green sense

Educational Campus Inventory

Centre for Science and Environment

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Shakti Sustainable Energy Foundation works to strengthen the energy security of India by aiding the design and implementation of policies that support renewable energy, energy efficiency and the adoption of sustainable transport solutions.

CSE

Maps in this report are indicative and not to scale.

Citation: Anumita Roychowdhury, Rajneesh Sareen and Mitashi Singh, 2017, *Green Sense: Educational Campus Inventory*, Centre for Science and Environment, New Delhi.

Published by
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Printed at Multi Colour Services

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1. Introduction

Why this toolkit for green campuses?

Education plays central role in building professional cadres and knowledge to take the sustainability agenda forward. Transforming places of formal learning—colleges, universities and other large educational institutions—as resource-efficient and low-carbon campuses can demonstrate practice for sustainability.

There is growing interest globally to frame practical strategies for resource savings, conservation and waste reduction to make centres of learning deliver on sustainability indicators and help education community connect with the practical value of sustainable practices that can also have a multiplier effect on the larger society.

The potential of transforming campuses of educational institutions to deliver on sustainability is enormous. As of 2013, India has 45 central universities, 318 state universities, 185 state private universities, 129 deemed to be universities, 55 autonomous institutes of national importance and 37,204 registered colleges. To illustrate, this translates, in terms of energy, into emission of 231 million tonnes of equivalent carbon dioxide (eCO_2) per annum approximately.[1] The need for water, land and biodiversity will be as enormous.

If designed and managed well for resource efficiency and sufficiency, these campuses can show how even a city can operate within the limits imposed by finite land, water and energy resources, material, green spaces and biodiversity, and also reduce waste. The education fraternity is large and campuses have substantial physical infrastructure. There are about 3 crore students.[2] As educational institutions teach, research and do community outreach, they can create multipliers in society to broad base the sustainability agenda. They can also commit resources and create management and planning capacity to enable change.

What is a green campus?

There is no 'silver-bullet' definition for a green campus. What makes a campus green will have wide range of determinants, including its climatic and ecological setting, terrain, level of technical application and management practices. 'Green campus' is not a technical terminology, but an ideology that shapes efficient use of resources, minimizes wastage and promotes a healthy lifestyle in campuses.

A green campus uses little water, harvests rain, optimizes energy efficiency and saves electricity, prioritizes renewable energy over fossil fuels, reduces waste, has a large green cover and open spaces, encourages eco-friendly transportation, emphasizes nutrition and healthy living and promotes environmentally responsible living.

Why is it important to adopt a green campus programme?

A green campus programme can open pathways to developing a more environmentally aware and responsible generation of citizens. This can equip resourceful teachers to foster environmental literacy and help every member of the education community to understand the scope and significance of the individual role in sustainable use of resources within the campus. This can encourage the education community to demonstrate and scale up the practice.

Green Campus moves beyond the rhetoric to show results

The CSE Green Campus initiative aims to change the practice on ground. It is a system of resource audits that the student community is expected to carry out within their respective campus to monitor real-world usage, consumption patterns and waste generation to benchmark environmental performance. The audit measures impact and motivates participants to work towards change.

- The monitoring process is participatory and transparent. It encourages translation of the audit work to influence the curriculum.
- The initiative trains students to record data systematically, think creatively, conduct analysis, collaborate as a team, and develop participatory and communication skills.

Box 1.1: Green campus movements around the world

Several initiatives are underway across the world to promote green educational campuses. Global multilateral agencies such as the UNEP are now framing guidance for green campus.

Concept of green school:[1] During the 1990s, following the Rio Earth Summit, the concept of green school emerged in Europe to make everyone aware of the misuse and over-exploitation of natural resources caused by our development frenzy. Children had to be sensitized. The World Summit on Sustainable Development in Johannesburg in 2002 catalysed efforts to bring about a shift in 'educating about the environment' to 'educating for sustainability'.

University initiatives:[2] Several universities across the world are either planning or implementing their campus plans. Federal and state governments provide tax incentives for buildings that surpass the standards set by the government.

*Ball State Universi*ty is planning installation of a campus-wide geothermal heating and cooling system to replace the current coal-fired boilers. The system is expected to yield US$ 2 million annual savings to the university.

Ecole Polytechnique Fédérale de Lausanne has installed the world's first solar glass window in 2013 comprising Graetzel cells. The innovative exterior installation enables production of renewable energy, shading from direct sunlight and reduction of the need for air-conditioning.

University of Oxford identified an opportunity to replace electrical installations (lighting fixtures and lamps) in old buildings on Beaumont Street to reduce energy consumption. The process involved fitting of energy-efficient LED lights, daylight and occupancy sensors and wireless switches. It resulted in GB £3,658 monetary savings per year, 36,582 KWh electricity savings per year and 19 tonnes of CO_2 savings per year. It also enabled improved usability of old buildings, improved aesthetics and reduced building maintenance.

