INDIAN RAILWAY
STATIONS DEVELOPMENT
CORPORATION LIMITED

05

Environment Management Guidelines for Station (Re)development

Table of Content

List of Figures

List of Tables

Preface

The Development Control plays an important role in guiding and facilitating the physical Development. Since the commercial development along with station redevelopment in the railway land is to be done under Section 11 of the Railways Act 1989, there was a need to have set of Manuals/Guidelines to guide the entire development. In fact the Union cabinet has approved (in terms of communication received from Ministry of Railways, GOI vide letter No. 2011/LMB.WCS/22/07/25 Pt.1 dated 17.10.2018) that 'Railways/RLDA/IRSDC shall consult urban local bodies/other statutory authorities while approving its plans in terms of powers conferred to it under Section 11 of the Railways Act 1989 so that the development in Railway Land is harmonious with surrounding development, generally following National Transit Oriented Development (TOD) Policy. No change in Land Use is required pan India by Railways for developing railway land for commercial use.' It is further approved that IRSDC shall be the Nodal Agency and the main Project Development Agency for redevelopment/development of all stations. MoHUA has also conveyed the approval of Union Cabinet to Chief Secretaries of All States/UTs to incorporate suitable provisions in the local byelaws/ development control norms in congruence with the National TOD Policy as well as relevant provisions of the Railways Act to facilitate Railways/RLDA/IRSDC to proceed with their development plans in consultation with local bodies/other statutory authorities, at the earliest.

Accordingly as the Nodal Agency for station redevelopment, IRSDC took upon the responsibility, on behalf of Railways/RLDA besides for guiding its own work for station redevelopment along with commercial development, to produce a series of Manuals/Guidelines to guide the Architects/Developers/Concessionaires as well as the Authority on the Procedures, Dos & Don'ts in preparing development plans and submitting the applications for approval of Layout Plans and Building Plans of the commercial development to IRSDC.

IRSDC aims to transform the railway stations and the adjoining land into a "RAILOPOLIS" - a Mini Smart 24/7 City Centre where one can live, work, play and ride while putting the land resources to optimal use following the National Transit Oriented Development Policy norms. The aim is to facilitate developments by streamlining policies and making the Manuals/Guidelines as transparent as possible to promote ease of doing business. The Manual on Form Based Codes explains various developments such as buildings set back, ground coverage, FAR, heights etc. while Manual on building plan approval and commercial assets covers the process for the approval of building plans. The Manuals are mandatory while the Guidelines are Recommendatory and the Development Agreement/Concession Agreement or any other legal agreement between IRSDC (Authority) and Developments/Concessionaires shall prevail over and above the guidelines.

The advantage of the Manual on Form Based Codes is that it facilitates flexibility in development of mix use (horizontal and vertical mixing) to make the development sustainable, user friendly and market responsive while most of the local building byelaws restrict mixing which is essential for development of TOD. The guidelines propose good practices related to Construction Standards that promote and protect health, safety and general welfare of the occupant and environment across its life cycle while permitting dynamic building use.

These "Manuals for Station (Re)development including Commercial Development" is a comprehensive set of documents which provide standards and guidelines in the following order of decreasing priority-

1. Safety Standards, (like fire safety, earthquake related controls, etc.)
2. Passenger and user comfort and convenience.
3. Environmental Conservation (Natural and Man-made)
4. Heritage Conservation
5. Design and aesthetic in harmony

These Manuals and Guidelines have been prepared over a period, after research, site visits, case studies, best practices, study of other similar national, international designs, National TOD Policy and Form Based Codes (as advised by MoHUA), National Building Codes, UBBL-2016 and Environment Management Guidelines issued by MoEF&CC. Some of these have also been applied and tested on the on-going projects of IRSDC.

PUBLIC CONSULTATIONS: The (draft) Manuals and Guidelines were posted on IRSDC's website. These documents are available for reference at- www.irsdc.in.The stakeholder consultation was held via six (6) national webinars during April 2021- July 2021. The attendees were provided with a brief overview of salient features of the Manual, Guidelines, etc. Over 1300 participants, which included about 25 Government Agencies, Educational Institutions, Professional Bodies, Centres of Excellence, and senior professionals, attended, and shared their valuable feedback during the Webinars and over emails.

These Manuals and Guidelines have now been adopted for Station Redevelopment Works after incorporating relevant feedback and other suggestions by all the stakeholders. Further, final draft Manuals and Guidelines were discussed in the Plan Sanctioning and Monitoring Committee (PSMC) where subject experts were also invited as

special invitees in July 2021. IRSDC's Board of Directors (BOD) has also deliberated on this subject in August 2021 for adoption and application to the program of (re)development of Railway Stations along with Commercial Development. These Manuals and Guidelines are expected to transform the railway area around stations into model development as envisaged also by MoHUA and spur similar development in surrounding area.

STRUCTURE OF ENVIRONMENT MANAGEMENT GUIDELINES FOR STATION REDEVELOPMENT

Sl. No.	Chapter	Content
1	Introduction	Introduction to this Guidebook, Empowerment, Procedure for obtaining EMP Clearance for Station Redevelopment Projects, Mandatory Compliances
2	Guidelines for Environmental Management	Guidelines for Air Quality monitoring and preservation, Environmental Management, Water quality monitoring and preservation, Noise monitoring and prevention, Energy Conservation measures, Waste Management, Green Cover, Sustainable Transport and to mitigate Human health issues
3	Environmental Management Plan (EMP)	Model Scope of Work for preparation of Environment Management Plans
4	Green Building Guidelines	Guidelines for Green Building Design
5	Appendix	Study of Natural Vs Engineered Systems of Air Conditioning and Water Management for Railway Station (re)development

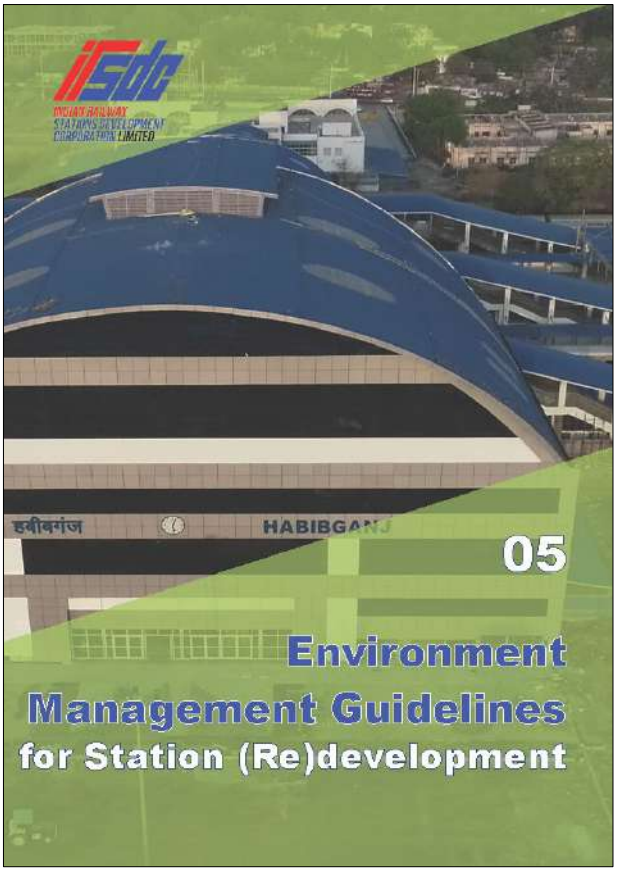
The manuals and guidelines are intended to be comprehensive for promoting balance and orderly development of railway stations and surrounding city area. Manuals and Guidelines inter-alia provide the framework, necessary technique, norms and standards, and development promotion techniques. Conditions may vary from place to place and accordingly these manuals and guidelines may be applied to all situations and places by adopting to local conditions. These manuals and guidelines fulfil the need for a planning process which facilitate efficient and dynamic station development in overall urban framework.

The manuals and guidelines are also intended to be a possible reference for various aspects of urban planning and design by State Governments, Development Authorities, Private Sector and Planning Organizations.

(Sanjeev Kumar Lohia)
Managing Director and Chief Executive Officer
Indian Railway Stations Development Corporation Ltd.

Section 0.1: About these Guidelines

Indian Railways envision that their Station Redevelopment works and Commercial Assets comply with the Environment Management Guidelines issued by Ministry of Environment, Forests and Climate Change, vide their letter no 19-172/2018-IA.III Dated 28.05.2020, address the concerns on par with Hon'ble NGT directives and the Indian Green Building Certification.

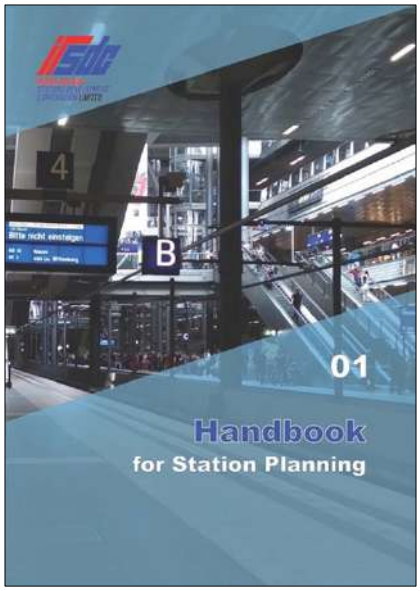


The guidelines are to be followed while preparing:

1. Station Redevelopment Scheme
2. Layout Regulating Plans
3. Sub-Plot Architectural Design
4. Environment Management Plan

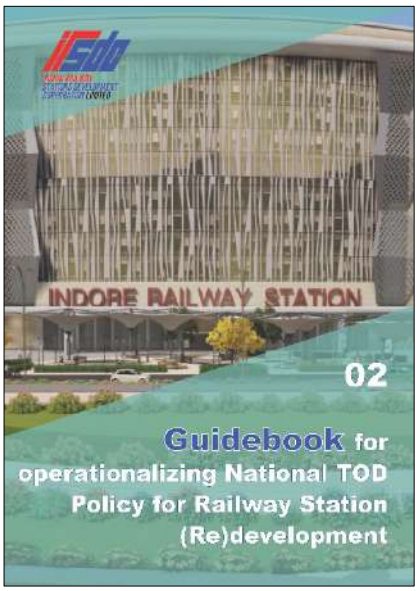
Table 1: Schedule of remaining parts of the Manuals for Station Redevelopment including Commercial Development

Handbook for Station Planning (for internal use only)



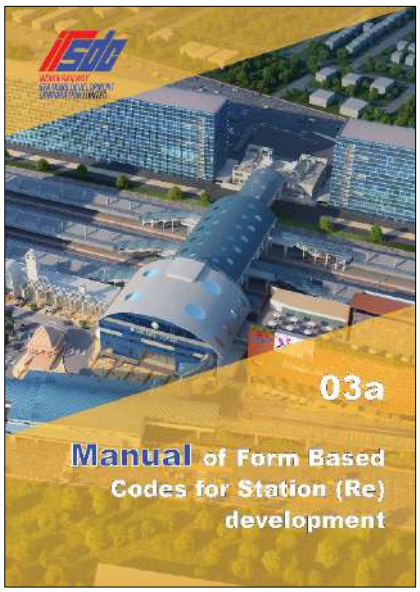
This document contains Norms, Standards and Tools for Design of Station Operational Areas.

