature survey on different rating systems and building codes which deal with large development has been conducted to help us understand the approach adopted by various other countries as well as our own so far with respect to large developments.

The research study provides a retrospective analysis of the existing green rating systems for large developments such as IGBC Green Townships by Indian Green Building Council, BREEAM Communities by Building Research Establishment’s Environmental Assessment Method of United Kingdom, Pearl Community Rating system of Abu Dhabi and CASBEE for Urban Development of Japan. It further investigates the need for guidelines to promote green large developments such as townships, neighbourhoods, educational and institutional campuses, Special Economic Zones, hospitals etc.

The research aims at discussing some of the important issues relating to sustainable form that would lead to sustainable urban development with possible references to India. The paper is based on available literature on different rating systems for large developments across the world.

This section is divided into four parts. The first part explains the need for green guidelines for large developments. This is followed by the second part discussing existing guidelines for green developments in various rating systems across the world. The third part reviews guidelines for site planning and land use planning, Transport and accessibility, Resources and Energy, Socio-cultural aspects and Water & waste management in different rating systems. The last section highlights the present scenario of India with respect to the natural resources and energy and justifies the need for green guidelines to promote sustainable urban developments in India.

Introduction

UN General Assembly convened a conference on the “human environment” at Stockholm in June 1972, which came out with the guiding principles on “human environment”. The intent of the conference was to emphasize man’s fundamental right to environmental quality and his responsibility towards protecting the environment for present and future generations.
The world commission on Environment and Development was created in 1983 to address the issues concerning continuing depletion of natural resources. The UN Conference on ‘Environment and Development in 1992 also known as the Earth Summit, UN Millennium Summit in 2000 have urged to ensure environmental sustainability. Similarly, the Intergovernmental Panel on Climate Change (IPCC) addresses the importance of social and environmental equity in development. Thus, all the major world conferences and initiatives on environment and development have stressed on economically viable, socially equitable and environment friendly development.

Sustainable urban development specifically means achieving a balance between the development within designated area and protection of the environment with an eye to equity in employment, shelter, basic services, social infrastructure and transportation. Rapid expansion of urban population around the world has arisen a wide awareness about minimizing the environmental costs of urbanization. Cities have become places of urban environmental degradation and wasteful use of resources.

One of the greatest challenges being faced by the world today is climate change. Climate change is the variation in earth’s global climates over time. The effect of climate change can be found on rising sea level, increasing temperatures, intensity of natural disasters etc. Rapid urbanization, industrialization and economic development have hampered the sustainable development of India. Urban areas are facing problems of air quality pollution, greenhouse gases, unsustainable consumption, inadequate sanitation and water supply. Thus, there is an urgent need for green guidelines to promote sustainable living. The intent of the guidelines is to design a development that produces and distributes services in an economic, environmental friendly and equitable way.

**Need for a Green Large Development**

**Background**

It is globally recognized that the building sector is the biggest consumer of energy and resources. Thus it has great implications for economy. The economic growth of India has a significant infrastructure development component which kept the economy going in spite of setbacks in the developed economies during the economic downturn.

---

39 World Commission on Environment and Development (WCED) known by the name of its Chair Gro Harjøm Brundtland was convened by the United Nations in 1983.
40 Millennium declarations in the UN Millennium summit in September 2000 contain 8 Millennium Development Goals (MDGs) to be achieved by 2015. These goals respond to the world’s main development challenges.
It is now recognised that the resource and energy consumption of this sector also poses the biggest threat to the planet in terms of climate change induced by anthropogenic greenhouse gas emissions and degrading environment by way of land, water, air and noise pollution. Environmental concerns are key components of all new development plans. The regulatory agencies are working on ensuring the essential aspects are addressed to minimize the impact of such development models and mitigate climate change in the process.

India is witnessing tremendous growth in infrastructure and construction development. The construction industry in India is one of the largest economic activities and is growing at an average rate of 9.5% as compared to the global average of 5%. As the sector is growing rapidly, preserving the environment poses a host of challenges.

Considering the rapidly growing urban population, overcrowding metro cities and their large requirement of energy and other resources, and waste it generates, India’s future is grave. The quality of life in most of the urban places, especially in the metropolitan and mega cities is degrading (Changing land use paper). People continuously confront problems of safe drinking water, power, and sewerage and garbage disposal. There is an urgent need for better governance, transport and basic amenities for the growing population. Improving urban strategies to enhance the quality of life needs a lot of attention.

**Growth in population**

**Global Scenario**

After peaking in 1962 and 1963, the growth rate of the human population has been declining at 2.20% per annum. In 2009, the estimated annual growth rate was 1.1%. The CIA World Fact book gives the world annual birth rate, mortality rate, and growth rate as 1.915%, 0.812%, and 1.092% respectively. The last one hundred years have seen a rapid increase in population due to medical advances and massive increase in agricultural productivity made possible by the Green Revolution.

**The Indian Context**

India, at present, is one of the leading economies driving the economic growth of the world. Buoyed by a high average growth rate of 8 percent per annum in 2009-10, the country is further poised to grow at a higher rate of 8.4 per cent in 2011, beating China by 2012. The Indian infrastructure sector has been the backbone of the Indian economy based on which the country is able to traverse through hard times.

India’s population is growing at a rate of about 17 million annually which means a staggering 45,000 births per day and 31 births per minute. The current birth rate of 20.97 has however come down from 23.28 in the year 2003. Population explosion is one of the
most threatening issues facing contemporary India particularly by the Indian cities. Large scale rural to urban migration and rapid urbanization are the factors responsible for the population explosion in cities.

**Population and the environment**

With the increase in global population, natural resources are under increasing pressure, threatening public health and development. Water shortages, soil exhaustion, loss of forests, air and water pollution, and degradation of coastlines afflict many areas.

**Urbanization**

Urbanization as defined by the United Nations is “the movement of people from rural to urban areas with population growth equating to urban migration”. Closely linked to modernization, industrialization, and the sociological process of rationalization, urbanization has become a major demographic issue in the 21st Century not only in India but all over the world.

Due to uncontrolled urbanization in India, environmental degradation has been occurring very rapidly and causing shortages of housing, worsening water quality, excessive air pollution, noise, dust, and heat, and problems of disposal of solid wastes and hazardous wastes.

The large metropolitan cities of India like Mumbai, New Delhi, Kolkata, Bengaluru, Chennai, Hyderabad, Kanpur, etc present a very depressing picture today. Growing urbanization and increasing construction activities along with rapid industrialization, energy production, commercialization and increase in the number of motorized vehicles are causing a dangerously serious threat to the environment, local as well as global. Urbanization and its allied process have made a profound impact on the environment of the metropolitan cities of India.

Strong initiatives have been taken in the recent years to mitigate the global climate change. Green building rating systems commonly known as the certification systems have evolved over the years to reduce the negative impact of buildings. The impetus of the initiatives is to reduce greenhouse gas emissions, conserve energy, land and water, and more wisely use natural resources.

Since the second half of the 1980s, there has been a growing movement towards sustainable construction leading to the development of various methods for evaluating the environmental performance of buildings. Methods developed overseas include BREEAM (Building Research Establishment Environmental Assessment Method) in the UK, LEED (Leadership in Energy and Environment Design) in the USA, Estidama Pearl community rating system in Abu Dhabi and others. These methods have attracted interest around the world. This kind of assessment, with the publication of the results, is
one of the best methods now available to provide an incentive for clients, owners, designers and users to develop and promote highly sustainable construction practices.

**Environmental impacts of Urbanization**

Urbanization is associated with higher incomes, improved health, higher literacy, improved quality of life and other benefits, but there are also serious environmental and social issues associated with it. With urbanization, concentration of people in cities is increasing and so is the demand for basic necessities like food, energy, drinking water and shelter.

Urbanization affects the environment in three major ways: Implications due to urban poverty which is a result of migration, stressed infrastructure and management systems and increasing consumerism.

1. **Urban Waste**

Increasing urbanization is resulting in the generation of increasing amounts of solid waste. It is estimated that 20-50% of solid waste generated remains uncollected. With increasing living standards, organic content in the waste is reducing and non-biodegradable wastes like metal, plastic and glass are on a rise. Urbanization and increasing trend of consumerism in cities are the main factors leading to generation of more waste.

2. **Urban Water Quality**

Ever increasing urbanization and their growing amounts of waste have over taxed the natural recycling capabilities of local rivers and lakes. Of the many problems associated with effluents, nutrient loading or eutrophication of local waters is one of the most serious problems.

3. **Urban Transportation**

Transportation systems are a major contributor to the decay of urban environment and reduced quality of life in the metropolitan areas due to their contribution to atmospheric emissions, noise and risk of accidents. Increasing vehicular pollution in major urban centers is becoming an area of growing concern. Poor maintenance of vehicles, degraded conditions of roads and use of impure fuels primarily precipitate problems of air and noise pollution arising from operation of motorized vehicles.

4. **Urban Air Quality**

Urban air quality has deteriorated largely on account of growth in industrial activity, transportation needs and energy production. In India, ambient air quality status derived from a network of 290 stations covering 90 towns and cities in recent years indicates that while suspended particulate matter (SPM) is consistently critical in many
cities, the concentration of nitrogen oxides and sulphur di-oxide is also increasing and is already transiting from moderate to high critical levels.

5. **Resource Consumption - Energy Demand**

Urbanization has profound effect on the amount and type of energy consumed. Along with population growth, economic development and industrialization, Urbanization is one of the principal forces driving the increase in energy demand.