Massachusetts Institute of Technology has developed a LEED gold-certified research laboratory, known as David H. Koch Institute for integrative cancer research. The highly energy-efficient features include heat-recovery methods and variable air flow system in HVAC, low-flow fume hoods to reduce fan energy, aggressive daylighting strategies, reflective roof-materials to reduce heat island effect, etc. These design initiatives have enabled thousands of dollars of savings for the institute and uplifted health, safety and productivity of the inhabitants.

University of Minnesota's Morris Campus features a biomass gasification plant, fuelled by crop residues from nearby farms, and has a 1.6 megawatt wind turbine. In 2012, the environment Protection Agency of the United States included this campus in its largest (top 20) green power users list.

University of California Los Angeles is fuelled by landfill gas—about 7 per cent of the total.

Georgetown University has prepared a Master Plan for 2037 that heavily addresses campus-wide sustainability and energy. The campus-wide sustainability plan involves commitments in areas such as energy and climate, water, solid waste, land and grounds, buildings, purchasing, food and transportation. The Energy plan includes assessment of energy consumption using ASHRAE energy audits.

Università degli Studi di Milano and *Politecnico di Milano* have been involved in the project Città Studi Sustainable Campus that focuses on redevelopment of an educational district (called Citta Studi) in Milan on the principles of sustainability. The project included four theme-based roundtables, on Energy, Environment, Accessibility and People. Under this fabric, another theme, Food and Health, was set up to focus on the issues that impact the lifestyles and health of the whole campus community. Areas of involvement included development of issues related to food (nutrition education), health (food and diseases, diet therapy, eating disorders, alcohol and diet), proposing food to foster students' ties with land and nature, enhancing sustainability of agro-food (energy saving, rationalization of consumption, reuse of surplus), catering guidelines for the whole campus, etc.

Yale University focused, as part of their strategic plan for sustainability, on sub-institutional level planning and action. The Office of Sustainability partnered with students and staff members in the Yale Schools of Divinity, Management, and Forestry and Environmental Studies to develop sustainability plans for each school/department. In the academic year 2010–11, the office used a 'do-it-yourself' pilot to induce department-level sustainability, supported by the formation of a separate green team and formulation of objectives. Thus, the Divinity School hosted a food justice conference that included members of the surrounding community as well as food experts from the university. The School of Management established protocols for 'zero-waste' events as well as procedures for monitoring energy efficiency in their new building. The School of Drama reduced paper and toner use by 25 per cent over the course of one fiscal year. The School of Forestry and Environmental Studies established mechanisms to advance multidisciplinary approaches for using the campus as a living laboratory.

- It allows the institution to record its resource use and equips it to skillfully manage their resources for optimum utilization. It can reduce operation and maintenance costs.
- The initiative's good practices can be shared among institutions and can inform policy process on resource efficiency. It can provide credible data for long-term policy change, infrastructure planning and curriculum development.
- Institutions can set up environmental management systems to address on-site and off-site environmental impacts.
- Adopting this initiative will make way for collection of data state and central governments could use for long-term policy changes with regard to infrastructure and curriculum.
- The initiative will contribute to national and global environmental needs directly by efficient management of natural resources and indirectly by propagating the necessary knowledge and skills further in the society.
- It will allow the institution to emerge as a progressive and spearheading entity in the sphere of sustainability, both nationally and globally. This increases attraction rate of the university.

The Green Campus toolkit

This toolkit for Green Campus is therefore designed to provide practical strategies to increase resource efficiency, improve ecosystem management for sufficiency, minimize waste and pollution and promote healthy lifestyles. It is an audit process to be done by students.

This toolkit comprises several steps:

1. **Monitoring and benchmarking resource use and waste generation**: Students will collect information about resource consumption, waste generation and green area management.
2. **Setting targets to achieve and surpass goals for zero-carbon and near-zero waste and water-prudent campuses and making the bio-region of campuses regenerative.** This will be done through conservation strategies, educational campaigns, retrofitting and green campus policy.
3. **Indicators will capture strategies for improvement and guidance for campus planning for infrastructure and managerial and operational interventions.**

2. Campus profiling

About the campus

Name of institution _____
Address line 1 _____
Address line 2 _____
Country _____
State _____
District _____
Pin code _____
Coordinator's name _____
Coordinator's email _____
Telephone number (landline) _____
Mobile number _____
Contact details of head/team lead _____
Name _____
Email _____
Mobile number _____

Area and population

Different land uses have different impacts on the environment. For instance, industrial use has a greater effect on air pollution, noise pollution, waste generation, water consumption, etc. as compared to residential use. This impact is generally an aggregation of several attributes such as type of building, materials used in building, built area, rooftop surface area, paved area, green area, etc.