Guidebook for operationalizing National TOD Policy for Railway Station (Re)development



This document contains Tools and Processes for Layout Planning within the Railway Land, with the intent of 'Land Value Capture' for optimum monetization.

Manual of Form Based Codes for Station (Re)development

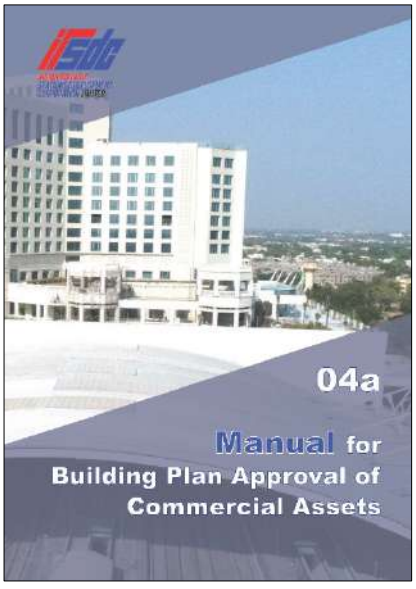


This document contains (a) Development Control Norms (b) Format for preparation of Layout Regulating Plans and (c) Parameters of Property Development Card.

Guidebook for Form Based Codes

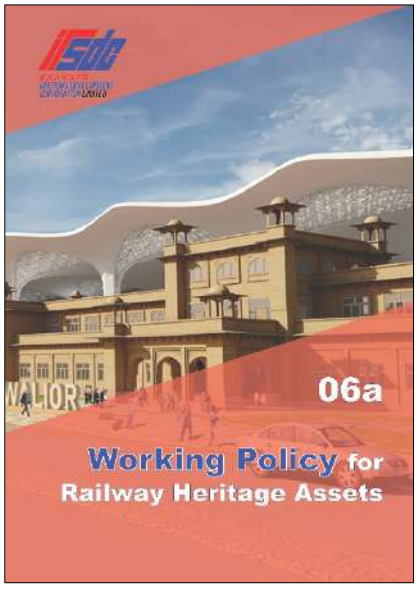
This document assists in preparation of Layout Regulating Plans and Property Development Card.

Manual for Building Plan Approval of Commercial Assets



This document contains the procedures and parameters for the approval of Building Plan of Commercial Assets.

Working Policy for Railway Heritage Assets



This document contains Working Policy for the desired response to Railway Heritage Assets.

Section 0.2: Inventory of Abbreviations and Definitions

0.2.1. Abbreviations

1.	AAC	:	Autoclaved Aerated Concrete
2.	BEE	:	Bureau of Energy Efficiency
3.	CFL	:	Compact Fluorescent Lamp
4.	CGWA	:	Central Ground Water Authority
5.	CGWB	:	Central Ground Water Board
6.	CPCB	:	Central Pollution Control Board
7.	CPHEEO	:	Central Public Health and Environmental Engineering Organization
8.	DG	:	Diesel Generator
9.	ECBC	:	Energy Conservation Building Code
10.	ECBC-R	:	Energy Conservation Building Code – Residential
11.	EIA	:	Environmental Impact Assessment
12.	EMP	:	Environment Management Plan
13.	EnHM	:	Environment and Housekeeping Management Directorate
14.	ESMF	:	Environmental and Social Management Framework
15.	GoI	:	Government of India
16.	HIRA	:	Hazard Identification and Risk Assessment
17.	IR	:	Indian Railways
18.	IRSDC	:	Indian Railway Stations Development Corporation
19.	LED	:	Light-emitting Diode
20.	MoEF&CC	:	Ministry of Environment, Forests & Climate Change
21.	MoHUA	:	Ministry of Housing and Urban Affairs
22.	MoR	:	Ministry of Railways
23.	MoUD	:	Ministry of Urban Development
24.	MSW	:	Municipal Solid Waste
25.	NBC	:	National Building Code 2016
26.	NOC	:	No Objection Certificate
27.	NTOD	:	National Transit Oriented Development
28.	PDA	:	Project Development Agency
29.	PWD	:	Public Works Department
30.	SEIAA	:	State Environment Impact Assessment Authority
31.	SPCB	:	State Pollution Control Board
32.	SQM/sq.m	:	square meter
33.	STP	:	Sewage Treatment Plant
34.	SuDS	:	Sustainable Drainage Systems
35.	TFL	:	Tubular Fluorescent Lamp
36.	ToR	:	Terms of Reference
37.	URDPFI Guidelines	:	Urban and Regional Development Plans Formulation and Implementation

Chapter 1: Introduction

Section 1.1: Empowerment

1.1.1. Vide letter no 2011/LMB/WCS/22/07/25 Pt-1 Dated 17.10.2018, Union Cabinet has approved IRSDC as the Nodal Agency and main Project Development Agency (PDA) for redevelopment/development of all stations and further approved that 'IRSDC shall consult urban local bodies/ other statutory authorities while approving its plans in terms of powers conferred to it under Section 11 of the Railways Act 1989 so that the development in Railway Land is harmonious with surrounding development, generally following National Transit Oriented Development (TOD) Policy. No Change in Land Use is required pan India by Railways for developing railway land for commercial use.'

1.1.2. Vide gazette notification no. 13/1/2017-INF dated 17-10-2017, Ministry of Finance (Department of Economic Affairs) has included "Railway terminal infrastructure including stations and adjoining commercial infrastructure" in the Harmonised Master List of Infrastructure Sub-sectors.

1.1.3. Ministry of Environment, Forests & Climate Change (MoEF&CC), vide their letter no 19-172/2018-IA.III Dated 28.05.2020 have clarified that: Projects in land appurtenant to "railway", identified for commercial development in and around railway stations shall be exempt from seeking prior environmental clearance under the provision of the EIA notifications, 2006 subject to the Following:

1.1.3.1. The projects shall draw up a sustainable Environment Management Plan (EMP), taking in to account all factors related to Environment Management viz. air pollution, water load, water pollution, land degradation, etc. The Ministry of Railways have an established Environment and Housekeeping Management (EnHM) Directorate, to specifically cater to Environmental concerns and mitigative measures in all facets of railway operations. IRSDC must have an Environment Management Plan for each Station Development project, duly approved by the EnHM Directorate of the Ministry of Railways, before undertaking any construction at site.

1.1.3.2. While individual Station Development projects may not require a specific Environmental Clearance from concerned SEIAA under the provisions of the EIA Notification. However, commercial development of building infrastructure in the premises shall have to fulfil standard environmental safeguards and stipulations, as listed in Sections 2 and 3 below.

1.1.3.3. The above notwithstanding, MoEF&CC reserves the right to monitor and verify the compliance of the stipulated guidelines/norms under the provisions of Environment (Protection) Act and its various subordinate legislations.

Section 1.2: Procedure for obtaining EMP Clearance for Station Redevelopment Projects

1.2.1. As conveyed by MoEF&CC vide letter dt. 28.05.2020, an Environment Management Plan (EMP) is to be approved from EnHM directorate of Railway Board as per procedure mentioned in it and reflected in this document, i.e. Environment Management Guidelines for Station Redevelopment..

1.2.2. Background: The Ministry of Environment and Forest issued notification on 14.09.2006 wherein it had specified the projects which require prior environmental clearance under the provisions of Environment (Protection) Rules, 1986 which does not include Railways. It has now been clarified that the projects in land appurtenant to 'railway', identified for commercial development in and around the railway stations shall be exempt from seeking prior environmental clearance under the provisions of the EIA notification, 2006 subject to conditions given in the letter referred in 1.2.1 above and reflected in this document, i.e. Environment Management Guidelines for Station Redevelopment. The conditions, therefore, are applicable on station redevelopment projects including commercial development.

1.2.3. In view of above, the modified procedure for obtaining EMP approval has to be followed. The model scope of work is for preparation of EMP as per the guidelines issued by MoEF&CC is as per Chapter 4. The EMP will be processed / scrutinised by an Environment Management Plan Approval Committee to be Set up by Ministry of Railways and detailed procedure as advised by the Committee as communicated subsequently.

1.2.4. The above procedure shall be applicable for all environmental clearances pending/ to be applied for all IRSDC projects.

Section 1.3: Mandatory Compliances

1.3.1. The project proponent shall submit all necessary/mandatory clearances/permissions from all relevant agencies and consultations with local bodies before commencement of work. All construction shall comply with applicable Manuals and Guidebooks.

1.3.2. The approval of the Competent Authority shall be obtained for structural safety of buildings due to earthquakes, adequacy of firefighting equipment etc. as per National Building Code including protection measures from lightening etc.

1.3.3. The project proponent shall obtain forest clearance under the provisions of Forest (Conservation) Act, 1980, in case of the diversion of Forest Land for non-forest purpose involved in the project.

1.3.4. The project proponent shall obtain the necessary permission for drawl of ground water/ surface water required for the project from the competent authority.

1.3.5. A certificate of adequacy of available power from the agency supplying power to the project along with the load allowed for the project should be obtained.

1.3.6. All other statutory clearances such as the approvals for storage of diesel from Chief Controller of Explosives. Fire Department, Civil Aviation Department shall be obtained, as applicable, by project proponents from the respective competent authorities.

1.3.7. The provisions of the Solid Waste (Management) Rules, 2016, e-Waste (Management) Rules, 2016, and the Plastics Waste (Management) Rules, 2016 shall be followed.

1.3.8. The project proponent shall follow the ECBC/ ECBC-R prescribed by Bureau of Energy Efficiency, Ministry of Power strictly.

Chapter 2: Guidelines for Environmental Management

Section 2.1: Guidelines for Air Quality monitoring and preservation:

2.1.1. Notification GSR 94(E) dated 25.01.2018 of MoEF&CC regarding Mandatory Implementation of Dust Mitigation Measures for Construction and Demolition Activities for projects requiring Environmental Clearance shall be complied with.

2.1.2. A Management Plan shall be drawn up and implemented to contain the current exceedance in ambient air quality at the site.

2.1.3. The project proponent shall install system to carry out Ambient Air Quality monitoring for common/ criterion parameters relevant to the main pollutants released (e.g., PM10 and PM25) covering upwind and downwind directions during the construction period.

2.1.4. Diesel power generating sets proposed as source of backup power should be of enclosed type. The diesel generator sets to be used shall be low Sulphur diesel type and shall conform to rules made under the Environment (Protection) Act, 1986.

2.1.5. The height of stack of DG sets should be equal to the height needed for the combined capacity of all proposed DG sets. The location of the DG sets may be decided with in consultation with State Pollution Control Board. The gaseous emissions from DG set shall be dispersed through adequate stack height as per CPCB standards. Acoustic enclosure shall be provided to the DG sets to mitigate the noise pollution.

2.1.6. Construction site shall be adequately barricaded before the construction begins. Dust smoke & other air pollution prevention measures shall be provided for the building as well as the site. These measures shall include screens for the building under construction, continuous dust/ wind breaking walls all around the site (at least 3-meter height). Plastic/ tarpaulin sheet covers shall be provided for vehicles bringing in sand, cement, murram and other construction materials prone to causing dust pollution at the site as well as taking out debris from the site.