6. **Water Demand**

India has an enormous reserve of water but still it suffers from urban water supply issues. The growing demand of water, along with poor water resource management and mounting pollution levels contributes to water supply problems in and around cities. Urbanization is leading to change in lifestyle and consumption pattern, which is leading to increased demand for water. Poor water management practices exacerbate local water shortages. Inefficient water distribution system is another major source of water loss. Water scarcity is closely linked with water quality. Freshwater lakes and rivers provide affordable and easy accessible water, but uncontrolled discharge of domestic sewage and industrial effluents has left many urban rivers heavily polluted and their water is unsafe for use.

**Existing Rating Systems for large developments**

**Building Research Establishment’s Environmental Assessment Method, BREEAM, United Kingdom**

BREEAM (Building Research Establishment’s Environmental Assessment Method) is the world’s leading and most widely used environmental assessment method for buildings, with over 115,000 buildings certified and nearly 700,000 registered. It sets the standard for best practice in sustainable design and has become the de factor measure used to describe a building’s environmental performance.

In 2002, BRE released and published a comprehensive framework for the early stage of development called - A sustainability checklist for developments: a common framework for developers and local authorities. This was the first guide to address social and economic issues in addition to environmental sustainability across whole developments instead of individual buildings types.

Since 2003, BRE has developed specifically tailored regional sustainability checklists for each of the nine (9) English regions. The regional sustainability checklists are vehicles for delivering comprehensive triple bottom line, sustainable development within the built environment through the planning system and its policies.
Regional Sustainability checklists are useful at the early master planning stage new settlements and communities. They enable developers, planning authorities and their advisors to specify and assess the sustainability attributes of developments, while ensure that the key sustainability objective and planning policy requirements have been addressed.

BREEAM Communities is an independent, third party assessment and certification standard which addresses key environmental, social and economic sustainability objectives and planning policy requirements that have an impact on proposed development projects within the built environment. score on a scale of Pass, Good, Very Good, Excellent and Outstanding.

BREEAM communities, is targeted at assessing the overall sustainability of a proposed development at the planning stage of the development control process. It focuses on both Multi-Residential and Mixed-Use Developments. BREEAM communities assess a large development site under 8 sections as outlined in the Regional Sustainability checklist, climate and energy – addresses built form mitigation and adaptation issues; place shaping – addresses local area design and layout; community – addresses consultation and local community involvement; ecology – addresses protection of the ecological value of the site; transport – addresses sustainable transport options; resources – addresses sustainable use of resources; business – addresses local and regional economic issues; buildings – addresses overall sustainability performance of buildings.

IGBC Green Townships, India

Launched in June 2010, IGBC Green Townships is a tool which enables the designer to apply green concepts and criteria, so as to reduce the environmental impacts that are measurable. It is designed to address the issues of sprawl, automobile dependency, social and environmental disconnect. Environmental planning, Land use planning, Resources management and Community development are the broad aspects to be addressed by developments under IGBC green townships.

CASBEE - Comprehensive Assessment System for Building Environmental Efficiency, Japan

CASBEE is a method for evaluating and rating the environmental performance of buildings. With the growth in the construction sector and increase in the scale of developments, CASBEE for Urban Development was launched in July 2006 to contribute to evaluate an area of development as a whole (IBEC, 2007).

As stated in CASBEE for Urban Development manual 2007, the purpose to develop the system is, “When a project is planned and implemented that comprises multiple buildings and other elements on a single, large scale site under a unified design
concept, assessment can go beyond the environmental design of each building, to identify new or expanded environmental measures, and their effects, that are made possible by the building group, and thereby contribute to the comprehensive improvement of environmental performance in urban renewal”. (IBEC, 2007)

Developed to assess the outdoor environment onsite and off-site environment, the centre of the assessment designation is not the building, but the space that surrounds the group of buildings. Environmental quality in urban development and Load reduction in Urban Development are the two main aspects to evaluate the urban scale efforts.

**Pearl Community Rating System, Abu Dhabi**

Estidama, an initiative launched in 2008 to transform Abu Dhabi into a model of sustainable urbanization, aims to create sustainable communities, cities and global enterprises and to balance the four pillars of sustainability: environmental, economic, cultural and social.

Pearl Rating system is one of the key initiatives of Estidama and aims to address the sustainability of a given development throughout its lifecycle. It is organized into seven categories that are fundamental to more sustainable development. These form the heart of the Pearl Rating System:

1. **Integrated Development Process**: Encouraging cross-disciplinary teamwork to deliver environmental and quality management throughout the life of the project.

2. **Natural Systems**: Conserving, preserving and restoring the region’s critical natural environments and habitats.

3. **Livable Communities**: Improving the quality and connectivity of outdoor and indoor spaces.

4. **Precious Water**: Reducing water demand and encouraging efficient distribution and alternative water sources.

5. **Resourceful Energy**: Targeting energy conservation through passive design measures, reduced demand, energy efficiency and renewable sources.


7. **Innovating Practice**: Encouraging innovation in building design and construction to facilitate market and industry transformation.
Review

This section provides a comparison of the four principal certification programmes for large developments used around the world in terms of the following:

- Site selection and Land use planning
- Transport and accessibility
- Resources and Energy
- Socio-cultural
- Water & waste management

Site selection and land use planning

Selection of an appropriate site after a detailed natural assessment is the most critical factor to ensure the sustainability of a project. The environmental baseline conditions surrounding, connected to and on the site must be considered and accessed carefully before initiating the project. Development has become synonymous with physical expansion and growth. There is a need for significant changes in the pattern of land use and construction that will provide communities with better quality of life and at the same time conserve natural resource.

Site selection and planning are crucial factors in achieving the objectives of sustainability of a project. It is important to include various environmental factors while carrying out this activity. With increasing urban development and environmental degradation, it has become imperative to carefully consider and assess the environmental baseline conditions surrounding, connected to and on the site before initiating the project.

Not only the developer, but the entire project team should be involved in site selection and should access the appropriateness of the site relative to the proposed development. Sustainable site planning addresses the overall objective of maximising the conservation and utilization of resources (land, water, natural habitat, fauna and energy) and enhances efficiency of systems and operations of site-related activities.

Environmentally, several buildings are built with little regard for the existing biodiversity, natural infrastructure such as flora and fauna, hydro-geology, wind patterns, solar path and water tables. This practice also extends to other sensitive areas such as preserved / protected coastal zones, heritage zones and high-biodiversity zones.
IGBC India

It is observed globally the conventional development is generally insensitive to natural environment. These developments may affect the production capacity of an agricultural land, destroy the biodiversity and the natural habitats or may even scrape off the natural landscape.

The IGBC Green Townships rating system facilitates restoration and preservation of the natural environment by encouraging strategies that aid interface between the built and natural environment. Compliance with statutory laws and regulatory codes, preserving 25% of existing trees and water bodies to minimize the site disturbance, avoiding development in ecologically sensitive areas and soil erosion control to preserve the top soil are the four mandatory criteria for a development to be rated under IGBC Green townships.

Conserving biodiversity such as forests, grasslands, wetlands, coastal & marine ecosystems and desert ecosystems within the project, restricting development footprint to minimize site disturbance, redeveloping contaminated sites and preserving agricultural land for food production are other aspects which enhance the fabric of the planned development and provide environment conducive for living and working.

Green Township rating system addresses the impacts of urban sprawl by encouraging compact, mixed use developments and promotes higher urban densities without affecting the quality of life.

The first section, Land use optimization, encourages compact and dense developments to conserve land without compromising on the quality of the life in the development. The density figures must confirm to the density requirements as per the local bye-laws.

The system also promotes the concept of mixed use development to reduce dependency on automobiles and harmful emissions associated with it provided that the urban land uses (residential, commercial, medical, institutional, recreational and cultural) are compatible with each other. The primary objective of the criterion is to enhance the community vitality.

To promote higher urban densities, the third section, “Housing Typologies”, encourages social and economic mix within the society by including housing for High Income Group (HIG), Middle Income Group (MIG), Low Income Group (LIG) and atleast 10% of housing for Economically Weaker Sections (EWS) in accordance with the bye-laws.

In any given development, buildings are the key consumers of energy and pose greatest threat to the environment around them. To minimize the negative environmental impacts associated with the development, IGBC Green Township system encourages
design and construction of eco-friendly buildings. According to the system, at least 20% of the total built-up area within the development should be in accordance with appropriate green building rating systems.

**CASBEE, Japan**

CASBEE for Urban Development addresses both the environmental quality in Urban Development (QUD) and Load Reduction in Urban Development (LRUD). QUD corresponds to “quality related to the enhancement of living amenity for the users (residents, workers, visitors) of the designated area.” (IBEC, 2007)

QUD1 is a comprehensive assessment of natural environmental elements within the site on an urban scale. Conserving natural environment is encouraged to create a comfortable microclimate. The first section focuses on reducing the heat island effect in the development (Discussed in the energy section). Consideration and conservation of terrain is the foremost criterion addressing appropriate site selection and effective land use planning in the proposed development. Developments where the building layout and shape are designed in consideration with the existing topographic character of the site are promoted. The system encourages efforts to overcome previous defects in the topographic characteristics of the land, with view to land usage, disaster prevention and river management. Evaluating existing topsoil in the designated area and its effective re-use retaining the properties to an extent of 80% is also considered. Conservation of water bodies and aquifers within the designated area are also encouraged by the system to preserve the natural water cycles.

Ecosystems are also a significant part of the natural environment for any given site. CASBEE evaluates the efforts of a developer to conserve and create habitat for flora and fauna within the designated area. This includes conserving natural resources such as woods, creating diverse habitat spaces for diverse organisms, preserving natural flora in the surroundings and providing significant green space.