At the city level, a campus site is classified under educational land use, but within a campus site there could be several subcategories of land use such as academic, recreational/assembly, living, commercial, utilities, transportation and greens. Generally, a well-balanced land-use composition with more green areas than built is efficient.

Land use and building use further guide the number of persons to be accommodated. Overcrowding and under-occupancy both lead to inefficiency. It is also important to know different types of population on campus, i.e. visiting, support staff, faculty or students. As each population has different operating hours, consumption of resources and respective impacts varies accordingly.

1.1 Total population:

CATEGORY	MALES	FEMALES
Students		
Faculty		
Visitors		

1.2 Provide area details:

TOTAL PLOT AREA (SQ. M)	TOTAL BUILT AREA (SQ. M)	TOTAL GROUND COVERAGE AREA (SQ. M)

1.3 Total support staff:

CATEGORY	MALES	FEMALES	OPERATING HOURS
Guards			
Housekeeping			
Drivers			
Gardeners			
Nurses			
Others (specify)			

1.4 Commercial activities

CATEGORY	NUMBER	AREA (SQ .M)	OPERATING HOURS
Shops			
Bank			
Canteen/cafeteria			
Others (specify)			

1.5 Halls for public functions

S. NO.	NAME OF THE HALL	CARPET AREA (SQ. M)	FLOOR AREA (SQ. M)
1.			
2.			
3.			
4.			
5.			
	Total		

NOTE:
Carpet area: Area enclosed within the walls
Floor area: Area taken up by floor space in the building

1.6 Public and private functions in a year

S. NO	NAME OF THE FUNCTION	NUMBER OF ATTENDEES (AVERAGE OR ACTUAL IF RECORDS EXIST)
1.		
2.		
3.		
4.		
5.		
8.		
9.		
10.		

1.7 Referring to the following images and information, provide area (in sq. m) for:

CATEGORY	COURT/FIELD AREA (SQ. M)	INDOOR/OUTDOOR	TYPE OF SURFACE
Parking			
Sports utility			
• Lawn tennis			
• Badminton			
• Basket ball			
• Skating			
• Handball			
• Cricket/football			
• Assembly area			
• Others			
Swimming pool			
Terrace			

A terrace surface may comprise a landscaped and green finish, reflective and heat-resistant tiles, plain cement finish or a polyurethane coating (mainly for waterproofing).

Landscaped and green finish

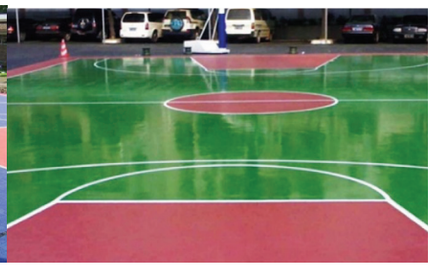
Reflective and heat-resistant tiles

Polyurethane coating

Surfaces under sports utility found in the Indian context can be classified into outdoor and indoor categories. Outdoor court surfaces generally range from grass, plain concrete and acrylic paint. Newly constructed courts, while following international standards, may use materials such as polypropylene tiles and styrene-butadiene rubber carpets.

Plain concrete

Polypropylene tiles



Acrylic layering

Indoor court surfaces are made of cement, acrylic paints, vinyl sheets or wooden board.

Acrylic paint on cement floor

Vinyl sheets

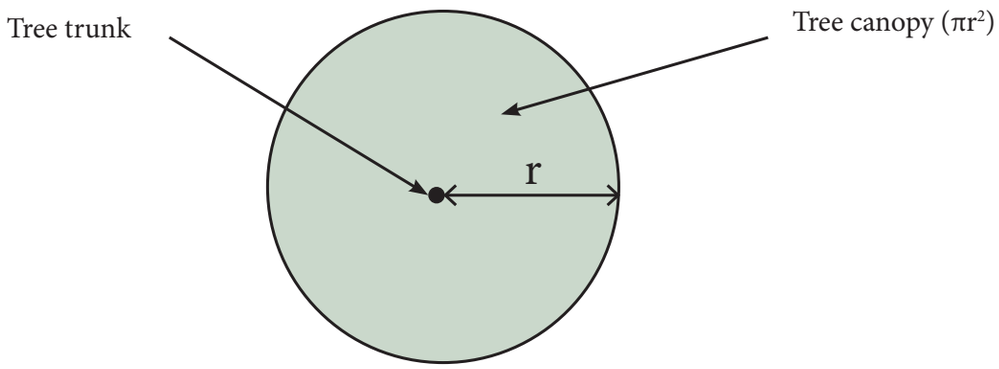
Wooden board

1.8 Referring to the following information, provide area (in sq. m) under:

CATEGORY	AREA (SQ. M)
Green area*	
• Grass area	
• Shrubs	
• Tree canopy**	
• Trees (number)	