2.1.7. Sand, murram, loose soil, cement, stored on site shall be covered adequately to prevent dust pollution.

2.1.8. Wet jet shall be provided for grinding and stone cutting.

2.1.9. Unpaved surfaces and loose soil shall be adequately sprinkled with water to suppress dust.

2.1.10. All construction and demolition debris shall be stored at the site (and not dumped on the roads or open spaces outside) before they are properly disposed. All demolition and construction shall be managed as per the provisions of the Construction and Demolition Waste Management Rules, 2016.

2.1.11. For indoor air quality, ventilation shall be ensured as per provisions of National Building Code of India.

Section 2.2: Guidelines for Water quality monitoring and preservation

2.2.1. The natural drain system should be maintained for ensuring unrestricted flow of water. No construction shall be allowed that obstructs natural drainage through the site, on wetland and water bodies. Check dams, bio-swales, landscape, and other sustainable urban drainage systems (SuDS) are allowed for maintaining the drainage pattern and to harvest rainwater.

2.2.2. Buildings shall be designed to follow the natural topography as much as possible. Minimum cutting and filling shall be allowed.

2.2.3. The quantity of freshwater usage, water recycling and rainwater harvesting shall be measured and recorded to monitor the water balance as projected by the project proponent.

2.2.4. A certificate shall be obtained from the local body supplying water, specifying the (i) total annual water available (with them), (ii) quantity already committed, (iii) quantity allotted to the project under consideration and (iv) balance water available. This should be specified separately for ground water and surface water sources, ensuring that there is no impact on other users.

2.2.5. At least 20% of the open spaces as required by the local building byelaws shall be pervious. Use of Grass pavers, paver blocks worth at least 50% opening, landscape etc. would be considered as pervious surface.

2.2.6. Installation of dual pipe plumbing for supplying fresh water for drinking, cooking, and bathing etc. and other for supplying recycled water for flushing, landscape irrigation, car washing, thermal cooling, conditioning etc. shall be done.

2.2.7. Use of water saving devices/ fixtures (viz. low flow flushing systems; use of low flow faucets tap aerators etc.) for water conservation shall be incorporated in the building plan.

2.2.8. Separation of grey and black water should be done by the use of dual plumbing system.

2.2.9. Water demand during construction should be reduced by use of pre-mixed concrete, curing agents and other best practices referred.

2.2.10. The local bye-law provisions on rainwater harvesting should be followed. If local bye-law provision is not available, adequate provision for storage and recharge should be followed as per the Ministry of Urban Development Model Building Byelaws, 2016. Rain water harvesting recharge pits/storage tanks shall be provided for ground water recharging as per the CGWB norms.

2.2.11. A rainwater harvesting plan needs to be designed where the recharge bores of minimum one recharge bore per 5,000 square meters of built-up area and storage capacity of minimum one day of total freshwater requirement shall be provided. In areas where ground water recharge is not feasible, the rainwater should be harvested, and stored to reuse. The groundwater shall not be withdrawn without approval from the Competent Authority.

2.2.12. All recharges should be limited to shallow aquifers.

2.2.13. No ground water shall be used during construction phase of the project.

2.2.14. Any ground water dewatering should be properly managed and shall conform to the approvals and the guidelines of the CGWA in the matter. Formal approval shall be taken from the CGWA for any ground water abstraction or dewatering.

2.2.15. No sewage or untreated effluent water would be discharged through storm water drains.

2.2.16. Onsite sewage treatment of capacity of treating 100% wastewater to be installed. The installation of the Sewage Treatment Plant (STP) shall be certified by an independent expert and a report in this regard shall be submitted to the Ministry before the projects commences its operation. Treated wastewater shall be reused on site for landscape, flushing, cooling tower and other end-uses. Excess treated water shall be discharged as per statutory norms notified by MoEF&CC. Natural treatment systems shall be promoted.

2.2.17. Periodical monitoring of water quality of treated sewage shall be conducted. Necessary measures shall be made to mitigate the odour problem from STP.

2.2.18. Sludge from onsite sewage treatment including septic tanks, shall be collected, conveyed, and disposed as per the Ministry of Urban Development, Central Public Health and Environmental Engineering Organization (CPHEEO) Manual on Sewerage and Sewage Treatment Systems, 2013.

Section 2.3: Guidelines for Noise monitoring and prevention

2.3.1. Ambient noise levels shall conform to standards for residential area/ commercial area/ Industrial area/ silence zone during day and night, as per Noise Pollution (Control and Regulation) Rules, 2000. Incremental pollution loads on the ambient air and noise quality shall be closely monitored during construction phase. Adequate measures shall be made to reduce ambient air and noise level during construction phase so as to conform to the stipulated standards by CPCB / SPCB.

2.3.2. Noise level survey shall be carried as per the prescribed guidelines and report in this regard shall be submitted to Regional Officer of the Ministry as a part of six-monthly compliance report.

2.3.3. Acoustic enclosures for DG sets, noise barriers for ground-run bays, ear plugs for operating personnel shall be implemented as mitigation measures for noise impact due to ground sources during construction.

Section 2.4: Guidelines for Energy Conservation measures

2.4.1. Compliance with the Energy Conservation Building Code (ECBC) of Bureau of Energy Efficiency shall be ensured. Buildings in the States which have notified their own ECBC, shall comply with the State ECBC.

2.4.2. Outdoor and common area lighting shall be LED or an improved version developed compatible to the purpose.

2.4.3. Concept of passive solar design that minimize energy consumption in buildings by using design elements, such as building orientation, landscaping, efficient building envelope, appropriate fenestration, increased day lighting design and thermal mass etc. shall be incorporated in the building design. Wall, window, and roof u-values shall be as per ECBC specifications.

2.4.4. Energy conservation measures like installation of CFLs/ LED for illuminating the area outside the building should be an integral part of the project design and should be in place before project commissioning.

2.4.5. Solar, wind or other Renewable Energy shall be installed to meet electricity generation equivalent to 1% of the demand load or as per the state level/ local building bye-laws requirement, whichever is higher.

2.4.6. Solar power shall be used for lighting in the apartment to reduce the power load on grid. Separate electric meter shall be installed for solar power. Solar water heating shall be provided to meet 20% of the hot water demand of the commercial and institutional building or as per the requirement of the local building bye-laws whichever is higher. Residential buildings are also recommended to meet its hot water demand from solar water heaters, as far as possible.

Section 2.5: Guidelines for Waste Management

2.5.1. A certificate from the Competent Authority handling municipal solid wastes, indicating the existing civic capacities of handling and their adequacy to cater to the MSW generated from project shall be obtained.

2.5.2. Disposal of Construction waste (and/ or Malba) during construction phase shall not create any adverse effect on the neighboring communities and be disposed taking the necessary precautions for general safety and health aspects of people, only in approved sites with the approval of Competent Authority.

2.5.3. Separate wet and dry bins must be provided in each unit and at the ground level for facilitating segregation of waste. Solid waste shall be segregated into wet garbage and inert materials.

2.5.4. Organic waste compost/ Vermiculture pit/ Organic Waste Converter within the premises with a minimum capacity of 0.3 kg /person/day shall be installed.

2.5.5. All non-biodegradable waste shall be handed over to authorized recyclers. Recyclers shall be appointed before project commences operation.

2.5.6. Any hazardous waste generated during construction phase shall be disposed-off as per applicable rules and norms with necessary approvals of the State Pollution Control Board.

2.5.7. Use of environment friendly materials in bricks, blocks and other construction materials, shall be required for at least 20% of the construction material quantity. These include Fly Ash bricks, hollow bricks, AACs. Fly Ash Lime Gypsum blocks, Compressed earth blocks and other environment friendly materials.

2.5.8. Fly ash should be used as building material in the construction as per the provision of Fly Ash Notification of September, 1999 and amended as on 27th August, 2003 and 25' January 2016. Ready mixed concrete must be used in building construction.

2.5.9. Any waste from construction and demolition activities related thereto shall be managed so as to strictly conform to the Construction and Demolition Waste Management Rules, 2016.

2.5.10. Used CFLs and TFLs should be properly collected and disposed off/sent for recycling as per the prevailing guidelines/ rules of the regulatory authority to avoid mercury contamination.

Section 2.6: Guidelines for Green Cover

2.6.1. No tree can be felled/ transplant unless exigencies demand. Where absolutely necessary, tree felling shall be with prior permission from the concerned regulatory authority. Old trees should be retained based on girth and age regulations as may be prescribed by the Forest Department.

2.6.2. A minimum of 1 tree for every 80 sqm of land should be planted and maintained. The existing trees will be counted for this purpose. The landscape planning should include plantation of native species. The species with heavy foliage, broad leaves and wide canopy cover are desirable. Water intensive and/or invasive species should not be used for landscaping. An area shall be earmarked for 'Green belt ' development.

2.6.3. Where the trees need to be cut with prior permission from the concerned local Authority, compensatory plantation in the ratio of 1:10 (i.e. planting of 10 trees for every 1 tree that is cut) shall be done and maintained. Plantations to be ensured species (cut) to species (planted).

2.6.4. Top soil should be stripped to a depth of 20 cm from the areas proposed for building, roads, paved areas and external services. It should be stockpiled appropriately in designated areas and reapplied during plantation of the proposed vegetation on site.

Section 2.7: Guidelines for Sustainable Transport

2.7.1. A Transport Management Plan, as per MoUD best practices; guidelines (URDPFI) shall be prepared to include motorized, non-motorized, public and private networks. Road should be designed with due consideration for environment, and safety of all road users. The road system can be designed with these basic criteria:

2.7.1.1. Hierarchy of roads with proper segregation of vehicular and pedestrian traffic.

2.7.1.2. Traffic calming measures

2.7.1.3. Proper design of entry and exit points

2.7.1.4. Parking norms as per applicable norms

2.7.2. Vehicles hired for bringing construction material to the site should be (i) in good condition, (ii) have a pollution check certificate, (iii) should conform to applicable air and noise emission standards and (iv) be operated during non-peak hours, as far as possible.

2.7.3. A detailed traffic management and traffic decongestion plan shall be drawn up to ensure that the current level of service of the roads within a 05km radius of the project is maintained and improved upon after the implementation of the project. This plan should be based on cumulative impact of ail development and increased habitation being carried out or proposed to be carried out by the project or other agencies in this 05 Kms radius of the site in different scenarios of space and time and the traffic management plan shall be duly validated and certified by the State Urban Development department and the P.W.D./ competent authority for road augmentation and shall also have their consent to the implementation of components of the plan which involve the participation of these departments.

Section 2.8: Guidelines to mitigate Human health issues

2.8.1. Applicable Central and/or State Labour laws along with all its provisions have to be implemented for the benefit of all workers working at the construction site and involved in loading, unloading, carriage of construction material and debris or working in any area.

2.8.2. All workers working at the construction site and involved in loading, unloading, carriage of construction material and debris or working in any area with dust pollution shall be provided with dust mask.