**PEARL Community Rating System**

“The islands, sand dunes, sea, coast lines, and native wildlife all blend to create Abu Dhabi’s incredibly intricate, sensitive and unique natural environment. This extraordinary mix has coexisted with the people living in it for thousands of years.”

*Capital 2030, A Sustainable Foundation*

The UPC has developed the Abu Dhabi 2030 Urban Structure Framework Plan to optimize the city's development through a 25-year program of urban evolution. In doing so, it is laying the foundations for a socially cohesive and economically sustainable community that preserves the Emirate's unique cultural heritage (Abu
Dhabi UPC). Plan 2030 calls for a creation of a national park system to preserve key areas, but goes beyond that with the concept of a ‘green gradient’.

The Natural Systems section encourages natural resource management and sustainable land use through analysis and assessment of natural systems, encouraging reuse of land, remediation of contaminated land, conservation of existing valuable features through protection or mitigation, enhancement in ecological value and habitat creation, restoration and provision of habitat connections.

The section has been divided into three categories, Assessment and protection of natural systems within and surrounding the designated area, Land use planning and strategies to enhance the ecological character of the site considered for development.

The intent of the first requisite, “Natural Systems Assessment”, is to ensure that before the design process begins, the environmental baseline conditions surrounding, connected to and on the site are considered and assessed addressing the topography, geology, soil, hydrology and groundwater, waste and contamination, coastal conditions, flora and fauna and archaeological features of the site. The system also encourages the assessment of the urban systems influencing the site. Location, site access, population, transport, economy and employment, land use, densities, access and mobility, community facilities, microclimate, etc are the key elements to be accessed in this section. The impacts of the natural system assets shall be adequately protected or their impacts shall be mitigated or compensated for a development to be rated under PEARL Rating system. Developments where it is practically impossible to demonstrate on-site mitigation, off-site compensation shall be demonstrated for compliance with the criteria.

The next section encourages reuse of contaminated land or land that has already been built on, to minimize the usage of undisturbed agricultural or forest land. Previously developed land occupied by a permanent structure, parking areas, etc are considered appropriate for re-development.

As mentioned above, the third section focuses on enhancing the ecological value of the site. This can be achieved by planting native or adaptive species within the designated area of development and creating a sustainable habitat that is connected to other similar habitats. The habitat type shall be a priority habitat of a type appropriate to site selection.

Sustainable food production and resident access to high-quality foods is encouraged to create a more localized approach to food. Food production areas shall be identified within the area of development and strategic plans confirming the source of local food crops shall be prepared for compliance with the criterion.
**BREEAM Communities, United Kingdom**

Protecting and conservation of ecological features on site benefits the existing site ecology and subsequent development to a significant extent. Maintaining native species can lead to cost savings through reduced maintenance, reduced risk of liabilities under protection of wildlife legislation, in addition to increasing and maintaining the aesthetic qualities of a development.

The first section of ecology and Biodiversity in BREEAM communities aims to determine the ecological value of the habitats in and around the site in order to maintain and enhance biodiversity and protect existing natural habitats.

Development is usually seen as being detrimental to the ecological value of the site. Negative effects of unavoidable damage in developments can be offset to some extent through enhancement in other areas of site. To improve and strengthen the ecological value of the site and existing habitats, the system encourages developing a Biodiversity Action Plan which provides survey analysis, advice and recommendations ensuring enhancement and protection for site ecology.

The third section aims to ensure that the trees and shrubs specified in the Biodiversity Action Plan (www.businessandbiodiversity.org) are native and contribute to the ecological value of the site.

Place shaping section in BREEAM Communities focuses on effective use of land, the design process and developing inclusive communities retaining most of the natural character of the site. The first section aims to ensure the most effective and efficient use of land by applying a sequential approach. Site considered for development is considered best when it is characterized as contaminated land, remediated or awaiting remediation or Brownfield. Undeveloped land with low ecological value can also be considered appropriate as there is no long term impact of development. (For more information: BRE Global Ltd 2008)

To ensure effective reuse of land and buildings, the system promotes sites where a certain percentage (50% to 100%) of existing land and buildings will be reused.

The next set of guidelines facilitates the design process. To ensure that the character of the landscape is respected and enhanced through appropriate location and design appropriate to the local environment, a landscaping scheme in consultation with the local authority is encouraged. The intent is to develop a site which can provide an integrated and ecologically sensitive green infrastructure with landscape and ecological assets preserved and appropriately augmented. To ensure that the development is accessible, aesthetically and architecturally attractive, developments accompanied with a Design and Access Statement addressing context, spatial relationships, connectivity, landmarks, urban design, conservation and internal environment of the site are
encouraged by the system. The Design and Access Statement shall cover two potential aspects of access, vehicular and transport links, and inclusive access. (For more information: BRE Global Ltd 2008: page 164)

To ensure access to high quality public green space for all, the system encourages designs with minimum distance to access green spaces. The development must confirm to the recommendations of Accessible Natural Green Space Standard (ANGST) guidance. (www.naturalengland.org.uk)

The next set of guidelines addresses issues related to Local demographics and Affordable housing. To ensure that the development contributes to the housing needs of the area in terms of type, size, and tenure and reflects the needs of the current and prospective community demographics, a statement of Community Involvement (SCI) shall be prepared addressing the involvement of stakeholders and community in planning processes, needs of the existing community and strategies to attract diverse community. Also, to prevent social inequalities and foster a socially inclusive community, effective integration of affordable housing within the development is promoted.

**Analysis**

India is a country of splendid diversity of soil, climate, food, clothing and culture. Our biodiversity has evolved over thousands of years. The stability in the sector of food security, fiber and shelter provisions and animal wealth has been threatened due to ever increasing population pressure and in-discriminatory use of land resources. It is well recognized that inappropriate use of land leads to decline of soil productivity and finally poorer quality of life. Increased urbanization without appropriate planning has led to mushrooming of several large IT Parks/housing townships in areas with little or no infrastructure. The conversion of farmlands into high-energy consuming townships and residential areas into commercial shopping areas is driven generally by cost dynamics and economics, but the hidden costs of adding infrastructure (such as roads, sewage systems, regular power supply and public transportation systems) into an existing area to upgrade it to accommodate newer functions are much higher in the long run.

Although India has increased its production from less than 100 million tons per year in early sixties to 195 million tons per year in this decade, self-sufficiency in dynamic socio-economic framework in a sustainable nature needs urgent attention and scientific guidance. Thus, sustainable land management based on detailed analysis of slope of the region, soil conditions (depth, water retention capability, infiltration and drainage), available water capacity and land capability has become very important. (rainfall in the region of development, condition of soil and existing constraints, availability of ground
water, human and animal population in the region before development and existing infrastructure)

The current land use pattern in India is influenced by diverse factors such as population density, urbanization, industry agriculture, animal husbandry, irrigation demands, and natural calamities like floods and droughts. Despite stresses the area under the forests has increased due to proactive reforestation and afforestation programmes of the Government of India. According to the Forest Survey of India (FSI), the total forest cover in the year 2007 was 69.09Mha.

India is the second most populous country in the world. There is a huge gap in the availability of land and demand for the same. To overcome this gap and reduce the impact of growing urbanization of the site and surrounding areas of development, it is important to for al new developments to be consciously designed. At present the existing rating systems only address issues pertaining to developing a particular site which includes preserving the natural resources on site and compliance with statutory laws. Factors that are essential for selecting a particular site and defining appropriate land use as per the carrying capacity of land are neglected.

Guidelines for land use in should aim to evaluate the carrying capacity of land to identify population limitation in terms of existing natural resource availability and map the natural resources, such as topography; soil; surface water and flora & fauna, within and around the designated area of development to identify the most appropriate land use.

**Transport & accessibility**

Urban sprawl is characterized by increase in the number of people commuting by cars. Being a major user of energy, transport has a significant effect on the environment. Burning of petroleum contributes to air pollution and global warming through the emission of nitrous oxides and carbon dioxide. Taking all the sectors into account, road transport has the worse environmental impact when compared to aviation, rail and shipping. Transport systems are also the key players in traffic congestion and automobile-oriented urban sprawl which consume natural habitat and agricultural lands and human health. Due to this, the various environmentalists have called for a transition from air and road to rail and human powered transport and electrification of transport.

Fuels burned in cities generate over three quarters of global carbon emissions stemming from anthropogenic sources.

Green rating systems across the world encourage developments to address these issues by designing effective and efficient transportation systems within the designated area.
IGBC India

“Green Townships” rating system addresses the issues of transport systems by encouraging transport management strategies which include increasing opportunities for bicycling, encouraging pedestrian friendly network, reducing the number of automobile trips, promoting public transportation and use of alternative vehicles.

The system encourages long term planning of cohesive transportation system to reduce adverse environmental impacts emanating from future traffic volumes. Ensuring accessibility for differently abled people, encouraging the use of public transportation to reduce fossil fuel consumption, vehicular emissions and its adverse effect on public health, encouraging use of eco-friendly vehicles by providing alternate refueling stations and providing interconnected street networks to facilitate transport efficiency are some of the aspects encouraged and promoted by the system.

CASBEE, Japan

Traffic volumes and management is considered in LRUD3 (Management of the local environment) under the social infrastructure section. Linkage and coordination between main movement routes in the development area, shuttle bus services and promotion of bicycle use are encouraged in the system.

Regional transportation planning section evaluates whether transport plans for the designated area are actively coordinated with higher-level administration plans and wide area transport plans. It evaluates consistency and coordination with the administrative master plans for transportation system.