Note: * Green area in a campus includes all the landscape elements like grass turf, shrubs, flower beds, trees, etc. but excludes the playground.
** *To measure tree canopy*: Prepare eight small sticks or any kind of marker and visualize the tree's leaf cover as a clock. Place/insert sticks in the ground right under the edges of our 'tree clock' at 12 o'clock, 6 o'clock, 3 o'clock and 9 o'clock positions. Then place sticks halfway between each of those four sticks. When all eight sticks are inserted into the ground, use a string to create a large circle around all the sticks, and measure the length of the string. The length of the string is the circumference of the tree canopy. Calculate the radius (r) using formula, $2\pi r$, and hence the area using formula, πr^2.

Figure 1: Top view of a typical tree



1.9 Provide details block-wise:

BLOCK	NUMBER OF FLOORS	FLOOR AREA (SQ. M)	POPULATION	OPERATING HOURS

3. Green mandate

Environmental planning and development requires institutional arrangement and a clear mandate. Ideally there should be a dedicated institutional body such as an environment committee or a special cell or green team to accelerate implementation of Green Campus strategies. This should have a reasonable mix of representation from students, faculty and the management. Students should make up the majority and the presence of academic staff will provide functional capacity to the green team. Inclusion of a member of the executive board or governing authority could further amplify the team's agenda. Research staff and non-teaching staff such as building or utility managers add strength to the team. This may be further divided into categories such as the water conservation team, paper use reduction team, no-plastic team, recycle team, research team, communication team, etc.

The green team should have a clear vision and set of objectives with respect to the campus. It should meet regularly and record minutes of discussions to maintain clarity on subjects. The process should be participatory and must evolve in stages for advanced action, which includes implementation of an action plan to improve environmental performance of the campus.

3.1 Do you have a green team? If you do, provide the organization setup for such initiatives.

_____
_____
_____
_____
_____
_____
_____

3.2 How often does it meet? Support with the minutes of two such meetings.

Monthly ☐ _____

Quarterly ☐ _____

Annually ☐ _____

3.3 Is it empowered to recommend projects to management? If it is, provide their constitution support in committees, reservations if any or weightage criteria for proposals.

Yes ☐ _____

No ☐ _____

3.4 Is it empowered to implement projects? If it is, support with such institutional arrangements.

Yes ☐ _____

No ☐ _____

Box 3.1: IITs' green strategy and action plan

The IITs, being premier institutions of the country, took the lead in working towards environmental issues and society in 2013. The IIT Council in a consultative meeting suggested implementation of a green agenda in a phased manner.

The green agenda begins with establishment of a Green Office. The office oversees the process and supply with technical resources (such as pollution-control technologies) required for achieving sustainable development of the campus. The office could set up a working group composed of interested and active students/faculty from various departments.

The duties of the Green Office involve development of a green policy/vision for the campus and a referential framework for conservation and efficient management of natural resources. The framework considers a new environmentally orientated master plan that has careful land use or space planning, GRIHA-compliant buildings, protected green areas and biodiversity, rainwater harvesting and recycling, active use of renewable energy, international standard waste management, and international norm-compliance for safety and risk-proofing against hazards.

The duties also include a green audit for infrastructure planning, execution and maintenance. It facilitates the quantification of green initiative in a transparent and publicly accountable way. It begins with the development of a baseline scenario by scientific collection of data on energy use, water use, waste management and CO_2 emissions. It develops targets for percentage reduction in each of the mentioned areas—by 2020, 2030 and so on. It then involves development of green technology packages and a strategy along with identification of green performance indicators and milestones to achieve sustainability.

The strategy suggests a time frame of months for the establishment of a green office and green policy/plan, three to six months for development of baseline scenario, six to nine months for development of targets and strategy, nine months onwards for implementation of plan, periodic monitoring and verification every twelfth month, a year for education on sustainability agenda, twenty-four months onwards for dissemination, outreach and capacity building of other institutions and society.

Source: Ministry of Human Resource Development, Government of India, 2013.

4. Measurement and monitoring

There are multiple evaluation processes that can be used to sense the current environmental picture in a campus. These assessments help gaining familiarity with available resources, issues, gaps, risks and possible areas of intervention towards achieving green campus.