2.8.3. Emergency preparedness plan based on the Hazard Identification and Risk Assessment (HIRA) and Disaster Management Plan shall be implemented.

2.8.4. Provision shall be made for the housing of construction labour within the site with all necessary infra structure and facilities such as fuel for cooking, mobile toilets, mobile STP, safe drinking water, medical health care, creche etc. The housing may be in the form of temporary structures to be removed after completion of the project.

2.8.5. Occupational health surveillance of the workers shall be done on a regular basis.

2.8.6. A First Aid Room shall be provided in the project both during construction and operations of the project.

2.8.7. Disposal of e-waste shall be as per applicable Government of India Guidelines.

Chapter 3: Environmental Management Plan (EMP)

a. An Environment Management Plan (EMP) shall be drawn up for the respective station development project and shall be duly approved by the EnHM Directorate of the Ministry of Railways before undertaking any physical development at the site.

b. Action plan for implementing the respective EMPs and environmental guidelines along with responsibility matrix of the company shall be prepared and shall be duly approved by competent authority.

Section 3.1: Model Scope of Work

3.1.1. Model scope of work for preparation of Environment Management Plan (EMP) for Railway Station Redevelopment Project & Information to be included in EMP Report.

3.1.2. Examine details of land use as per Master Plan and land use around 10 km radius of the project site. Analysis should be made based on latest imagery.

3.1.3. Submit details of environmentally sensitive places, land acquisition status, rehabilitation of communities and present status of such activities.

3.1.4. Examine baseline environmental quality along with projected incremental load due to the project.

3.1.5. Environmental data (Primary/Secondary) to be considered in relation to the project development would be (a) land, (b) groundwater, (c) surface water, (d) air, (e) biodiversity, noise (g) socio economic and health.

3.1.6. Topography of project site, slopes, drainage pattern of the site and surrounding area shall be highlighted.

3.1.7. Examine the number of trees to be felled for the project and suggest appropriate compensatory plantation.

3.1.8. List out the compliances/NOC/permission to be obtained and also provide the time frame and differentiate the responsibilities IRSDC/ concessionaires/ Contractor/ Operator to obtain compliances/ NOC/ permission (if any) mentioned in MoEFCC guidelines given in Chapter 1.

3.1.9. Roles and responsibility of the developer etc for compliance of environmental regulations.

3.1.10. Examine the details of Source of water, water requirement, use of treated wastewater and prepare a water balance chart.

3.1.11. Rainwater harvesting proposals should be made with due safeguards for ground water quality. Maximize recycling of water and utilization of rainwater. Examine details.

3.1.12. Examine soil characteristics and depth of ground water table for rainwater harvesting.

3.1.13. Examine details of solid waste generation treatment and its disposal.

3.1.14. Examine and submit details of use of solar energy and alternative source of energy to reduce the fossil energy consumption. Energy conservation and energy efficiency.

3.1.15. DG sets are likely to be used during the construction and operational phase of the project. Emissions from DG sets must be taken into consideration while estimating the impacts on air environment. Examine and submit details.

3.1.16. Examine road/rail connectivity to the project site and impact on the traffic due to the proposed project. Present and future traffic and transport facilities for the region should be analyzed with measures for preventing traffic congestion and providing faster trouble-free system to reach different destinations in the city.

3.1.17. Examine detailed traffic and transportation study made for existing and projected passenger and cargo traffic.

3.1.18. Examine the details of transport of materials for construction which should include source and availability.

3.1.19. Examine separately the details for construction and operation phases both for Environmental Management Plan and Environmental Monitoring Plan with cost and parameters.

3.1.20. Examine the details of Disaster Management Plan including emergency evacuation during natural and man-made disasters.

3.1.21. Details of litigation pending against the project, if any, with direction /order passed by any Court of Law against the Project should be given.

3.1.22. The cost of the Project as well as the cost towards implementation of EMP should be clearly spelt out.

3.1.23. Social impacts of the project should also highlight along with appropriate mitigation measures if required

3.1.24. In the absence of Environmental and Social Management Framework (ESMF) specific to IRSDC projects, any further clarification on carrying out the above studies including anticipated impacts due to the project and mitigative measure, project proponent/consultant may refer to the model ToR available on MoEF&CC website and safeguards guidelines issued to IRSDC by MoEF&CC for the commercial development on the railways land (Given in Chapter 1).

3.1.25. Report Structure of EIA/EMP Report:

a) Introduction,
b) Project Description,
c) Analysis of Alternatives,
d) Description of Environment [Land Air, Water, Noise],
e) Anticipated Environmental Impacts and Mitigation Measures,
f) Environmental Monitoring Program, Additional Studies,
g) Project Benefits,
h) Environmental Management Plan,
i) Summary and Conclusion

Chapter 4: Green Building Guidelines

4.1. All stations are to be designed to meet 5 star/ platinum or equivalent rating from Indian Green Building Council or similar agency.

4.2. All Commercial Development to meet Green Building rating as per industry standards and Government regulations.

Appendix01- Study of Natural Vs Engineered Systems of Air Conditioning and Water Management for Railway Station (re)development

Part 1. Opting for a non-AC fan-ventilated high ceiling space vs. an Air- conditioned space:

a) *In general, it has been decided that as per MSSR, concourse and lobby common areas of the redeveloped stations shall NOT be air-conditioned, and temperature shall be maintained as ± 10 °C of the external ambient temperature.*

More than just the dry-bulb temperature as measured by the "external ambient temperature", human comfort is affected by *mean radiant temperature*, determined by the surface temperatures of objects surrounding the human body. The combined effect of surface and air temperatures are included in a concept known as operative temperature, which is simply the arithmetic mean of the air temperature and the mean radiant temperature (weighted mean of all the surfaces "seen" by the point at which the temperature is being taken).

I would like to propose that all the *operative* temperatures of the concourse/waiting spaces be maintained at ± 8 °C of the external operative temperature, since this is possible to achieve without recourse to engineered systems. The proposal needs to be extensively researched as it is simply an expert's hunch: it is not yet established in Indian practice. The closest researchers who understand these ideas in India are to be found at the Center for Advanced Research in Building Science & Energy (CARBSE), at CEPT University, Ahmedabad.

Traditionally, air-conditioning temperature set-points were set to 24 ± 1 °C following early twentieth-century pathbreaking research work by ASHRAE (American Society for Heating, Refrigeration, and Air-Conditioning Engineers), mainly conducted in warm humid Florida. Due to the late twentieth-century work of Scottish researcher Fergus Nicol, mainly in Pakistan and India, the *adaptive* standard of comfort has been accepted internationally, most notably by ASHRAE itself. This allows temperatures up to 28 ± 1 °C as long as three conditions are met:

a) The temperature is not *air* temperature but *operative* temperature, and
b) There is reasonable air movement (through ceiling fans, for example), and
c) The subjects are acclimatized to higher temperatures, in other words, are "coming in from the heat" so to say, which is definitely mostly the case in India (and Pakistan, as Professor Nicol discovered).

The Center for Advanced Research in Building Science & Energy (CARBSE), at CEPT University, Ahmedabad, has conducted similar research in India, to develop an Indian "adaptive" standard, but unfortunately the research was mainly for mixed-mode offices and should be applied only to offices in India. *There is no standard of comfort for public spaces in India*, and that needs to be established.

(In the absence of such standards research, the numbers used by the author in this essay below are speculative, meant to be illustrative and approximate in orders of magnitude; they are here only to illustrate the principle, and do not purport to be authoritative or final.) The idea of comfort conditioning of public spaces such as platforms where people wait for trains is a noble one, but even in developed, cold and rich countries, this is accomplished NOT through a massive volume of air-conditioning or heating, but by squeezing the waiting space to be more like a bus stand for, say, 10 people to sit and wait on a bench (typically a glass cabin of 6 x 3 x 3 m on a platform), so that the heating or air- conditioning provided can be done *affordably*.

To take an example, 6 x 3 x 3 m of air-conditioned space for 10 people could be managed within a peak load of, say, 2 TR (using 3-4 kW of electrical power) while, say, the Habibganj concourse hall as designed of 20 x 20 x 6 m (for say 100 people, 10 times as much) would need 40 times as much, or ~80 TR of air-conditioning (using 30 times as much power, ~90-120 kW of electrical power).

It is worth noting that a majority of passengers travel in non-air-conditioned coaches, and so not expected or need to be provided air-conditioning. This is not a matter of thermal shock, which is a severe medical condition, common coming in from extreme cold (frostbite), but a matter of addiction and expectation.

This is a controversial area. Advocates of air-conditioning say that everybody should be made comfortable for as long as they can be, even if they are travelling later in a non-air- conditioned environment.

Proponents against air-conditioning say that everybody who is going to be travelling in a non-air-conditioned environment not become addicted to air-conditioning at the station, and let them not have the expectation of air-conditioning so as to not be disappointed later in a non-air-conditioned environment.

There is no comparison between air-conditioned and non-air-conditioned space and their enabling factors. Air-conditioning takes large capital costs both in plant and insulation, huge operating costs, creates global warming,

uses much scarce electricity, and is addictive (meaning, once you are in air-conditioning you would like to maintain that comfort, which may actually be indirectly good for the Railways since that would mean the public might gradually extend themselves to scrape together the money to buy higher value air- conditioned class tickets!)

Heating is less energy intensive than air-conditioning since, following the second law of thermodynamics, we all emit 60-120 W of metabolic heat all the time, and all the environmental heat enters spaces that needs to get rid of them. It is more energy intensive to cool than to heat. Though it is true that stations like Metro Rail stations, being underground, cannot help but be air-conditioned in warm climates, but as mentioned before, even in developed, cold and rich countries, heating of waiting passengers is rarely accomplished through a massive volume of heating, but by squeezing the waiting space to be more like a bus stand for, say, 10 people to sit and wait on a bench. This despite the fact that it is lower emissions to heat than cool, and that passengers in developed countries can probably afford to pay for heating.

Air-conditioning is an electromechanical technology that uses compression and expansion of a refrigerant to pump heat out of a space. It is designed so as to 'fix' poorly thermally designed spaces using excessive energy, but has unfortunately become a cause for architects designing thermally uncomfortably spaces and 'fixing' them with air-conditioning. Such is the case with the design of the closed spaces as seen in the designs send by IRSDC to this author (Habibganj concourse, designed like an underground Metro Rail station).

The amount of heat pumped out with 1 unit of electricity can vary from 0.9 to 14 units of heat (the last on certain easy mornings, when this can happen, though normally the expected amount pumped out is not more than 4 units). Air-conditioning is better provided with insulation, which means we need to find the cost-effectiveness of insulation. This should be as below:

Without looking at the cost-effectiveness, IRSDC *should adopt the* ECBC (*Energy Conservation Building Code*) requirement (or, after a few years, even the super-ECBC requirement) for ALL air-conditioned spaces since ECBC is mandatory and arrived at after a long process of stakeholder consultation. This would increase the capital outlay of air-conditioning *but pay off in the long run*, even assuming no increase in the price of electricity, which is what IRSDC should be interested in. ECBC 2017 (2020 update) should act as the reference document for this.