Demand for transport in Japan is growing at a pace that exceeds road development, and the approach of developing roads and other transport facilities to counter congestion is reaching its limits. The Ministry of Land, Infrastructure and Transport, Japan has introduced “Transport Demand Management” (TDM) encouraging users to switch to other transport behavior to relieve road traffic congestion at the city and district levels. CASBEE for urban development encourages developments that participate in the measures adopted by the local authorities for TDM.

PEARL Community Rating System

“Livable Communities section in the system focuses on the urban elements that influence the quality of the urban and the built form, which through direct and deliberate control of the planning and design process has significant influence on the quality of place and hence on the overall quality of human life.” (The Pearl Community Rating System: Design & Construction, April 2010)

As the town and cities of the emirate grow there is a need to create an urban fabric that supports mass transit modes of movement. Liveable communities section intends to
encourage responsive design and sustainable land use through creating a community that is easy to move around by all modes and connects well to the wider sub region. Neighbourhood connectivity section aims to achieve high level of pedestrian and vehicular connections within the neighbourhood and with existing and potential future surrounding developments. Open space network aims to create an interconnected network of parks and open space, differing in size, character and purpose to support a variety of human activities and natural systems.

Developing a travel plan to reduce single occupancy vehicle use and implementing the same by providing alternatives to traveling by car is also encourage in the system. Public health and mobility enhancement is facilitated through a pedestrian environment covered under the community walkability section.

**BREEAM Communities, United Kingdom**

The transport and movement section in BREEAM communities aims to encourage and enable the use of public transport. A proposed development supported within an existing public transport corridor (bus, train, tram or any other form of public transport) is awarded the maximum credits.

If a development does not fall within an existing public transport corridor, the next criteria aims to ensure availability of frequent and convenient public transport links to fixed public transport nodes (bus, train, tram or tube) and local centers.

The third section aims to encourage more frequent use of public transport during the entire year by providing safe shelters for bus, train, tram or tubes. Lighting inside the shelter, adequate size to accommodate the users of the development, visibility and safety are the key factors considered in the section.

The reduction of short car journeys has a twofold effect; not only is the impact on the environment lessened, but it gives those without a car access to facilities and job opportunities. Research shows that the majority of car journeys are less than 5 miles, so by providing essential facilities close by and on safe pedestrian routes, an overall reduction in car journeys is likely. To reduce the dependency on travel by car, essential facilities should be located within reasonable walking distance. The facilities should be located on key pedestrian routes, focused around public transport nodes. Dedicated, segregated cycle lanes with proper signage are also encouraged in the system.

BREEAM communities system also encourages activities such as car club to reduce the number of privately owned cars and provision of flexible parking spaces for cars which can serve various functions at different times during a day. Also ensuring that the streets around homes are pedestrian friendly and a traffic assessment is carried out regularly, is an important aspect of the BREEM system.
Analysis

Motor Vehicles are constantly increasing in number since the year 1990. The total number of registered motor vehicles in India as on 31st March 2006 was 8,96,18,000 (Press Information Bureau, GOI). With this, the vehicular emission load has also increased many folds. Managing the transport sector while minimizing externalities such as local pollution, congestion and GHG emissions is a major challenge. With the increasing urbanization, an efficient transport system is a critical infrastructure requirement in cities for greater economic productivity and better quality of life.

Transport is responsible for an appreciable share of pollution, both local and global. As a number of towns in India are growing very rapidly, a very high level of vehicle growth can be expected in the future. With this, the emission from the burning of fuels and the consumption of the naturally available fuels is going to increase manifolds. Transport systems also have adverse effects on human health.

Guidelines on transport systems have been designed to reduce the consumption of fossil fuels, reduce the emission of harmful pollutants and to enhance human health by promoting pedestrian walkways.

Resources & energy

Buildings are responsible for about 40% of total energy use in the world. With the recent boom in the construction sector, there has been a sudden increase in energy consumption, especially in countries like India and China.

IGBC India

The demand for infrastructure grows with the growing Indian cities. Power deficit is the most common issue faced by the entire country. India’s peak power deficit is expected to widen in the current fiscal year to 12.6% from 11.9% in the fiscal year 2009. Rising investment into infrastructure and speed of urbanization will increase demand for power in some states. IGBC Green Townships aim to reduce energy consumption through energy efficient street lighting, motors, pumps etc. In addition to this on-site power generation using renewable energy technologies can significantly reduce the load on grid power supply.

To reduce the heat island effect and minimize the impact on the urban climate, the system encourages providing shades to constructed surfaces on the site through landscape features and using materials with high reflective index.

The first section is designed to maximize energy efficiency in infrastructural equipment, thereby reducing the environmental impacts resulting from energy use. The efficiency
of street lighting, traffic lights, motors and pumps shall exceed the efficiency requirements of ECBC / ASHRAE 90.1 by at least 10%.

The system also promotes the use of renewable energy technologies to reduce the impacts associated with burning of fossil fuels. Under this section, the installed capacity of the renewable energy system shall be at least 20% of the annual energy consumption under the developer’s scope.

The third section encourages utilities to buy off-site renewable energy so as to reduce the environmental impacts associated with the energy produced from fossil fuels by investing in off-site green power (solar, wind, geothermal, biomass, or low impact hydro sources) for at least 50% of the total consumption in areas under developer’s scope.

**CASBEE Japan**

The social Infrastructure section in the Load Reduction category, LRUD2, encourages area network of unused and renewable energy. Various forms of unused energy like waste heat from cleaning plant, heat from river and sea water, waste heat from factories and many more are listed by the Agency for Natural Resources and Energy. Under the “Law Concerning Special Measures to Promote the Use of New Energy (The New Energy Law) there are fourteen different types of “New Energy” which can be considered in this section.

*Passive cooling to be included as per QUD1. Mitigate heat island effect with passage of air, shading and green & open water.*

In order to promote effective energy use for the entire designated area, the system awards the maximum credits to developments where 10% of the annual electrical power demand is met by a network of unused and renewable energy.

The system also encourages load levelling of electrical power and heat through area network to reduce the large fluctuations that occur in electricity demand seasonally, weekly, daily or hourly. The third section encourages an area network of high-efficiency energy system, example District Heating and Cooling System. The intent of the criterion is to exploit the economies of urban scale to achieve efficiency that is difficult to achieve in individual buildings.

**PEARL Community Rating System**

The UAE has almost the highest rate of energy consumption per person in the world. The demand for energy is exceeding the supply at a very high rate. The resourceful energy section facilitates careful consideration of energy issues during the design of communities.
The system focuses on developing a renewable energy strategy for the community to conserve energy through demand reduction and efficient generation and distribution. An analysis of the total annual energy consumption (MWh) of the entire community, peak power demand (MW) of the entire community as well as the total energy supplied by the onsite renewable technologies is required to facilitate the design and development team to take informed decisions during the inception of the project. Building energy guidelines to promote energy conservation within the community and the provision of metering facilities to monitor the performance of infrastructure systems are also a mandatory requirement of the system.

The first section of the energy criteria set emphasizes on reducing the demand for energy through passive environmental design. It encourages consideration, evaluation and deployment of various passive cooling strategies to improve the outdoor microclimate and building energy performance. “Urban heat reduction” is also one of the key aspects to achieve comfortable environmental conditions in the development.

Efficiency of the infrastructure also plays a significant role in reducing the energy consumption and carbon emissions. The section promotes efficient lighting systems (roads, pathway, parks, traffic lights, directional signage, etc), deployment of high efficiency district cooling systems and use of smart grid technology.

The third section aims to promote the use of on-site renewable energy to reduce transmission losses, curb peak power demand, and reduce reliance on fossil fuel based power generation. As per the criteria, 1% - 25% of the communities total energy consumption should be supplied through renewable energy generated with the community site boundary. To promote and create demand for large scale renewable energy generation facilities, PEARL communities system encourages developments to invest in off-site renewable energy generation. The total energy consumption of the community infrastructure shall be supplied by the off-site source in this case.

**BREEAM Communities, United Kingdom**

The climate and energy section in BREEAM communities focuses on passive cooling strategies, energy efficiency of the infrastructure of the development and deployment of renewable energy technologies.

The first section in BREEAM Communities aims to reduce heat absorption within the development thus reducing the incidence of overheating and the need for powered cooling. The formation of a heat island is the result of reflection of solar radiation by surfaces with low solar reflective index, emission of hygroscopic pollutants from cars and heavy industry and absorption of heat by building materials such as concrete, brick and tarmac during the day. Absence of water and vegetation also cause high temperatures, increased use of air conditioning and raised pollution levels. Provision of
appropriate shaded green space and tree cover, green roofs and vegetated walls, open water and fountains in public spaces and shaded public spaces and pathways contribute in mitigating the heat island effect and save energy.

The energy efficiency section is designed to increase the overall efficiency of the development through energy efficient design and management. As per the system an energy strategy shall focus on minimizing energy demand for the site through passive solar design, maximizing the thermal efficiency of building envelopes and minimizing demand for water heating, cooling, lighting and power in individual buildings through efficient equipment and controls. In addition to optimizing the energy efficiency of the buildings, the residual energy demand for the site shall be met by Low or Zero Carbon (LZC) technologies.

The department for Business Enterprise and Regulatory Reform (BERR) and Low Carbon Buildings Programme (LCBP) has recognized various technologies that can be considered as LZC technologies. (Refer to BRE Global 2008)

Third section of Energy management aims to promote the increased use of renewable energy sources to reduce the dependence on fossil fuels emitting carbon di-oxide and conserve the finite global fossil fuel resources. BREEAM Communities also encourages the future use of active solar technologies in buildings which are currently not intended to be installed with active solar devices by the developer.