Environment Impact Assessment (EIA): The environmental consequences of a decision to go ahead with a plan, policy, programme or activities are generally assessed prior to their implementation to inform the effectiveness and efficiency of that decision. EIA is an interdisciplinary and multi-step process that ensures environmental considerations are included in the decisions. It helps identify the effects and how those can be mitigated before any damage takes place. EIA is not limited to the analysis of impact on the physical environment. It may also consider socio-cultural coherence, economy, health and well-being of the people within impact area of the decision.

4.1 Have you conducted an Environment Impact Assessment? If you have, provide a brief report/summary.

Yes ☐ _____

No ☐ _____

Eco-audits: Various types of evaluations intended to identify environmental compliance, implementation gaps of policy/plans, if any, along with performance of related corrective actions can be carried out through eco-audits. Eco-audits are a comprehensive reflection on whether or not current and/or future environmental efforts are actually making a difference as per the commitments. Presence of an institution and an environmental policy may come as a prerequisite for a good eco-audit.

The Green Campus initiative is also an eco-audit with specific objectives towards greening of the campus. General steps for conducting an eco-audit are shown below:

Temporal functions related to an eco-audit are given below:

PRE-AUDIT	ON-SITE	POST-AUDIT
• Plan the audit • Select the audit team • Schedule the audit facility • Acquire the background information	• Understand the scope of audit • Analyse the strengths and weaknesses of the internal controls • Conduct the audit • Evaluate the observations of audit programme • Prepare a report of the observations side by side	• Produce a draft report of the data collected • Produce a final report of the observations and the interference with accuracy • Distribute the final report to the management • Prepare an action plan to overcome the flaws • Keep a watch on the action

4.2 Have you conducted an eco-audit? If you have, please provide a brief report/ summary.

Yes ☐ _____

No ☐ _____

Risk assessment: Risk assessment is a systematic process of evaluating potential risks that may be involved in a projected activity, decision or undertaking. Risk can be determined through qualitative or quantitative estimation against a well-defined situation or a recognized threat (also called hazard).

Box 4.1: A method to assess risk

Step 1: Identify the hazards
Step 2: Decide who might be harmed and how
Step 3: Evaluate the risk level using the table and matrix below and decide on precautions
Step 4: Draw inferences based on your findings and implement them
Step 5: Review your assessment and update if necessary

RISK LEVEL	LIKELIHOOD/PROBABILITY	SEVERITY/CONSEQUENCES
High—Red	Frequent—Likely to occur often	Catastrophic—Results in fatalities and/or loss of system
Medium—Yellow	Probable—Will occur several times	Critical—Severe injury and/or major system damage
Low—Green	Occasional—Likely to occur sometime	Marginal—Minor injury and/or minor system damage
	Remote—Unlikely to occur, but possible	Negligible—Less than minor injury/or less than minor damage
	Improbable—It can be assumed it will not occur	

LIKELIHOOD/ PROBABILITY	SEVERITY/CONSEQUENCE			
	NEGLIGIBLE	MARGINAL	CRITICAL	CATASTROPHIC
Frequent				High
Probable				
Occasional		Medium		
Remote				
Improbable	Low			

4.3 Have you conducted a risk assessment? If you have, provide a brief report/ summary.

Yes ☐ _____

No ☐ _____

Ecological footprint: The impact of human activities measured in terms of the area of biologically productive land and water required to produce goods consumed and absorb wastes generated is known as ecological footprint. Productive surface areas include all cropland, grazing land, fishing grounds and forests required to produce food, fibre and timber. It also considers the land required to absorb emissions from the energy used in production, and to provide space for its infrastructure, including roads and built areas.

One can calculate ecological footprint for individual people, groups of people (such as a nation) and activities (such as producing a consumer good). For a campus, it can be calculated by considering all of the biological materials consumed, and wastes generated, by the campus in a given year. For this, the amount of material consumed (tonnes per year) is divided by the yield of the specific land or sea area (annual tonnes per hectare) from which it was harvested, or where the waste material was absorbed. The resulting hectares are then converted to global hectares (gha). The sum of the global hectares needed to support the resource consumption and waste generation of the person gives that person's footprint.

Box 4.2: Did you know?

As of 2017, we need 1.7 Earths to meet humanity's current demand for ecological resources.

The low footprint of India might be deceiving. India is a developing nation with huge population and a substantial deficit in infrastructure and service provision. As per the 2011 census, India inhabits about 1.21 billion people, of which 68.9 per cent live in rural areas without access to much infrastructure and amenities. For calculation of environmental footprint, a big denominator and small numerator therefore result in a lower than average figure.

Source: Global Footprint Network, 2017

4.4 Have you calculated your ecological footprint? If you have, how much is it?

Yes ☐ _____

No ☐ _____

4.5 Have you conducted any other assessment related to environment? If you have, provide a brief report/summary.

_____

_____

_____

_____

4.6 Have you established an environmental mission/vision for your campus/block? If you have, elaborate and support with controlled documentation.