In dry and hot climate stations such as Jodhpur or Jaisalmer, as long as water can be secured sustainably (recycled greywater can be suited for this), one should use evaporation through misting to convert the dryness into lower temperature with acceptable humidity; large spaces can be mist cooled like this, as has been done in public spaces in Arizona, USA. However, this technology cannot be/should not be combined with air-conditioning, so it should be applied to hot and very dry climates only.

What should be done next by IRSDC?

Considering this is a nationwide exercise, one needs to commission a climate map of Railway Stations in India, and formulate policy using that map, such that:

a) Stations in moderate or cool climates are required not to condition or cool the waiting areas (or kiosks, if any) at all.
b) Stations in intermediate climates are instructed to provide passive comfort in mass waiting areas and/or air-conditioned comfort in smaller waiting rooms of up to 150 sqm and/or waiting kiosks up to 20 sqm.
c) Stations with warm and humid climates are instructed to condition the waiting areas for air-conditioned passengers only, in smaller waiting rooms of up to 150 sqm and/or waiting kiosks up to 20 sqm.
d) Stations with hot and dry climate are instructed to evaporatively cool the waiting areas for air-conditioned passengers only with misting only (with recycled water), in smaller waiting rooms of up to 150 sqm and/or waiting kiosks up to 20 sqm. For other passengers these stations need to provide passive comfort in mass waiting areas.

What is the meaning of passive comfort in point #(b) and #(d) above? The following techniques of traditional architecture (requiring no cost-benefit analysis since they are lower on capital AND on operating costs) should be used:

- Shading, this itself often is enough, which is why open platforms with a shaded roofs work reasonably acceptably
- Air movement through fans whenever the air temperature is below, say, 32 °C.
- Natural ventilation using outdoor air – either plain or, if the humidity ≤ 30%, evaporatively cooled (especially night purge ventilation whenever possible)
- Cool roof with evaporating water on mats (if it is possible to source water, including treated recycled water)
- Misting with evaporating water in nozzles (if it is possible to source water, including treated recycled water)

- Evaporative coolers with evaporating water in wood wool pads (if it is possible to source water, including treated recycled water)

Essentially, these techniques will bring the operative temperature (not the air- temperature) to be maintained at -10 °C of the external operative temperature in warm climates. At least the operative temperature should be -5 to -8 °C of the external operative temperature in warm climates; this should be sufficient to provide some comfort to the waiting passengers (but requires research).

The techniques above will limit the extent of air-conditioning as well as dramatically reduce the operating (O&M) costs and make them negligible as compared to air-conditioning. Policies need to be formulated that prohibit the use of electromechanical equipment in fine weather (to be defined by research).

Policies will also be needed to be formulated to develop vendors to provide these services on a ESCO basis. This can all be done by an appropriate RfP.

Part 2. Opting for a greater mix of landscaped drainage systems vs. a fully pipe- based drainage system:

What India, especially the Railway Stations, needs to adopt has been described in US and Canada as “Low-impact development” (LID), a term used in Canada and the United States to describe a land planning and engineering design approach to manage stormwater runoff as part of green infrastructure. LID emphasizes conservation and use of on-site natural features to protect water quality.

In the EU, LID techniques are called Nature-based solutions. In Australia, they are termed Water-sensitive Urban Design, and in China/Singapore, they fall in the scope of Sponge city.

This approach implements engineered small-scale hydrologic controls to replicate the pre- development hydrologic regime of watershed through infiltrating, filtering, storing, evaporating, and detaining runoff close to its source. Green infrastructure investments are one approach that often yields multiple benefits and builds city resilience.

In following the lead of developed and rich nations (as they adopted in the earlier part of the twentieth century), our country has widely adopted engineered piped drainage over natural bio-swale systems.

b) What are the hurdles for this and how to overcome them?

Besides lack of capacity, the main barrier – specially in public or large projects – is non- recognition in the IS code/CPWD manual, etc. The acceptance of practice or definition of performance criteria is critical to this adoption. If IRSDC is sufficiently interested in leading this effort, it deserves to become a three-month exercise in its own right for which an RfP to locate a suitable expert could be commissioned and developed by this author.

The other important and practical hurdle for not using these systems in Indian practice is lack of capacity. This has to be built-up through architecture, landscape architecture and civil engineering schools which need to adopt LID practice as a specialized field in its own right.

This needs to be followed up (and that will happen) by vendor development; the availability of contractors in the market who can implement LID and be ready to maintain the same at an O&M cost to defined standards (which can be adapted from international practice).

c) Case Studies illustrating the cost-benefit Analysis and also other O&M + Placemaking advantages

Current case studies within India can best be got from the work of Mohan Rao, founder of Integrated Design (InDe) in Bengaluru (email: <mohaninde@gmail.com>) who is India’s most committed designer in this field. This work is hard to quantify, either on cost-benefit or performance, mainly because there are no benchmarks for even standard performance of zero discharge systems. Current standards only talk of a number – zero (runoff) – without defining all aspects of the hydrological cycle. Only runoff is seen as important enough for quantification. The three other aspects of hydrology – infiltration, percolation and evapotranspiration – are ignored.

Having Studied Landscape Architecture from SPA Delhi, Mohan remains one of the most active practitioners and advocates of passive drainage as compared to drainage systems in practice. He has also worked for private corporations and large organizations across India, using engineered and vendorized systems such as the one described at https://abtdrains.com/products/low-impact-development/permavoid/ which are implemented through vendors for passive rather than active drainage.

A 142-page report from EPA of USA may help to set precedent for a cost-benefit analysis. This is available in the public domain at https://www.epa.gov/sites/default/files/2015-10/documents/lid-gi-programs_report_8-6-13_combined.pdf

The placemaking advantages of such systems are obvious, since these systems can be completely used by visitors for recreation, including children, while serving a drainage function at the same time (the Singapore greenways illustration below tells this very well, this picture could also be that of a parkway next to a future Railway Station in India!)

Figure 1: Singapore greenways illustration

d) *Strategies for mainstreaming the cheaper/ better option into the planning, construction and long-term O&M process.*

Through the process of documentation, IRSDC should be convinced that passive drainage/LID, consisting of green infrastructure and bio-swales, is cheaper, faster, and lower in O&M costs, much as is being discovered by advanced nations, such as in north America and even in tropical Singapore, compared to engineered systems of drainage such as pipes, culverts, and drains. Officials in the US found that the traditional practices such as detention ponds and retention basins were not cost-effective and the results did not meet water quality goals.

Design using LID principles follows four simple steps:

1. Determine pre-developed conditions and identify the hydrologic goal.
2. Assess treatment goals, which depend on site use and local keystone pollutants.
3. Identify a process that addresses the specific needs of the site.
4. Implement a practice that utilizes the chosen process and that fits within the site's constraints.

The basic processes used to manage stormwater include pre-treatment, filtration, infiltration, and storage and reuse.

Figure 2: Photograph showing Swale in IIT Jodhpur (Photo Courtesy: SHiFt)

Figure 3: Photograph showing Swale (Photo Courtesy: InDe)

Figure 4: Photograph showing Swale (Photo Courtesy: InDe)

Part 3: Integration of Waste water recycling system with landscaping vs. a fully structured STP system:

In a 1990s study commissioned by Bremen's BORDA, a German team of researchers found that although many Indian cities had electromechanical centralized STP systems installed in the early decades of independent India, they were typically not in use as political pressures dictated that scare electricity be given to residential areas of citizens (and voters!) rather than be used to treat their sewage (which requires 24/7 electricity, which though not much, still cuts into the ration available for residential areas). The net result of this situation is clearly seen in these decades, where we have untreated sewage being dumped into rivers, polluting waterways, rivers, and lakes.

BORDA suggested a low-energy passive technology as an alternative, which uses planted bed filters to clarify the sewage and uses only gravity and a larger land area to work. This is termed DEWTS (Decentralized Waste Treatment Systems), and is today disseminated through an NGO, CDD (Consortium for DEWATS Dissemination, https://cddindia.org), Bengaluru. The reason that DWTS is called decentralized is that instead of treating sewage for large cities, it can typically deal with large regions within cities (hence requiring 'decentralized' facilities to be planned). It has even been used for individual housing projects and individual houses (!) in extreme cases. Since DEWATS is a proprietary term of CDD, it has been termed DWTS in this document.

The main resource taken up by DWTS as opposed to electromechanical STPs is low-lying and preferably flat land. It typically takes up to 2 sqm/person to set up a properly sized DWTS plant (as compared to electromechanical STPs of similar capacity that can be set up in 5% or less of that area depending on the number of users served) although there is no pumping energy and it is water positive, wielding treated water which can in theory (after tertiary treatment) be good for drinking. But in south Asia, following ritual taboos, this treated water is typically used only for washing, irrigation, flushing & HVAC after softening, but not for drinking. The Delhi Jal Board has recently achieved some success in implementing this technology at scale.

A closely related technology Soil Bio Technology (SBT), has been patented by IIT Bombay at Powai, and though it takes up a (very) small amount of pumping energy, they are able to train vendors and get private parties to provide O&M for the same. CDD being an NGO is not so interested in developing vendors, but have many installations in the Bengaluru area.

In following the lead of developed and rich nations, our country has widely adopted engineered electromechanical STPs over natural DWTS or SBT type systems.

a) What are the hurdles for this and how to overcome them?

The most important and practical hurdles for not using these systems in Indian practice is lack of capacity. This has to be built-up through architecture, landscape architecture, and civil engineering schools which need to adopt DWTS practice as a specialized field in its own right.

This needs to be followed up (and that will happen) by vendor development; the availability of contractors in the market who can implement DWTS and be ready to maintain the same at an O&M cost to defined standards that can be adapted from European practice.

A client who had sufficient area and was inclined towards adopting this low-energy natural system was recently resisted in his choice of technology by his own facility manager. When this author tried to find the reason why, it was discovered that the primary problem was that there would be no one to blame or call if the DWTS system stopped working (plants die, or if there is a faint odour of sewage) while in the case of electromechanical systems, the systems are physically closed in a space and running on the basis of devices (pumps and motors) that can be repaired or replaced (!)

The above anecdote points to a pressing need for vendor development. The only way to speed that process is to specify it, and CDD or CSE or Vision Earth Care could be employed for this.

b) Case Studies illustrating the cost-benefit Analysis and also other O&M + Placemaking advantages

SBT case studies: Indore airport uses this technology for all its sewage treatment. Many cases and the primary Indian vendor can be found at http://www.visionearthcare.com/home/soilbiotechnology whose website also features many private and public clients and includes a link https://www.cseindia.org/soil-bio-technology-sbt- 3774 to the Centre for Science and Environment (CSE).