**Analysis**

India ranks sixth in the world in terms of energy demand, accounting for 3.5 percent of the world’s commercial energy demand in 2011. Within the Asia-Pacific region, India has exhibited one of the fastest growth rates in commercial energy supply. India has the fifth largest installed power capacity of the world, the first four being US, Japan, China and Russia, and is one of the top power consumers.

India has witnessed an impressive growth rate in GDP. Increasing standards of quality of life necessitates a matching growth in the availability of energy. The development process is also driving a shift in energy use from non-commercial energy sources to commercial sources, particularly electricity. Electricity is the main driving force for development in today’s industrial world.

The power demand in India is set to explode in the coming years. Various estimates suggest that if India wants to sustain a 8-9% GDP growth over the long term, it will need to have 400,000 MW of installed capacity by 2020. India is facing formidable challenges in meeting the energy requirements and providing adequate energy to users in a sustainable manner and at affordable costs.
Large developments have multiple uses of electricity and need a distribution network to distribute electricity among different types of users. During electricity distribution, parts of electricity get lost in distribution network. Guideline for Energy Efficient Electrical Systems aims to promote optimization of this technical loss. In addition to this, Street lighting is a very important element in the large development and consume up to 10% of the total energy used. Designing optimized systems using efficient lighting equipment and controls will provide energy efficiency benefits and potential economic benefits by increased commercial activity due to properly lit and safe circulation in large developments. Guideline for efficient street lighting systems is designed with the same intent.

Since all new developments are located in the outskirts and open areas, reliable and efficient supply of electricity becomes a critical factor. Smart Grids attempt to predict and intelligently respond to the behaviour and actions of all electric power users connected to it and efficiently deliver reliable, economic, and sustainable electricity services. Guideline on smart grids aims to foster demand side management and demand side response, reduce power outages, increasing reliability, efficiency, and safety of the grid, reduce carbon footprint and minimize fossil fuel consumption and provide better autonomy to customers to manage their electricity needs.

**Socio cultural**

The population of the world is projected to increase by more than one-third over the next 2 decades adding two billion people (United Nations, 2002). This additional growth is set to concentrate in urban areas. Cities around the world gain roughly millions of new residents a week. It is projected that by 2015 the world will have 21 mega cities. With this the burden on the environment is projected to increase significantly.

We are currently looking at the world of urbanization. Urbanization refers to an influx in population within a city, over a period of time. Many assume that there is a direct correlation between economic growth and urbanization.

Urbanization’s ethical dilemma confronts economic growth and sustainable development. Humankind must promote an environmental ethic through governance, population planning, participation and empowerment.

Any sustainable development must further social, economic and environmental development on a large scale. The disparity between the rich and poor will continue to widen without proper implementation of effective management.

---

41 Understanding Urbanization's Effect on Sustainable Development, Andrew Moreno, Lifted Magazine 2007
IGBC India

The rapid growth of cities can be attributed largely to urban rural migration. Urban growth results in a lot of movement as more and more people move from villages to live in cities.

IGBC India encourages the project to take up various social initiatives, within or outside the project boundary to create a harmonious relationship with the local community and develop strategies for their welfare and rehabilitation. Social initiatives such as promoting local traditions through craft and cottage industry, creating employment opportunities for local farmers, provision of schools and hospitals and any other initiative which shall contribute towards the welfare of the local community are encouraged by the system.

For community interaction and healthy wellbeing of the users, the system encourages the developer to provide open landscaped areas to an extent of at least 20% of the total area considered. IGBC Green Townships also addresses the need for secure and affordable food production systems to minimize environmental damage from long distance transportation of food. At least 5% of vegetable and fruit requirements of the community shall be met by dedicated permanent and viable production areas within the site.

The system also encourages developers to provide opportunities of employment for people within the township to combat sprawl and reduce long distance travel and emissions associated with it. The development must ensure diverse employment opportunities (part time, technical jobs, service oriented jobs, retail and hospitality, etc) which cater to all sections of the society.

To retain the cultural heritage and character of the site considered for development, the system encourages to integrate existing buildings of cultural and historical importance in the planning process for economic, cultural, environmental and community benefits. The intent of the guideline is to restore and reuse historical buildings to maintain cultural connectivity and reduce environmental impacts associated with new construction.

* Risk and crime mitigation not addressed

CASBEE Japan

Since Japan faces potential catastrophic risk of earthquake in most of its regions, Disaster and crime prevention become one of the key aspects to be considered before a development takes off from the master plan. The system encourages and evaluates consideration of earthquakes, landslides, floods and other disasters in land use planning for outdoor areas within the designated area. To minimize the scale of disaster
and prevent the expansion of destruction from multiple outbreaks of fire after a major earthquake, provision of appropriate open spaces, evacuation routes and urban fire-retarding divisions, district-scale zoning units which form an effectively arranged network of fire retarding belts, are addressed and encouraged in the guidelines for risk mitigation (IBEC, 2007).

Developments are evaluated according to the standard distance travelled between the furthest point and daily-use stores and facilities, medical and welfare facilities and educational and cultural facilities.

QUD3 evaluates efforts to raise the internal and external comfort of the designated area, through consideration of the community and residents, community formation and scenery. The first section focuses on the use of local resources and encourages developments where industries are set up to employ the traditional local skills and abilities of diverse human resources and promotes the use of locally-produced materials for building cladding, paving and other materials. The next section encourages conservation and reuse of historical, cultural and natural assets which characterize the designated region.

With a view to regional promotion, CASBEE encourages development of facilities and open spaces (green spaces, plazas, waterside areas) as centres for community activity and interaction and promotes inter-generational exchange in the community within the designated area to create an environment where all generations can live together with balanced lives.

To ensure that the new development is suitable for the surrounding community, the system encourages participation by residents of the designated area in the planning processes, participation by building users and residents in maintenance management and urban development beyond completion of the project and participation by nearby residents in post completion maintenance, management and urban development.

* Risk and crime mitigation addressed

**PEARL Community Rating System**

The risk assessment forms the basis for determining the extent of safety & security measures implemented for a specific development. “Safe and Secure Community” in the living communities section aims to provide a safe and secure environment for the community’s occupants and visitors. The system encourages the adoption of appropriate strategy outlining the approach to mitigate risks identified by the risk assessment.
The safe and security layout plan shall be designed in accordance with the CPTED (Crime Prevention through Environmental Design) design principles. (Pearl Community Rating System: Design & Construction, April 2010)

The system also encourages regionally responsive planning to reflect the unique climatic, social and historical influences of the site and region in the community plan.

* Risk and crime mitigation addressed

**BREEAM Communities, United Kingdom**

The Community section in BREEAM addresses the development’s ability to create a sense of place, and have a positive effect on the local community and environment. It includes character and innovation, form and materials, internal environment and urban and social integration. (BRE Global 2008: page 127)

The first section encourages the construction of accessible and easily adaptable buildings to meet the changing needs of current and future occupants, thus creating an inclusive community.

To ensure that the needs, ideas and knowledge of a community are considered to enhance the quality and acceptability of the development, community involvement is promoted in the design of the development. It focuses on actively engaging the local community stakeholders at different stages of design.

BREEAM Communities also addresses the social aspects of development post occupancy. A development user guide with information on local transport services, utility suppliers, energy efficiency measures, local amenities, water conservation tips, etc developed for both the site and the eventual building shall be prepared and circulated in the community for compliance with the criterion.

To ensure proper functioning of the community facilities, the system encourages the existence of a management structure. It promotes a community owned and led Community Development Trust that operates in both urban and rural areas to bring about long-term social, economic and environmental benefits in the community.

Risk mitigation is addressed to ensure that sites and developments take due account of flood risk, and where it is present. The content of a FRA (Flood Risk Assessment) shall be appropriate to the scale and nature of the development and address important issues such as development description and location, definition of the flood hazard, probability, detailed development proposals, flood risk management measures, off site impacts, residual risks and climate change.
Analysis

Ongoing urban development attracts an increasing number of migrants. Despite the benefits of urban development, problems with inequality among the social groups continue to exist. Many cannot achieve their expectations because lack of employment opportunities and overpopulation grossly exceeds the opportunities created by the urban economies. Often referred to as a process of building a "community", the merging of different social classes is rare to observe.

The long term impact of past industrialization, exploitation and environmental damage cannot be wished away. The development in today’s century has to be conscious of its long term impact. In 1972, the then Prime Minister of India, Mrs. Indira Gandhi emphasized, at the UN Conference on Human Environment at Stockholm, that the removal of poverty is an integral part of the goal of an environmental strategy for the world. The concepts of interrelatedness, of a shared planet, of global citizenship, and of ‘spaceship earth’ apply equally to the responsibilities of environmental protection and human development.

Poverty and a degraded environment are closely inter-related, especially where people depend for their livelihoods primarily on the natural resource base of their immediate environment. Improving natural resource management practices and restoring natural systems at grassroots level are central to strategy to eliminate poverty. Conventional economic development leads to the elimination of several traditional occupations. The process of sustainable development, guided by the need to protect and conserve the environment, leads to the creation of new jobs and opportunities for the reorientation of traditional skills to new occupants.

Wasteful consumption linked to market driven consumerism is stressing the resource base of developing countries. To counter this, desirable limits and standards for consumption need to be established and applied through appropriate mechanisms including education and incentives. Basic education is also an essential part of sustainable development to enable the poor to access the benefits offered by development initiatives and market opportunities.