Yes ☐ _____

No ☐ _____

Controlled documentation: This is a formal reference document that could be reviewed, amended and distributed during its life cycle. It usually has a unique identification number, purpose of the document, clear specification of the issuing authority and nature of information. The documentation could be a policy, plan, guidelines, standard, report, operational record, data sheet, contract, etc.

4.7 Have you set environmental goals for your campus/block? If you have, elaborate and support with controlled documentation.

Yes ☐ _____

No ☐ _____

4.8 Do you have an action plan for implementing and monitoring progress towards goals? If you have, elaborate and support with controlled documentation.

Yes ☐ _____

No ☐ _____

4.9 Have you pursued a green campus/block/compound designation such as Green Rating, GRIHA, ISO 14001, etc.? If you have, elaborate and support with controlled documentation.

Yes ☐ _____

No ☐ _____

4.10 Do you encourage sustainable behaviour via [support with controlled documentation]:

☐ Policies

☐ Education campaigns

☐ Incentives (stickers, buttons, gift cards)

☐ Contests

☐ Awards

5. Energy

We as humans are highly dependent on energy in our daily lives. We consume energy non-stop and in different forms—light, sounds, heat and electricity—and often waste it.

When we talk about energy, it is important to recall the sources. There are mainly two types of energy sources: renewable and non-renewable. Renewable sources involve harnessing energy from the sun, wind and water. Biological growth-based fuels such as garbage, dead trees, branches, livestock dung and bio-diesel can also be replenished so they fall under renewable sources of energy. All forms of fossil fuels such as coal, oil and natural gas are non-renewable sources of energy. Unfortunately, mankind is dangerously addicted to non-renewable sources of energy which is single handedly responsible for increase in greenhouse gas emissions, warming of the planet and climate change. Substituting fossil fuels with energy from renewable sources is the most logical answer to the problem.

Guiding principles

Reducing the energy footprint

- Reduce energy intensity of the built environment of the city by at least 30–35 per cent to prevent energy guzzling and contribute towards India's INDC commitment of reducing energy intensity of growth.
- Improve energy savings in buildings by setting energy performance targets and adopt enabling strategies.

Take steps to have a solar campus—enhance the use of renewables.

- Promote rooftop solar power in all new and existing residential, commercial, and institutional buildings and link it to reduced use of diesel generator sets.
- Instal renewable energy solutions to meet electricity generation equivalent to 5 per cent of the demand load.

Energy consumption can be reduced by two techniques—conservation and efficiency measures. Energy conservation refers to reducing of energy consumption by using less of an energy service. Efficient-energy use refers to using less energy for a constant service. It involves a smart approach in the buildings for natural sunlight, ventilation and maintaining the ideal room temperature. Conducting an energy audit is the first step towards identifying opportunities to reduce energy and related costs.

Box 5.1: Emissions from electrical appliances

Whether an AC or a light bulb, all appliances that consume electricity send greenhouse gases into the air. Reducing electricity consumption—for example, by remembering to turn off the lights and fans when you leave a room—can have a substantial positive impact on environment.

The comfort standard with regard to air conditioners in India is taken at around 27°C (with a fan on). This eliminates the need to run a power-guzzling AC the whole day to cooling below this temperature. Also, many appliances like TV consume electricity when they are switched off but are still on stand-by mode. A plugged mobile charger consumes electricity even if the mobile is not connected. To get rid of these energy vampires, switching off the electrical sockets is necessary.

Energy audit is an inspection and analysis of energy use and flow in a building, process or a system, with an aim to reduce the energy input into the system without negatively affecting the output.

5.1 Have you done an energy audit? If you have, details should cover energy consumption source-wise and consumption land-use-wise supported by submetering data, if available, e.g. common areas, block-wise consumptions etc.

Yes ☐ _____

No ☐ _____

Box 5.2: Did you know?

A 16–20-watt LED bulb has the same brightness as a regular 100-watt bulb? It is over 80 per cent more energy efficient than regular bulbs as well.

Energy conservation can go beyond saving electricity:

- Cleaning/replacing air conditioner filters can save 160 kg of CO_2 emissions a year. It also ensures faster cooling.
- Buying recycled paper products: It takes 70–90 per cent less energy to make recycled paper and it also prevents the loss of forests, which are 'carbon sinks' for the world. Besides, these products are more aesthetic and presentable

Source: A. Sikdar et al. 2011. *Climate Change and Natural Resources*. Centre for Science and Environment, New Delhi.