Figure 5: Executed SBT (500 KLD) at Nehru Park, Delhi (Photo Courtesy: CSE)

Figure 6: Executed SBT (50 KLD) at Naval Dockyard Housing Society, Mumbai (Photo Courtesy: CSE)

Figure 7: Executed SBT (200 KLD) at Jammu Airport, Jammu (Photo Courtesy: CSE)

Figure 8: Executed SBT (200 KLD) at Vadodara Airport (Photo Courtesy: CSE)

Figure 9: SBT plant at Lovegrove pumping station, Mumbai Municipal Corporation (Photo Courtesy: CSE)

Figure 10: SBT plant at Vazir Sultan Tobacco (VST), Hyderabad (Photo Courtesy: CSE)

The details of the above mentioned SBT case studies are tabulated below as follows:

Table 2: Details of SBT Case Studies

S. No.	Name of SBT	Year	Area of Installation (sqm)	Capex (Rs.)	Opex (Rs. Per year)	Design Capacity
1	SBT at Jammu Airport	2017	450	51 lacs	5 lacs	200 KLD (expandable to 500 KLD)
2	SBT at Naval Dockyard Housing Society, Mumbai	2002	500	6 lacs	2 lacs	50 KLD
3	SBT at Vazir Sultan Tobacco, Hyderabad	2004	400	8 lacs	2 lacs	100 KLD
4	SBT at Lovegrove Pumping Station, Mumbai	2006	2500	300 lacs	45 lacs	3 MLD
5	SBT at Nehru Park, New Delhi		325	NA	3.6 lacs	570 KLD
6	SBT at Vadodara Airport	2016	450	116 lacs	18 lacs	200 KLD (expandable to 500 KLD)

1. Housing Example: Detailed Case Study of SBT at Naval Civil Housing Society:

The SBT plant in this colony consists of a raw water collection tank, a constructed soil filter bioreactor and an effluent collection tank. The raw sewage after screening is collected in the tank from where it is directed towards the trench filled with gravels. Each trench is 25 m long and 1.5 m wide. The sewage is then pumped and distributed over the reactor bed. The bed surface area is 500 sqm. The total depth of the bed is 0.7 m with 0.3 m of red soil layer (laterite soil) and 0.4 m of layer of stone at the bottom.

The treated sewage gets collected in the effluent collection tank and is (re)circulated in order to achieve the desired quality of treated wastewater. Half the volume of water is recirculated with a batch running time of 6.5 hours. The bed is then rested for drying prior to next cycle of use. The green plants used in the system are only for ornamental purpose and add to the aesthetics of the environment

Table 3: Salient features of SBT at Naval Civil Housing Society

Parameters	Description
Year of implementation	2002
Technology detail	SBT

Number of Buildings (Flats) wastewater treated	7 Buildings (24 Flats each)
SBT Plant capacity	50 KLD
SBT Plant area	500 sqm
Wastewater reused (180 days)	16.2 million litres per annum (45 KLD)
Green area irrigated	2.2 acre
Capital cost of system (in 2002)	Rs. 7 lacs
O&M costs (per annum)	Rs. 1 lac
Savings (per annum)	Rs. 1.1 lac

Figure 11: Trickling of wastewater through uPVC pipes on the Bioreactor (Photo Courtesy: CSE)

Table 4: Treatment efficiency of SBT at Naval Civil Housing Society (Source: CSE)

Parameters	Inlet (avg)	Outlet(avg)
pH	7.0	7.4
DO (mg/l)	0.72	4.8
TSS (mg/l)	187.8	9.1
BOD (mg/l)	95.3	5.9
COD (mg/l)	187.9	8.3

Legend. Biological Oxygen Demand (BOD); Chemical Oxygen Demand (COD); Dissolved Oxygen (DO); Total Suspended Solids (TSS).

The housing colony has a 1.5 km long linear stretch of green area and well-maintained parks/gardens with lush green trees, plants and landscaping. The treated water is locally used for maintaining estimated green area of 2.2 acre. The treated water is used for meeting 180 days horticultural water requirements. The DWTS system includes a collection tank for storing 20 KLD treated water and the remaining excess water is disposed in the municipal sewerage system. The project is a high visibility and high impact intervention with considerable socio-economic benefits in the neighborhood.

This DWTS has reduced dependence of the neighbourhood on water tankers. Prior to the implementation of SBT plant 6-7 tankers were required to supply water for meeting green area and landscaping water requirements in the neighborhood. The average cost of water tanker (capacity 8,000 liters) in Mumbai is Rs. 1,200 per tanker. Since this operation, the society has met all water requirements of maintaining green area by local reuse of the treated water available from SBT plant. The reuse of treated water has resulted in Rs. 1.1 lacs savings annually.

Figure 12: Green Stretches irrigated by Treated Wastewater (Photo Courtesy: CSE)

DWTS case studies: the key resource person in Delhi area for this is Dr. Suresh Rohilla (email: <srohilla@cseindia.org>) who works at the Centre for Science and Environment (CSE), and the link which leads to many case studies of this technology is https://www.cseindia.org/mount/home

Figure 13: Executed DWTS Plant Filter Bed at IIT Jodhpur Phase I (Photo Courtesy: SHiFt)

Figure 14: Executed DWTS at Bhil Basti, Delwara, Udaipur (Photo Courtesy: CSE)

Figure 15: Executed DWTS at CSE, New Delhi (Photo Courtesy: CSE)

Figure 16: Executed DWTS at Nehru Garden, Alwar (Photo Courtesy: CSE)

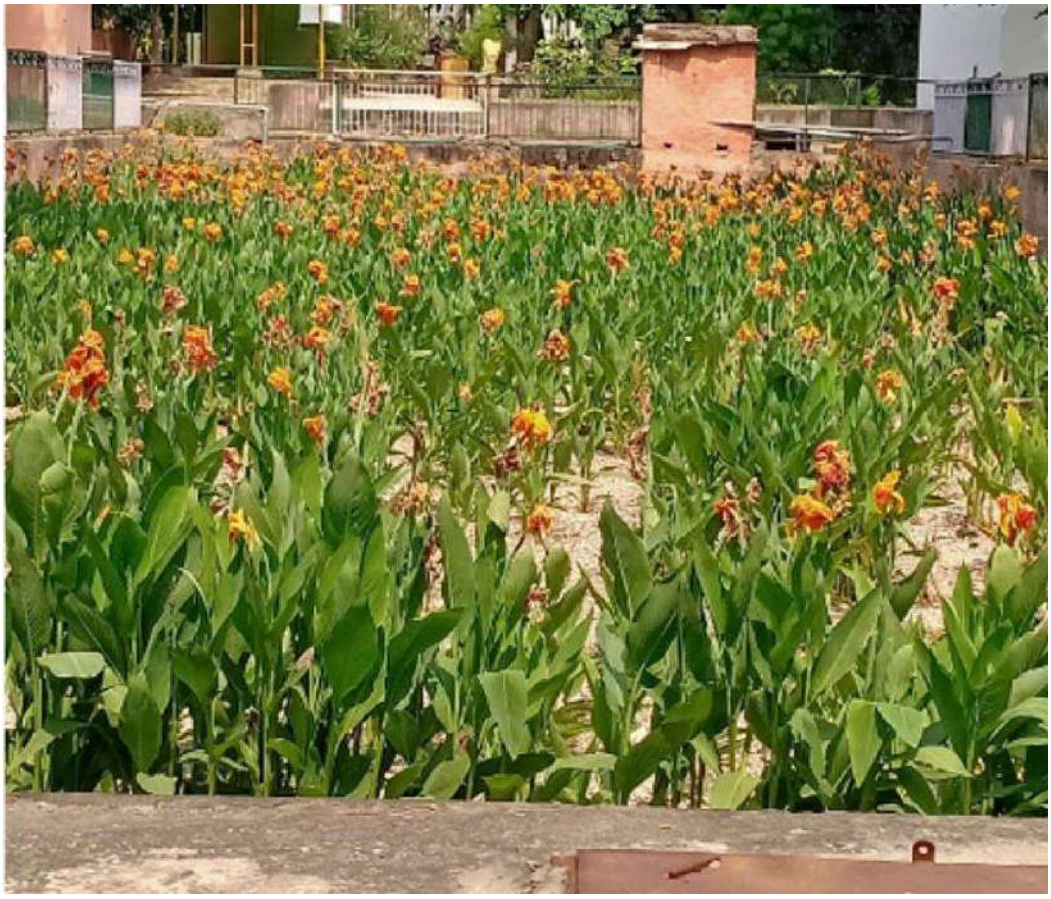
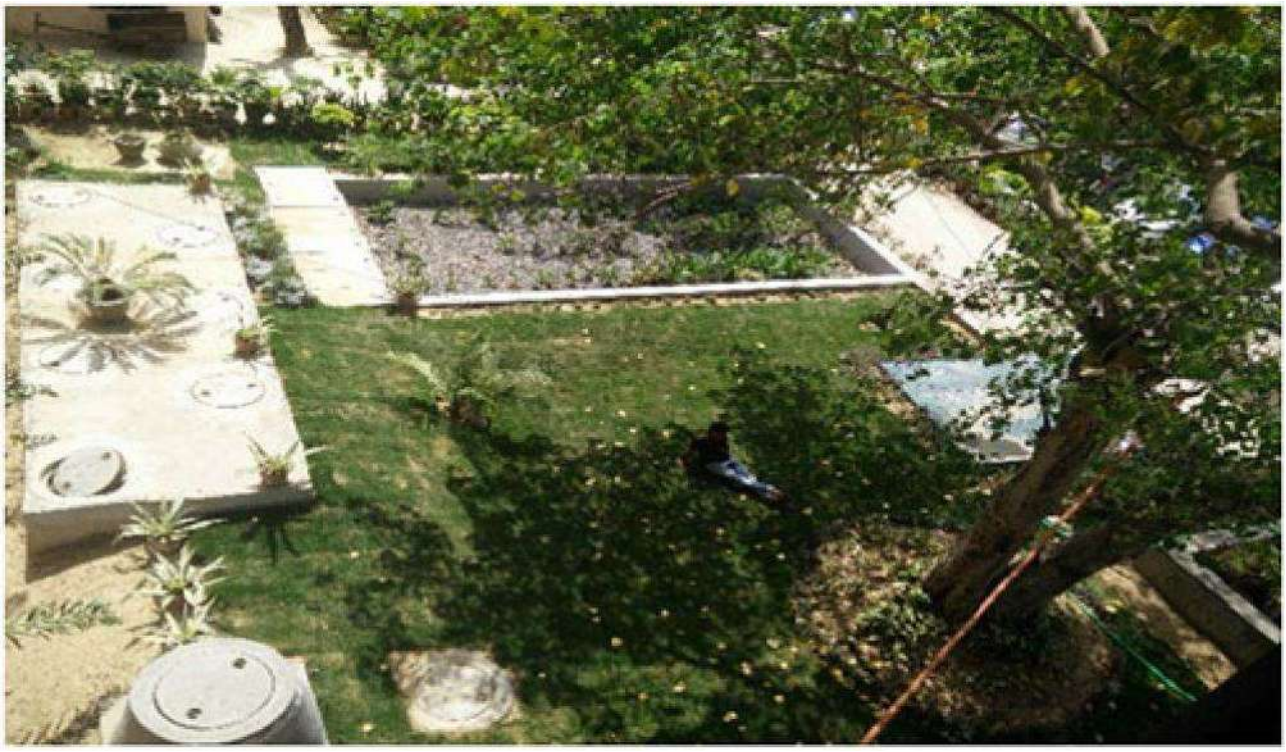


Figure 17: Executed DWTS at Varunalaya, Delhi Jal Board (Photo Courtesy: CSE)



The details of the above mentioned DWTS case studies are as follows:

Table 5: Details of various DWTS case studies

S.No	Name	Year	Area (sqm)	Capex (Rs)	Opex (Rs/yr)	Capacity
1	IIT Jodhpur, Phase I	2015	1620	~80 L	NA	220 KLD
2	DWTS at Bhil Basti, Delwara, Udaipur	2012	NA	22.5 L	NA	21 KLD
3	DWTS at CSE, New Delhi	2005	NA	2.25 L	0.3 L	8 KLD
4	DWTS at Nehru Garden, Alwar	2016	730	32 L	2.4 L	100 KLD
5	DWTS at Varunalaya, Delhi Jal Board	2015	2690	16 L	NA	8 KLD

2. Institutional Example: Detailed Case Study of DWTS at NEERI:

Since IRSDC is in the public sector, it makes sense for them to consult the National Environmental Engineering Research Institute (NEERI), Nagpur. The scientists at this lab have been working with DWTS systems and in fact use it for their campus as well. The system was designed and implemented by Dr Rakesh Kumar, Director Gr. Scientist & Head of the NEERI Zonal Laboratory, assisted by his students.