The integration of agriculture with land and water management, and with ecosystem conservation is also very essential for both environmental sustainability and agricultural production. To ensure the sustainability of natural resource base, the recognition of all stakeholders in it and their roles in its protection and management is essential. Although India has increased its production from less than 100 million tons per year in early sixties to 195 million tons per year in this decade, self sufficiency in dynamic socio-economic framework in a sustainable nature needs urgent attention and scientific guidance.

---

42 Sustainable Development in India : Perspectives by Sunderlal Bahuguna
Water management

While the world's population tripled in the 20th century, the use of renewable water resources has grown six-fold. Within the next fifty years, the world population will increase by another 40 to 50%. This population growth coupled with industrialization and urbanization will result in an increasing demand for water and will have serious consequences on the environment.

Below figure clearly reflects that water stress situation of the country. The entire country is falling under high to very water stress zones. The situation is likely to get worsened in due course of time.

Source: WaterGAP 2.0 - December 1999

IGBC Green Townships

Water management is addressed in the infrastructure management section of IGBC Green Townships. The intent of the guidelines is to harvest rainwater in order to enhance the ground water table and reduce municipal water demand. The minimum volume collected should be 25% of 5-year average one day rainfall for any given site or location.

Treatment of waste water is an important aspect to avoid pollution of water streams. IGBC Green Townships encourage developments to provide centralized waste water treatment infrastructure to treat 100% waste water that is generated within the designated area as per minimum quality standards defined by Central or State pollution control board. To reduce the demand for municipal water, in addition to rain water harvesting, use of recycled or treated water is encouraged for irrigation, flushing and water based heat rejection systems.

*Water use guidelines, efficient systems not addressed.
CASBEE Japan

PEARL community rating system

Limited rainfall, hot climate and significant embodied energy involved in desalination of water emphasize on the need of water conservation for Estidama. The precious water section of Pearl Community Rating system includes the community water calculator to be used throughout the design process. The calculator assists the developer to access the supply and outflow of water for the designated area.

The first section aims to develop a comprehensive water strategy during early stages of design to reduce overall water consumption within the community. Water strategy developed for the community should address minimum water requirement for irrigation, water features and district cooling system. The intent of the guideline is to ensure that the non-recoverable community water demand associated with irrigation, heat rejection and water features, does not overburden the available building waste water.

* Community water balance = (Water consumption x municipal recycled water efficiency) – irrigation demand – district cooling – water features

The next section encourages the use of Building Water Guidelines for occupants of the community to promote water conservation in buildings within the designated area. A significant amount of water is sometimes wasted due to leakage, system degradation or failure. To ensure minimum loss of water, the system encourages designs where water transmission and distribution facilities are installed with water meters to monitor water network and detect leakage in the system.

For any given community or development, buildings, water features, irrigation systems and heat rejection systems consume large amount of water and sometimes supersede the supply. Use of efficient irrigation technologies, selecting appropriate plant types, using recycle water and adopting alternatives to water based heat rejection systems are various measures encouraged by the system to reduce the community water usage.

Water reduction targets for the interior water use of all buildings is encouraged to promote reductions in the water consumption of buildings and associated plots within the community.

BREEAM Communities, United Kingdom

Two third of water used by those living in Britain is 'imported', says the institute, and often from countries that are already suffering from shortages (www.edie.net - Faversham House Group Ltd 2010). Population growth, urbanisation, changing diets, pollution of water resources and climate change, global water resources are set to put further stress on supplies.
Water is one of the most undervalued natural commodities in the world, directly affecting national security through its impact on economic growth, energy security, food supply and healthcare. UK's water footprint is impacting on global water scarcity (www.edie.net - Faversham House Group Ltd 2010).

**Analysis**

Water is a precious natural resource supporting human activities and ecosystems, and at the same time very complex to manage judiciously. Despite the growing urbanization, 2/3 of urban population still lacks access to basic services, such as safe and clean water and sanitation. This shows that rapid urbanization and increasing demand is causing conflicts around water service delivery. As per India’s Initial National Communication to the United Nations Framework Convention on Climate Change, it is projected that severity of droughts and intensity of floods in various parts of India is likely to increase. Further, a general reduction in the quantity of available runoff is also projected.

Although efforts are being made to promote improved water management practices such as water conservation, artificial recharge and watershed management, and integrated water development, the projected water demand of over 980 billion cubic meters in 2050 will require intensive development of guidelines for water usage on large scale.

Water consumption in large developments largely depends on the available water resources and land use within the designated area. Currently, all upcoming developments in India are facing issues of water shortage at the supply end. This is due to the growing needs and limited resources. Analysing the increased tendency for the commercialization of public sector water system operators, the increased involvement of private sectors in areas previously restricted to the public, water shortages, groundwater contamination and competition over limited resources, GRIHA guidelines for water management aims to address these issues holistically.

Per capita consumption of water is expected to increase to 167 litres/day by 2050. Cities are reaching out to distant water sources. Delhi and Chennai receive water from rivers that are 250 kms and 450 kms away. Growth of the Indian economy is driving increased water usage across sectors. Waste water is increasing significantly and in the absence of proper measures for treatment and management, the existing freshwater reserves are being polluted. As per the available data, only 31% of the 9,275 MM Litres per day of waste water generated by 23 metropolitan cities is treated. A change in the consumption patterns and increased demand of water for irrigation and industrial products is also seen.
Looking at the above situation, guidelines for sustainable water management on site include reducing landscape water requirement, providing adequate quality of water for potable & non-potable applications and deployment of water monitoring and leak detection plan on community level. To ensure a sustainable waste water management system, the guidelines emphasize on treating municipal supply of water, groundwater or harvested water and promote application of dual plumbing systems to recycle and reuse treated waste water on site.
Annexure 2: Green building materials

Production, manufacture, installation and recycling of building materials consume significant amounts of non-renewable resources and energy and produces harmful wastes as by-products. Any material to be used is to be analysed on a life-cycle basis, both in terms of environmental impact and cost.

The basic characteristics of green building would be –

- Potential to conserve natural resource
- Low embodied energy
- Potential of recycling and reuse
- Low emission of toxic substance or pollutants at each stage of their life cycle.
- Adaptability to low-energy construction systems
- Local availability

Alternatives to energy intensive materials

Cement/Concrete

Cement manufacturing being highly energy-intensive process and since in mass construction cement is mostly used in concrete in large quantities, the amount of cement in concrete can be reduced by replacement with feasible alternatives.

These are:-

- Use of recycled aggregates such as crushed concrete, brick, glass or other masonry waste
- Use of lightweight concrete (aluminium powder added to lime produces a lightweight cementations material)
- Ready-mix concrete or high-volume fly ash concrete or pozzolana material Blended Portland cement (BPC) concrete for construction (commercially available from ACC, Lafarge cement, JaypeeBuniyad, etc.) may be used
- Pozzolana material content (Flyash/ blast furnace slag/calcined clay) attained through use of BPC as per IS 1489 (flyash and calcined clay based) or IS455 (slag based) or direct addition of pozzolana material (flyash as per IS3812).
Metal

- The major metal used in building industry is steel followed by aluminium. Steel has good scrap value while has the highest recyclable content. The alternatives are –
  - Use of steel plates, sheets and tubes manufactureds with processes that use high-recycled content.
  - Using roofing sheets, window frames and cladding systems using recycled aluminium.
  - Use of salvaged steel and recovered aluminium scrap for non-structural uses.

Masonry units

Walling system constitutes major part of the structure of building and hence contributes to a large percentage the total embodied energy. In addition to brick and concrete masonry blocks where cement is replaced by lime, gypsum, fly ash, furnace slag or waste wood fiber, rice husk ash etc. The following masonry units as an alternative to burnt brick may be used:

- Stablized compressed earth blocks – solid or hollow
- Stabilized adobe mud blocks (sun dried mud blocks mixed with fly ash, lime and gypsum)
- Clay fly ash burnt bricks
- Fly ash sand lime bricks
- Clay red mud burnt bricks (made from bauxite and clay)
- Lacto blocks (laterite soil and cement or lime)
- Precast stone blocks (waste stone pieces with lean cement concrete, obliterates plaster)
- Precast concrete blocks – (Solid or hollow) can be used as roofing blocks or prefab floor slabs also.
- Fly ash based aerated cellular concrete blocks (flyash, lime or cement gypsum and aluminium powder) can be used as roofing blocks or prefab floor slabs also.
- Autoclave Cellular Concrete (ACC-a lightweight, precast building material) also known as AAC (Autoclaved Aerated Concrete)
Mortars and plasters

The consumption of cement in mortars and plasters can be reduced by modifying the conventional cement and sand mixture. Fly ash or rice husk ash, both waste products can be added in suitable proportion replacing cement and surkhi (the pozzolona commonly used in India).

Wood

The main issue concerning wood pertains to its origin, which should be from a sustainably harvested source. Since it has large applications as a building material as also for furniture, alternatives using wastes from sawmill paper etc. have to be thought of. Some engineered or composite products that would replace primary wood are:

- Hard boards (800-1200 Kg/ M3) – made by pressing wood fibers to form panels.
- Particle board/ medium density fiberboard (1600-8000 Kg/m3) - made from chips, flakes, splints or fibers or wood bound with glue or reign to form boards. These can also be made using agricultural residues such as bagasse, jute stick, cotton stalk, straw and rice-husk.
- Low density fiberboards (400 to 600 Kg/m3) – made from recycle paper and wood fiber without any adhesive.
- Block boards and veneered wood panels – made from core strips of solid laid side-by-side and glued. On this the outer veneers are glued.
- Rapidly renewable materials/products which are made from small diameter trees and fast growing low utilized species harvested within a 10 year lifecycle or shorter such as bamboo, rubber, eucalyptus, poplar, jute/cotton stalks. The products include among others, engineered products, bamboo ply boards, rubber, jute stalk boards.
- Products utilizing industrial waste, agricultural waste, such as fibrous gypsum plaster boards
- Mica laminates and veneer on composite boards instead of natural timber

Applicability of the composite panels

- Medium density fiberboard – doors and windows, paneling, ceiling, flooring, partitioning and built in furniture.
- Low density fiberboard – Thermal /acoustic insulation, wall and ceiling linings.
- Particle boards – paneling, false ceilings, flooring, partitioning and furniture
- Cement bonded composite paneling – partitions, cladding, false ceilings.
- Bamboo ply panels – false ceiling, partitions, door shutters furniture
- Jute stalk board panels – false ceilings, partition walls, paneling and furniture
- Rice husk board – Partitions, false ceilings, boards, panels.