Submeter: A submeter is a metering device that measure energy use in individual blocks. It monitors energy usage of tenants, departments, pieces of equipment or other loads separately.

S. NO	NAME OF THE BLOCK/COMMON AREA	LAND USE	FLOOR AREA (SQ. M)	ENERGY SOURCE	ANNUAL CONSUMPTION (KWH)	AC/ NON-AC
1.						
2.						
3.						
4.						
5.						
8.						
9.						
10.						

Note: Land use can be provided as institutional, recreational, residential, commercial, etc.

Energy in a campus could come from different sources. Conventionally, the source is the grid supply purchased from an electricity service provider. Additionally, energy could be supplied from renewable sources such as solar, micro-hydro and wind. Other sources include diesel generator sets and uninterruptable power supply for contingency arrangement.

5.2 Do occupants know where their energy comes from? Provide a pie chart with sources (such as thermal, renewables, etc.) based on connected load and their absolute numbers in kilowatts or kilowatts peak (for solar).

Yes ☐ _____

No ☐ _____

5.3 Do you track your energy use and cost? Provide five-year data with trends. (Support with recent energy bills.)

Yes ☐ _____

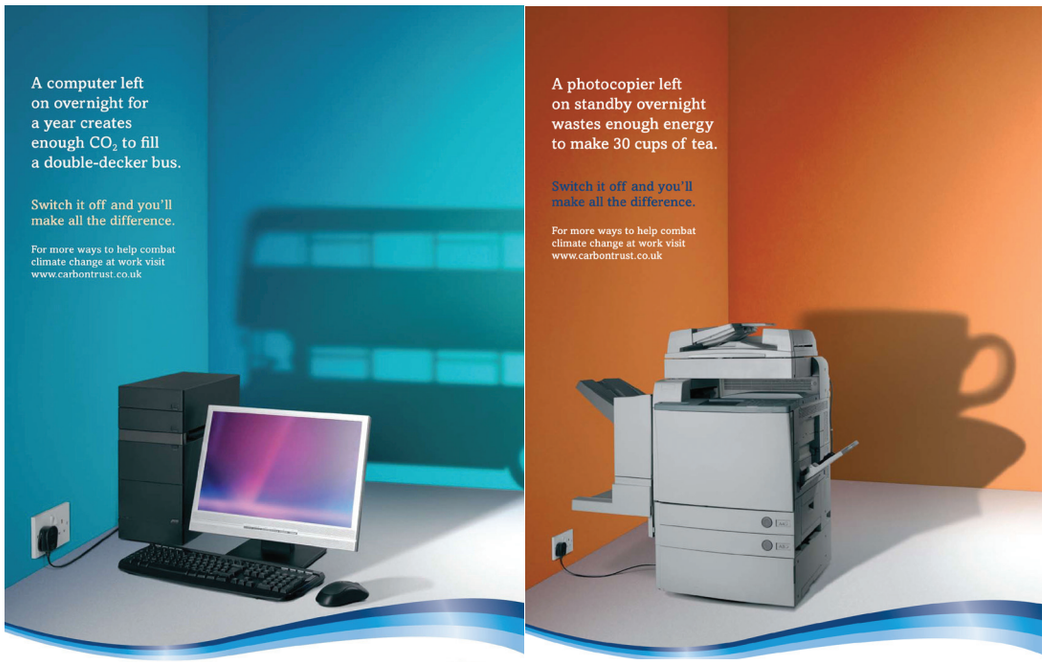
No ☐ _____

S. NO	ANNUAL ENERGY CONSUMPTION (KWH)	YEAR	COST (Rs)

5.4 Do you offer energy conservation lessons and programmes? If you do, provide details.

Yes ☐ _____

No ☐ _____



Source: https://www.carbontrust.com

5.5 Do you encourage responsible energy use via [tick appropriate box and provide necessary details]:

Policies ☐ _____

Education campaigns ☐ _____

Contests ☐ _____

Incentives ☐ _____

Awards ☐ _____

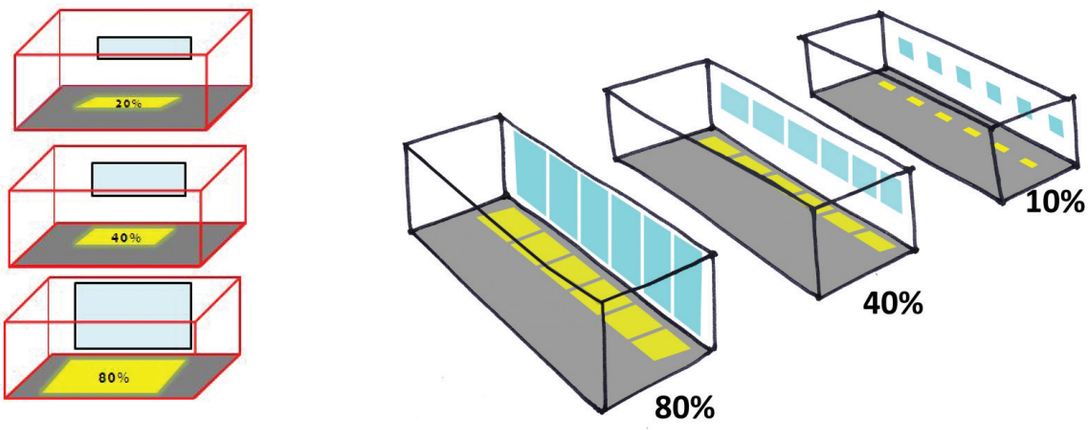
5.6 Do you use natural lighting when and where possible? What is average window-wall ratio on the southern facade of the building?

Yes ☐ _____

No ☐ _____

Window-wall ratio (WWR): WWR is the ratio of window area to the gross exterior wall area for a particular facade. The gross wall area includes both the window area and the area of the wall surface. The walls considered for calculation of WWR are those that form the north and south facade. The east and west facade is generally opaque to avoid heat gain and increase in energy load as a result of the sun's movement.

Figure 2: Typical schemes showing window-wall ratio



5.7 Have you installed occupancy sensors for lighting control? If you have, how much of the total floor space and percentage of lighting load are covered by such initiatives?

Yes ☐ _____

No ☐ _____

Occupancy light sensor: Occupancy light sensor is a device that senses occupancy of a space by people and turns the light on or off automatically. The sensors may use infrared, ultrasonic, microwave or other technology. These sensors are used extensively in green or energy-efficient buildings as they lead to considerable energy savings (see *Table 1: Savings from occupancy sensor lighting controls in different rooms*)