The DWTS system at the Institute treats the grey water generated in the bathrooms, wash basins, laboratory's washbasins and kitchen. Keeping in mind the potential of local reuse for meeting the water requirement for maintenance of green area a phytorid technology based DWTS system was implemented in 2005.

The project is a very good example of DWTS implementation on institutional scale. The case study demonstrates treatment of wastewater near the source of generation and resource potential in terms of local reuse for meeting non-potable water requirements i.e. for maintaining the green landscape, plantations and cleaning of parking area.

Table 6: Salient features of DWTS at NEERI

Year of implementation	2005
Technology detail	Phytorid Technology
Type of wastewater	Grey water (wastewater from the bath, wash basins, laboratories and kitchen)
Phytorid Plant Capacity	5 KLD
Phytorid Plant Area	10 sqm
Wastewater reused (180 days)	0.9 million liter per annum (900 KLD)
Green area irrigated	550 sqm
Capital cost of system (2005)	Rs. 0.7 Lacs
O&M costs (per annum) including electricity to pump	Rs. 0.1 Lacs
Savings (per annum)	Rs. 1.3 Lacs

The 5 KLD capacity phytorid-based treatment system treats wastewater from the bathrooms, kitchen and laboratory washings. The plant is located on 10 sqm area. The system consists of a settler; an inlet zone filled with gravel media for the removal of suspended solids and planted cells containing media of large and medium sized gravels. The depth of the cell is 1.5 m and it maintains a horizontal sub-surface flow. Baffles are provided to ensure upward and downward movement of the wastewater. Hence the bottom of the cell is an anaerobic zone while the upper part is an aerobic zone.

The horizontal filter bed is provided with a slope of 1/200. The plants growing on the filter bed are Scirpus, Typha and Canna. After the treatment, the water is collected in a collection tank from where it is pumped out for further usage. The treated water is free from suspended particles and doesn't have any bad odour.

Table 7: Treatment Efficient of DWTS at NEERI (Source: CSE)

Parameters	Inlet (avg)	Outlet (avg)
pH	3.2	6.3
TSS (mg/l)	18.9	3.3
BOD (mg/l)	132	17
COD (mg/l)	187	38
Phosphate(mg/l)	25.57	0.82

Legend. Total Suspended Solids (TSS); Biological Oxygen Demand (BOD); Chemical Oxygen Demand (COD).

This DWTS system treats 5 KLD wastewater that is locally reused for green area water requirement, car washing and for cleaning of the parking area. The local availability of water for the non- potable water has reduced Institute's dependence on municipal or supply through private tanker.

The average cost of water tanker (8,000 liters per tanker) in Mumbai is Rs. 1,000-1,200, thus by using the treated water as alternate source of water about Rs. 1.3 lacs are saved annually. The green landscaped area in the institute will be self-sustainable over the years without much depending on the municipal or tanker water supplies. DWTS system caters to non-potable water requirements of the Institute. The landscaped area and garden in the Institute has provided added environmental benefits to the area and has improved the aesthetics.

The phytorid technology based DWTS system at institute set up as demonstration project has been successful in creating awareness, information, dissemination and a good example for practitioners to learn about the potential of natural wastewater treatment system. The in-situ treatment and reuse of grey water upto 95% could attract a total of 5 credits on the IGBC system. Various university campus and industrial areas/townships have now implemented similar system for wastewater treatment.

Figure 18: Phytoid based DWTS System (Photo Courtesy: CSE)

Figure 19: Green Landscape maintained on Treated water (Photo Courtesy: CSE)

3. Residential Example: Detailed Case Study of DWTS at Residential Building, Sangli:

This DWTS project is implemented in an individual household building located in Sangli City, Maharashtra. The present source of water supply to city is mainly from river Krishna. The average water supply in the city is around 106 lpcd. The city generates 50 MLD sewage but 55 per cent untreated sewage is disposed in the nallah and ultimately in river Krishna. Several areas in the city are still to be connected to sewer network. The local body has a deficit of 10 million in water account and the city has very limited capacity to undertake new water or wastewater management projects.

This individual residential building is situated on Dhamli road on suburbs of Sangli city. The area is still to be connected to municipal sewer network.

Table 8: Salient Features of DWTS at Residential Building, Sangli

Year of implementation	2010
Technology detail	FFBT
Type of building	Individual residential household of 4
Fixed Film Bio Filter capacity	1 KLD
Fixed Film Bio Filter plant area	2.8 sqm
Green area irrigated	240 sqm
Wastewater reused (180 days)	90 Kilo liter per annum (500 liters per day)
Green area irrigated	240 sqm
Green area irrigated	240 sqm
Capital cost of system (2010)	Rs. 35,000
O&M costs (per annum)	Rs. 800-1,000
Savings (per annum)	Rs. 10,000

Table 9: Treatment Efficiency of DWTS at Residential Building, Sangli

S.No.	Parameter	Inlet	Outlet	CPCB std
1.	pH	8.32	7.20	6.5 - 8.5
2.	COD (mg/l)	580	40	<250
3.	BOD (mg/l)	260	4	<30
4.	Total Solids (mg/l)	1,130	680	
5	TDS (mg/l)	800	668	<2100
6	TSS (mg/l)	330	12	<30
7	Chlorides (mg/l)	60	60	<600
8	Sulphates (mg/l)	22	20	<1000
9	Oil and Grease (mg/l)	Nil	Nil	

Legend. Chemical Oxygen Demand (COD); Biological Oxygen Demand (BOD); Total Dissolved Solids (TDS); Total Suspended Solids (TSS). **Source:** CSE

The individual household building is located on suburbs of a water scarce city and has no sewerage network. The septic tanks/ soak pits contaminate the groundwater and are cause of nuisance due to inadequate septage management mechanism in Sangli city.

The treatment of wastewater at source of generation and local availability of treated water for appropriate non-potable use at individual household building scale has not only resulted socio-economic benefits to the building owner but also provides environmental benefits. The treated wastewater is locally used for meeting horticultural water requirement of the household and used for maintaining 240 sqm – plantation and landscaping.

Figure 20: Underground Wasterwater Treatment System (with Piping and Equalization Tanks)

In economic terms the availability of 90 KL of treated water per annum for meeting horticultural water requirement has resulted an estimated Rs. 9,000-10,000 per year savings to the building owner that would otherwise be required to arrange water supply from private tankers. The well-maintained garden and the landscaping with treated water have improved the aesthetics of the building. The trees and plantations attract butterflies and birds, and demonstrate the other environmental benefits.

The project implementation and satisfaction of owner is creating awareness. The neighbours are now encouraged and planning to invest in installing Fixed Film Bio Filter technology-based treatment systems.

Figure 21: Plantation using Treated Wastewater (Photo Courtesy: CSE)

Table 10: Cost breakup of Conventional Wastewater Treatment Technologies (Source: CSE)

Name	Type	Advantages	Disadvantages	Land requirement (ha/MLD)	Capital cost (million ₹/ MLD/ year)	O&M cost (million ₹/ MLD/ year)
Waste stabilisation pond (WSP)	Conventional and natural	• Does not involve installation of electromechanical equipments • Robust system and can withstand hydraulic and organic shocks • Simple to construct, operate and maintain • Treated wastewater is safe to reuse for irrigation and aquaculture • High BOD reduction, nutrient removal and pathogen reduction	• High area requirement • If poorly maintained, odour nuisance and mosquito breeding problem	0.80 – 2.3	1.5 – 4.5	0.06 – 0.1
Duckweed pond	Conventional and natural	• Low operation and maintenance cost • Does not require skilled labour • Significant nutrient removal • Production of protein rich material which can be used as animal feed • No odour nuisance and mosquito breeding problem due to complete cover by duckweed	• Low pathogen removal due to reduced light penetration • Not suitable for extreme weather conditions especially in winters	2 – 6 (for 7 – 20 days of retention period)	1.5 – 4.5	0.18
Oxidation pond	Conventional and natural	• Less sludge generation as compared to aerobic processes	• Low suspended solid removal • Large land requirement • High power requirement due to aeration	–	30 – 80	0.2 – 1.0
Activated sludge process (ASP)	Conventional and natural	• Low area requirement • Performance is not affected by seasonal variations and wastewater characteristics	• High energy consumption • Highly skilled supervision for operation and maintenance of the plant • Continuous power supply is required for its operation as interruption in power supply even for short period of time can affect adversely	0.15 – 0.25	2 – 4	0.3 – 0.5
Upflow anaerobic sludge blanket (UASB)	Conventional and natural	• No external energy requirement • Recovery of gas is possible, having high calorific value • Low sludge generation • Can absorb hydraulic and organic shock loading	• Cannot meet the desired discharge quality standards without adequate post treatment • Effluent released is anoxic with high immediate oxygen demand, unsuitable for disposal in water body and for reuse • Poor coliform removal • Sensitive to seasonal temperature variations and low removal efficiency in winter • Release of corrosive and odorous hydrogen sulfide and ammonia in the air • Sludge washout from the reactor can result in instability leading to deteriorations in treatment performance	0.2 – 0.3	2.5 – 3.6	0.08 – 0.17
Biological trickling filter	Conventional and natural	• Lower process monitoring • Simple operation, does not require high skilled personnel for O & M • Generate sludge with better settling characteristics	• Blockages in distribution arm and clogging of the filter media • Require larger land area as compared to ASP	0.25 – 0.65	2 – 4 (slightly lower)	0.3 – 0.5 (slightly lower)
Rotating biological contractor (RBC)	Conventional and natural	• A higher level of treatment than conventional high-rate trickling filters due to a longer contact time (8 to 10 times greater); and • Reduced susceptibility to changes in hydraulic or organic loading than the conventional activated sludge process • It can be designed to remove 80–90 per cent of BOD but full nitrification can only be achieved when the organic loading rate is less than 5 g BOD/m^2/day	• Energy consuming • Skilled professional required for O&M	–	3.36	1.68
Fluidised aerobic bioreactor (FAB)	Emerging and electro-mechanical	• Primary sedimentation is not required • Small space requirement • Capacity to handle shock loads • Low and stabilised sludge production	• Periodic cleaning of the reactor bed is required as there is possibility of choking of the reactor bed • Excess biomass growth or low hydraulic loads can result in blockages • Long shutdowns may lead to septic conditions, and restart may involve a long stabilisation period	0.06	3 – 5	0.06 – 0.75