**Use low Volatile Organic Compounds (VOC) paints/adhesives/sealants**

Following are recommended:

- Water-based acrylics over solvent-based paints.
- Cement paint/epoxy resin paint for external surfaces.
- Water based enamels, primers and polishes.
- Acrylics, silicones and siliconized acrylics are the safest sealants for use in the interiors. Solvent based products such as urethanes and butyls should preferably not be used indoors, they can be used for exteriors.
- Adhesives with low VOC or no VOC emissions such as acrylics or phenolic resins.
- In case of using composite wood products it should be ensured that such products do not contain any added urea formaldehyde resin.

The VOC (Volatile Organic Compounds) content of paints, coatings and primers used must not exceed the VOC content limits mentioned below:

- **Paints**
  - Non-flat - 150 g/L
  - Flat (Mat) - 50 g/L
  - Anti corrosive/anti rust - 250 g/L
- **Coatings**
  - Varnish - 350 g/L

---

*VOCs are carbon compounds that evaporate at room temperature and react in sunlight to help form ground-level ozone, an integral component of photochemical smog. VOCs can cause respiratory, skin and eye irritation; headaches; nausea; muscle weakness; and more serious ailments and diseases.*
- Lacquer - 550 g/L
- Floor coatings - 100 g/L
- Stains - 250 g/L
- Sealers
- Waterproofing sealer - 250 g/L
- Sanding sealer - 275 g/L
- Other sealers - 200 g/L

Examples of low-energy products and technologies used in structural applications
- Technologies such as pre-stressed slab, extruded structural clay joist and filler slab, hollow floor/roof slabs, precast reinforced brick/tile panels, pre-cast waffle/ cored units, pre-cast in situ thinribbed slabs, filler slabs or burned clay filler pots with RCC structure, micro-concrete roofing, precast hollow plank roofing, funicular shells, zipbloc system, composite columns, reinforced grouted brick masonry, stone masonry, precast stone blocks, pre-cast concrete blocks, pre-cast finished concrete blocks, light-weight concrete blocks over dense concrete blocks, and rat trap masonry.

Non-structural application: masonry/infill wall system
- Infill wall system using traditional mud walling system, stabilized adobe walling, compressed earth blocks, hollow, perforated/ modular bricks, interlocking bricks, traditional stone masonry, pre-castnon-load-bearing concrete blocks, finished concrete blocks, light weight concrete blocks over dense concrete blocks, pre-cast brick panels, composite ferrocement walling, interlocking concrete blocks, rat trap masonry.
Annexure 3: Glossary and Abbreviation

Site selection

Ecological sensitive zone:

Ecologically Sensitive Areas (ESAs) have been identified and notified by the Indian Ministry of Environment & Forests (MoEF) since 1989. Notifications declaring areas as ESAs are issued under the Environment (Protection) Act 1986. The clauses of the EPA which allow for the notification of ESAs hold the possibility of realising landscape-level conservation.

Sustainable urban environmental planning

Soil erosion: Soil is naturally removed by the action of water or wind. In general, background erosion removes soil at roughly the same rate as soil is formed. But 'accelerated' soil erosion — loss of soil at a much faster rate than it is formed — is a far more recent problem. It is always a result of mankind’s unwise actions, such as overgrazing or unsuitable cultivation practices. These leave the land unprotected and vulnerable. Then, during times of erosive rainfall or windstorms, soil may be detached, transported, and (possibly travelling a long distance) deposited. Accelerated soil erosion by water or wind may affect both agricultural areas and the natural environment, and is one of the most widespread of today’s environmental problems.

Sedimentation control:

A sediment control is a practice or device designed to keep eroded soil on a construction site, so that it does not wash off and cause water pollution to a nearby stream, river, lake, or bay. Sediment controls are usually employed together with erosion controls, which are designed to prevent or minimize erosion and thus reduce the need for sediment controls.

Mobility systems

Road hierarchy: A road hierarchy is a means of defining each roadway in terms of its function such that appropriate objectives for that roadway can be set and appropriate design criteria can be implemented.

Indian Roads Congress (IRC) Codes: Codes/norms devised by Indian Roads Congress for road design.
Right of Way (ROW): The legal right of a pedestrian, rider, or driver to proceed with precedence over other road users at a particular point. It is referred to the width of the land on which road is built, across from one plot boundary to the other.

Carriage way: It is defined as the width of the ROW which carries motorized vehicular traffic.

Design speed: It is the vehicular speed limit which the road has been designed to carry. Design speed is generally different for different categories of roads in the hierarchy based on function.

Arterial road: Roads for intra-urban through traffic, with no frontage access, no standing vehicle, very little cross traffic and minimum roadway intersection spacing 500m.

Sub-arterial road: Roads for intra-urban through traffic, with frontage access but no standing vehicle, having cross traffic, high capacity intersections and minimum roadway intersection spacing 300 m.

Collector road: Streets for collecting and distributing traffic from and to local streets and also for providing access to arterial and sub-arterial roads, having free frontage access but no parked vehicles and having heavy cross traffic and minimum roadway intersection spacing 150 m.

Local road: Streets for access to residence, business or other abutting property, having necessary parking & pedestrian movement and free access.

Service road: Service road is normally provided along arterial and sub-arterial roads to give frontage access to abutting property.

Design service volumes: Design service volume is the volume of traffic in PCUs per hour that the road can carry. It is normally around 0.7 times the maximum capacity for which the road has been designed.

Passenger car unit (PCU): Capacity of urban roads is generally expressed in terms of a common unit, namely Passenger Car Unit (PCU). Each vehicle type is converted into equivalent PCU based on their relative interference values.

Intelligent Transport System (ITS): Intelligent Transport Systems utilize computers, communications, positioning and automation technologies to use available data to improve the safety and management of transportation.
Energy

**Electrical system:** An electrical system comprises of the infrastructure that brings in electric supply and consists of Electrical substation, transformers, distribution systems, circuit breakers, electrical meters, capacitors, etc.

**Power factor:** The power factor of an AC electric power system is defined as the ratio of the real power flowing to the load to the apparent power in the circuit, and is a dimensionless number between 0 and 1 (frequently expressed as a percentage)

**Distribution losses:** These losses are mainly on account of the losses in the cables and bus bars

**kW:** kilo Watts. kW is called actual or real power, or simply the amount of power that is available to do real work.

\[ kW = \text{Volts} \times \text{Amps} \times \text{Power Factor} \text{ or } [kVA \times \text{Power Factor}] \]

**kVA; kilo Volt Ampres** = kVA is known as “apparent” power. This is because only a portion of the available kVA may be available to do real work. The remainder is simply excess current.

\[ kVA = \text{Volts} \times A \]

**Power quality:** Power quality is the set of limits of electrical properties that allows electrical systems to function in their intended manner without significant loss of performance or life. The term is used to describe electric power that drives an electrical load and the load's ability to function properly with that electric power. Without the proper power, an electrical device (or load) may malfunction, fail prematurely or not operate at all.

**Luminaire:** luminaire is an electrical device used to create artificial light and/or illumination, by use of an electric lamp. All light fixtures have a fixture body, a light socket to hold the lamp and allow for its replacement—which may also have a switch to operate the fixture, and also require an electrical connection to a power source, often by using electrical connectors

**Ballast:** An electrical ballast is a device intended to limit the amount of current in an electric circuit. Ballasts vary greatly in complexity.

**Luminous efficacy:** It is a measure of how well a light source produces visible light. The luminous efficency describes the efficacy of a lamp. It is expressed as the ratio of the emitted luminous flux in lumen and the power used in watts.
**Illuminance:** Illuminance is the total luminous flux incident on a surface per unit area.

Smart mini-grid: It is an intelligent electricity distribution network, operating at or below 11 KV.

DERs: Distributed energy resource (DER) systems are small-scale power generation technologies (typically in the range of 3 kW to 10,000 kW) used to provide an alternative to or an enhancement of the traditional electric power system.

**Demand side management:** Demand Side Management (DSM), entails actions by the utility that influence the quantity or patterns of use of energy consumed by end users.

HSA and VSA; Horizontal Solar Angle and Vertical Solar Angle are the angles between Sun and the normal of the surface in vertical and horizontal plane.

**Fenestration:** All areas (including the frames) in the building envelope that let in light including windows, plastic panels, clerestories, skylights, glass doors that are more than one-half glass, and glass block walls.

**Fresh air intake:** An opening through which outside air is drawn into the building. This may be to replace air in the building that has been exhausted by the ventilation system or to provide fresh air for combustion of fuel.

**Heat load, heat loss or heat gain:** Terms for the amount of heating (heat loss) or cooling (heat gain) needed to maintain desired temperatures and humidity in controlled air. Regardless of how well-insulated and sealed a building is, buildings gain heat from warm air or sunlight or lose heat due to cold air and radiation. Engineers use a heat load calculation to determine the HVAC needs of the space being cooled or heated.
Louvers: Blades, sometimes adjustable, placed in ducts or duct entries to control the volume of air flow. The term may also refer to blades in a rectangular frame placed in doors or walls to permit the movement of air.

Orientation: It is the direction an envelope element faces, that is, the direction of a vector perpendicular to and pointing away from the surface outside of the element.

Lighting power density: It is calculated by dividing the total lighting load in wattage with total area (m²). The units are W/m².

Pump performance: Pump efficiency can be calculated based on the formula given below.

Efficiency: hydraulic power/electrical input power
Hydraulic power: Q (m³/s) × Total head, (hd – hs) (m)× ρ (kg/m³) × g (m/s²) / 1000
Where, hd – discharge head,
hs – suction head,
ρ – density of the fluid,
g – acceleration due to gravity

Water and wastewater management

Drip irrigation: Drip irrigation can help use water efficiently in meeting the irrigation requirements of a landscape. An irrigation method involving small pipes placed at the base of plants delivering water slowly to the plant roots. A well-designed drip irrigation system loses practically no water to runoff, deep percolation or evaporation.

Exotic/ornamental plants: The term is often used to describe plant species that have been, or are being, introduced in to parts of the world other than their historical or documented range by humans, often as ornamental plants.

Landscape: The art of arranging or modifying the existing features of (an area of land, a highway, and so on), to improve its appearance by planting trees, shrubs, or grass or altering the contours of the ground.

Lawns: A lawn is an area of recreational or amenity land planted with grass, and sometimes clover and other plants, which are maintained at a low, even height. Lawns are a standard feature of ornamental private and public gardens and landscapes in much of the world today.
Albedo: Albedo refers to the reflectance of a material. The higher the albedo of a material, the more it reflects the radiation falling on its surface. For example, a material with an albedo of 0.5 would reflect 50% of the total radiation falling on its surface.

**Micro-irrigation systems**: Micro-irrigation refers to low pressure irrigation systems that spray, mist, sprinkle or drip. The term ‘micro-irrigation’ describes a family of irrigation systems that apply water through small devices. These devices deliver water onto the soil surface very near the plant or below the soil surface directly into the plant root zone. In urban landscapes, micro-irrigation is widely used with ornamental plantings.

**Native species**: Any plant species that occurs and grows naturally in a specific region or locality. Native plant species do not require watering other than during the initial years of establishment.

**Pervious**: Perviousness refers to the tendency of a material to allow another substance to pass through it. For example, highly pervious paving can allow water to pass through it.

**Sprinkler irrigation**: Irrigation by pumping water under pressure through nozzles and spraying it over the land is called sprinkler irrigation. There are several types of portable sprinklers, and each type is best suited to certain lawn shapes and landscape configurations.

**Vegetated area**: An area or part of any site that has plantation or greenery on it in any form, that is, grass, plants, trees, and so on.

**Xeriscape**: Landscaping designed specifically for areas that are susceptible to drought or where water conservation is practiced. It refers to gardening in ways that reduce or eliminate the need for supplemental irrigation. Derived from the Greek xeros meaning ‘dry’, the term xeriscape means literally ‘dry landscape’.

**Solid waste management**

**Anaerobic**: A biochemical process or environmental condition occurring in the absence of oxygen

**Biodegradable**: A compound that can be degraded or converted to simpler compounds by microorganisms

**Biogas**: Biogas is a mixture of methane (70-75%), carbon dioxide (10-15%) and water vapor (5-10%). It is taken through a GI pipeline to utility points. Drains for condensed water vapor are provided online. The biogas burns with a blue flame and is ideal for cooking. Alternately, it can be used to produce electricity in a dual fuel biogas-diesel engine.
HRT: Hydraulic retention time is a measure of the average length of time that a soluble compound remains in a constructed reactor.

Compost: A mixture of organic wastes partially decomposed by aerobic and/or anaerobic bacteria to an intermediate state. It can be used as a soil conditioner.

GHG: Greenhouse gases are gases in an atmosphere that absorb and emit radiation within the thermal infrared range. This process is the fundamental cause of the greenhouse effect. Common greenhouse gases in the Earth's atmosphere include water vapor, carbon dioxide, methane, nitrous oxide, ozone, and chlorofluorocarbons.

Leachate: Liquid that has percolated through solid waste or another medium and usually contains extracted, dissolved and suspended materials, some of which may be harmful.

Anthropogenic: Anthropogenic means generated/caused through human activity.

**Risk mitigation/adaptation and climate change**

Mitigation: The UN defines mitigation in the context of climate change, as a human intervention to reduce the sources or enhance the sinks of greenhouse gases.

Adaptation: Adaptation refers to the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damage, to take advantage of opportunities, or to cope with the consequences.

Climate change: Climate change refers to a statistically significant variation in either the mean state of the climate or in its variability, persisting for an extended period (typically decades or longer). Climate change may be due to natural internal processes or external forcings, or to persistent anthropogenic changes in the composition of the atmosphere or in land use. Note that the Framework Convention on Climate Change (UNFCCC), in its Article 1, defines "climate change" as: "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods". The UNFCCC thus makes a distinction between "climate change" attributable to human activities altering the atmospheric composition, and "climate variability" attributable to natural causes.
### Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Full Form</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADaRSH</td>
<td>Association for Development and Research of Sustainable Habitats</td>
</tr>
<tr>
<td>BIS</td>
<td>Bureau of Indian Standards</td>
</tr>
<tr>
<td>BREEAM</td>
<td>Building Research Establishment – Environmental Assessment Method</td>
</tr>
<tr>
<td>CASBEE</td>
<td>Comprehensive Assessment System for Building Environmental Efficiency</td>
</tr>
<tr>
<td>CFC</td>
<td>CholoroFluoro Carbons</td>
</tr>
<tr>
<td>EC</td>
<td>European Commission</td>
</tr>
<tr>
<td>ECBC</td>
<td>Energy Conservation Building Code</td>
</tr>
<tr>
<td>EIA</td>
<td>Environmental Impact Assessment</td>
</tr>
<tr>
<td>EU</td>
<td>European Union</td>
</tr>
<tr>
<td>GRIHA</td>
<td>Green Rating for Integrated Habitat Assessment</td>
</tr>
<tr>
<td>HVAC</td>
<td>Heating Ventilation and Air Conditioning</td>
</tr>
<tr>
<td>MNRE</td>
<td>Ministry of New and Renewable Energy</td>
</tr>
<tr>
<td>MoEF</td>
<td>Ministry of Environment and Forests</td>
</tr>
<tr>
<td>MoUD</td>
<td>Ministry of Urban Development</td>
</tr>
<tr>
<td>LEED</td>
<td>Leadership in Energy and Environmental Design</td>
</tr>
<tr>
<td>NBC</td>
<td>National Building Code</td>
</tr>
<tr>
<td>NAAQS</td>
<td>National Ambient Air Quality Standards</td>
</tr>
<tr>
<td>NUTP</td>
<td>National Urban Transport Policy</td>
</tr>
<tr>
<td>PCRS</td>
<td>Pearl Community Rating System</td>
</tr>
<tr>
<td>RSPM</td>
<td>Respirable Suspended Particulate Matter</td>
</tr>
<tr>
<td>SEZ</td>
<td>Special Economic Zone</td>
</tr>
<tr>
<td>SP</td>
<td>Special Publication</td>
</tr>
<tr>
<td>TERI</td>
<td>The Energy and Resources Institute</td>
</tr>
<tr>
<td>Acronym</td>
<td>Description</td>
</tr>
<tr>
<td>---------</td>
<td>-------------</td>
</tr>
<tr>
<td>UDPFI</td>
<td>Urban Design Planning Formulation and Implementation guidelines</td>
</tr>
<tr>
<td>USEPA</td>
<td>United Stated Environmental Protection Agency</td>
</tr>
<tr>
<td>WHO</td>
<td>World Health Organization</td>
</tr>
</tbody>
</table>
Annexure 4: Reference

Andrew Moreno, Lifted Magazine 2007. Understanding Urbanization’s Effect on Sustainable Development,

Sustainable Development in India: Perspectives by Sunderlal Bahuguna


Accessible Natural Greenspace Standard (ANGSt)

Centre for Science and Environment, 2008, Do-it-yourself: Recycle and Reuse wastewater-decentralized sewage treatment options.

MoEF, 2010, Report of the Committee to Evolve Road Map on Management of Wastes in India, Ministry of Environment and Forests, Govt. of India.
MoEF, 2010, Report of the Committee to Evolve Road Map on Management of Wastes in India, Ministry of Environment and Forests, Govt. of India.


Lankao, P R, 2007. “Are we missing the point? Particularities of urbanization, sustainability and carbon emissions in Latin American Cities”, Environment and Urbanization Vol 19, No 1, April, pages 159–175


European Union, 2009. ‘Adaptation to climate change-Policy instruments for adaptation to climate change in big European cities and metropolitan areas’.


Millennium declarations in the UN Millennium summit in September 2000


TERi & TVPL, 2009, Environmental Building Guidelines for Hyderabad Metropolitan Area, HMDA.
www.urbanindia.nic.in


Best Development Practices: A Primer, EPA Smart Growth Network.

Walking Distance Research, Fairfax Government, TOD Committee

http://cpcb.nic.in/oldwebsite/Plastic%20Waste/Reuse_of_plastic_waste_in_road_construction.html

http://www.cwet.tn.nic.in/Docu/233_potential_stations_as_on_31_03_11

http://eosweb.larc.nasa.gov/cgi-bin/sse/grid.cgi