Moving bed bioreactor (MBBR)	Emerging and electro-mechanical	• Less space or underground requirement	• Energy consuming	0.055	10.8	63.81
Sequential batch reactor (SBR)	Emerging and electro-mechanical	• Excellent effluent quality • Smaller footprint because of absence of primary, secondary clarifiers and digesters • Biological nutrient (N&P) removal • High degree of coliform removal • Less chlorine dosing required for post disinfection • Ability to withstand hydraulic and organic shock loads	• Comparatively higher energy consumption • To achieve high efficiency, complete automation is required • Highly skilled operators needed • No energy production • Uninterrupted power supply required	0.055	11.5	45.12
Submerged aerobic fixed film process (SAFF)	Emerging and electro-mechanical	• Low and stabilised sludge production • Require less space for installation • High BOD removal, TSS reduction • Absence of odour and any other corrosive gases	• Problem of clogging of the filter • Reliance on propriety filter media • Requires skilled supervision • High energy consumption			
Membrane bioreactor (MBR)	Emerging and electro-mechanical	• Low hydraulic retention time than the conventional system • Very low footprint • Produce high quality effluent with small amount of sludge generation • Provision for modular expandability • Less susceptible to upsets due to flow variations	• Chemical cleaning of the filter is required every three to six months • High energy consumption	0.045	10.8	83.25
Vortex technology	Emerging and electro-mechanical	• It is a good substitute of planted filter as it requires less land area • The maintenance is easier as it is a closed and transparent system • No issue of local weather and soil quality as in the case of planted gravel filter • The vortex system is very effective in eliminating odours	• Require energy for its operation • Needs to be clubbed with other treatment (primary/secondary) systems	0.0001–0.0006	50,000 (₹/KLD/yr)	8500 (₹/KLD/yr)

Table 11: Cost breakup of New Emerging Decentralized Wastewater Treatment Technologies (Source: CSE)

Name	Treatment Method	Treatment capacity	Reuse of treated water	Capital cost (₹/KLD)	O&M cost (₹/KLD/ year)	Features
Green bridge	Filtration, sedimentation, biodigestion and biosorption by microbes and plants	50 – 200 KLD/ sq m	In situ treatment of water bodies	200 – 500	20 – 50	• Suitable for in-situ treatment in rivers, flowing streams • No skilled labour is required for its operation and maintenance • It improves the overall aesthetics, aquatic life of the water body • Pollution load reduction is upti 80 per cent in general • Increase in dissolved oxygen (DO) from 150-200 per cent
Biosanitiser/ Eco chip	Bio catalyst-breaking the toxic/ organic contents	100 mg/ KLD	In situ treatment of water bodies, Horticulture	Chip costs 10,000 excluding civil / construction cost	NA	—
Nualgi	Phycoremediation (use of micro/ macro algae)- fix CO_2, remove nutrients and increase DO in water	1Kg treats upto 4ML	In situ treatment of lakes/ ponds, Increase in fish yield.	₹350 / MLD	9000 – 10,000/ML	• The growth of diatoms is very fast-starting within 5 minutes and continues as long as the nutrients lasts ie.,about 1 week to 10 days • 1 kg of Nualgi results in the release approximately 100kgs of oxygen • 100kg of Nualgi can treat 4 million litres of water
Bioremediation	Decomposition of organic matter using biological products	1 billion CFU/ml	In situ treatment of lakes/ ponds	Rs. 20,000-30,000/MLD for flowing water and Rs. 4000-5000/ML for still water	1.9 lakhs / MLD for flowing water 2.8 L / Acre in case of still water (for eg. Lakes)	• Reduce odour emission considerably • It is cost effective. No construction or additional infrastructure is required • Effective in removing highly toxic and health hazardous gas H_2S from the environment completely • These strains exhibit growth even at low temperature as low as 4 degree celcius and in the optimum pH range of 6-9 • The strain of bacteria maintains a satisfactory level of DO and therefore aerators, which consume high power, can be avoided or its use can be reduced • Controls the nutrient level in water thus helps in controlling "Eutrophication" process
Soil Bio technology	Sedimentation, filtration, biochemical process	5KLD – tens of MLD	Horticulture Cooling systems	10,000 – 15,000	1000 – 1500	• The process can be run on batch or continuous mode • No sludge production • Mechanical aeration is not required • The hydraulic retention time range from 30 mins to 1 hour without any pre-treatment • The overall time of operation is 6-7 hours. The bed is dried prior to next cycle of use.
Soil scape filter	Filtration through biologically activated medium	1 – 250 KLD	Horticulture	20000-30000	1800 – 2000	COD reduction in the range of 70-98% Area requirement is 1 sq m
DEWATS	Sedimentation, anaerobic treatment, plant rootzone treatment, oxidation process	Should be more than 1 KLD, but plants bigger than 1 MLD are also not feasible as would need extensive land	Horticulture, mopping floors, cooling towers and flushing	35,000 – 70,000	1,000 – 2,000	• Consist of several modules like settler, anaerobic baffle reactor, planted filter bed and a pond. • There's no need to have all the modules at each site, selection of modules depend on the quality of the water required after treatment • Settler helps in trapping the settlable solids whereas ABR helps in reducing BOD by 80-90%, while PFB helps in trapping the nutrients. Pond takes care of the odour • Minimal running cost, as no electro-mechanical equipment used
Ecosanitation Zero discharge toilets	Separation of faecal matter and urine		Flushing Horticulture Composting	30000 – 35000 (includes civil work)	35000 – 40000 (includes salary of the caretaker)	• Easy to install with no sewerage system requirement. • No electrical power supply or motor driven devices required • Hygienic conditions are maintained at the same level as in conventional water borne systems. • Can easily be operated and maintained by the community
Fixed Film Biofilter Technology (FFBT)	Settling and flow equalisation followed by enhanced natural degradation (biochemical process)	0.5 KLD to tens of MLD	Horticulture Car Washing	25,000 – 35,000	1000 – 2000	• Biofilter used may be stones, gravels, sand or PVC filter material whichever provides maximum surface area and is easily available. • Enhanced degradation of contaminants takes place in minimum area, since suitable micro-culture is added to the Biofilter cell
Phytorid	Settling followed by plant root zone treatment in specially engineered baffled treatment cells whch provides both aerobic and anaerobic treatment	5 KLD – tens of MLD	Horticulture	14,000 – 35,000	1,000 – 2,000	• Use of chosen wetland plants that are locally available • Retention time is between 5 – 7days • BOD and TSS removal average between 70-90% while faecal coliform is about 85-97% in treatment cells • Average nitrogen and phosphorus removal are in the range of 69-90%

Table 12: Comparative analysis for Waste Water Treatment systems (by G C Modgil, Sterling India)

Comparison of alternatives for Waste Water Treatment				
S.no.	Description	Type		
		Fluidised aerobic bed reactor	Anaerobic Treatment Extended aeration process (EAP)	DWTS
1	Screening	Required	Required	Required
2	Grit Removal	Required	Required	Required
3	Equalisation	Required	Required	Required
4	Aeration Tank	Required	Required	Required
5	Settling Tank	Required	Required	Required
6	Reactor Height	Tall	Medium	Medium for Digester in residential areas
7	Reliability	Irregular moving media, not very reliable	Oldest mechanical process, works quite effectively	Satisfactory
8	Smell	High	Moderate	Moderate
9	Land area requirements	600 sqm/MLD	2,000 sqm/MLD	12,500 sqm/MLD
10	Treatment time	Medium	Medium	High
11	Life cycle Cost	High	Medium	Very Low
12	Treated Effluent Quality	Low	Moderate	Moderate
13	Tertiary Treatment required	yes	yes	yes
14	System Startup Time	High	Medium	Low
15	Sludge Generation	High	Medium	Very Low
16	Inflow fluctuation tolerance	low	low	high
17	Operating Labour	High	Medium	Low
18	Maintenance	Low	Low	Very Low
19	O & M Cost	High	Medium	Very Low

There are clearly placemaking advantages of SBT and DWTS as the space is overgrown with plants. The sewage does not come and flow on the surface of the gravel; instead remaining at sub-surface level under the gravel bed. If the SBT or DWTS area is to be used as a public park for people (including children) to visit, special care can be taken to allow them access only to those parts of the system which are aseptic, i.e., will not cause infection when a visitor comes in contact with the system inadvertently.

c) *Strategies for mainstreaming the cheaper/better option into the planning, construction and long-term O&M process.*

Through the process of documentation, it can be demonstrated to IRSDC that DWTS/SBT, consisting of green infrastructure and plant bed filters, is cheaper, faster, and lower in O&M costs, much as is being discovered by advanced nations, such as in EU, compared to engineered electromechanical systems of Sewage treatment involving membranes, pumps, motors, bacterial conversion, and sludge disposal.

After that, IRSDC should pilot a few systems designed by experts and under their care so as to see for itself the effectiveness or otherwise of these natural systems.

The basic processes used to manage sewage through DWTS include filtering, primary treatment, secondary treatment (aerobic with plants) and tertiary treatment.

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- Prof. Dr. D.S. Meshram, President
- S.B. Khodankar, Secretary General
- A.K Jain, Ex Commissioner (Planning),DDA

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Project Team

IRSDC Team

- Sanjeev Kr. Lohia, MD & CEO, IRSDC
- R. K. Singh, Director (Projects and Planning)
- V.B. Sood, CGM (Projects and Planning)
- P.S. Uttarwar, Sr. Expert (Planning and Architecture)
- Deep Sharma, GM (Civil)
- Paromita Roy, JGM (Urban Design and Planning)
- Mriganka Saxena, Sr. Expert (Urban Design / Planning)
- Karm Jit Singh, Consultant (Retd.Dy.Director/ Building Section, DDA)
- Rishav Paul, Architect
- Utkarsh Chaudhary, Architect
- Nitish Mehrotra, Civil Engineer

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  - Somi Chatterjee, Sr. Conservation Arch.
  - Sudhir Vohra, Sr. Architect
  - Ashim Manna, Sr. Urban Designer
  - Sheeba Amir, Sr. Urban Planner
  - Saparya Varma, Sr. Conservation Arch.
  - Somya Johri, Sr. Conservation Arch.
  - Abdullah Nisar Siddiqui, Green Building Expert
  - Sutanu Pati, MBA- Finance
  - Abhijit Sinha, Sr. Editor
  - Sanjay Prakash, Sustainability Expert, SHiFt
  - Shinjini Bhattacharyya, Conservation Arch.
  - Vinshi Raj, Urban Regenerator
  - Sabreena Ashraf, Urban Regenerator
  - Saad Yaazdani, Architect
  - Chetan Aggarwal, Architect

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STATIONS DEVELOPMENT
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