Table 1: Savings from occupancy sensor lighting controls in different rooms

ROOM TYPE	BREAK ROOM	CLASSROOM	CONFERENCE ROOM	CORRIDOR	OFFICE, PRIVATE	OFFICE, OPEN	RESTROOM	STORAGE AREA	WAREHOUSE
Occupancy sensor lighting energy savings	29 per cent	40–46 per cent	45 per cent	30–80 per cent	13–50 per cent	10 per cent	30–90 per cent	45–80 per cent	35–54 per cent

Source: United States Department of Energy, 2017. https://energy.gov/sites/prod/files/2017/01/f34/wireless_occupancy_sensor_guide.pdf

5.8 Do you immediately report inoperable occupancy light sensors/switches via work order? Provide the service-level agreement for the help desk or maintenance services for such initiatives.

Yes ☐ _____

No ☐ _____

Operation and management of utility and services in a campus are sometimes entrusted to an external service provider/agency via a service-level agreement. The agreement includes details such as types of service provided, frequency of services, cost of services and other terms. Swift response by the agency on reporting of inoperable utility indicates efficiency in operation and management.

5.9 Have you evaluated existing lighting for opportunities to reduce lighting in over-lit areas? Give examples of measures (such as LED or CFL replacements, etc.), associated savings and cost-benefit analysis, if any.

Yes ☐ _____

No ☐ _____

Lighting power density (LPD), according to the Energy Conservation Building Code (ECBC),[1] 2017, is the maximum lighting power allowance per unit area of a space and is expressed in watt/m^2. LPD value is defined as per the function of building and also function of space. For a University, LPD value is provided as 11.2 W/m^2 (as per the Building Area method) and for separate space function (as per the Space Function method) (see *Table 2: Lighting power density value for areas in an educational campus*).

Table 2: Lighting power density value for areas in an educational campus

CATEGORY	LPD (W/M²)
Classroom/lecture hall	13.7
Staff room/office	10.0
Laboratory	15.1
Exhibit space/convention centre	14.0
Restroom	7.70
Stairway	5.50
Corridor/transition	7.1
Lobby	9.1
Workshop	17.1
Conference/meeting halls	11.5
Storage	6.80
Electrical/mechanical units	7.1

Source: Energy Conservation Building Code, 2017

5.10 Do you turn off lights and other equipment when not in use? If you do, what are the switch-off and switch-on timings and are controls manual or controlled through the building management system?

Yes ☐ _____

No ☐ _____

5.11 Do you use natural ventilation/windows when possible? Support by detailing schemes followed, such as night purge, non-AC blocks, etc.

Yes ☐ _____

No ☐ _____

5.12 Do you purchase BEE star-rating equipment/appliances? Please elaborate and support with recent purchase specifications for such orders, for example, a copy of the purchase order, specifications, etc.

Yes ☐ _____

No ☐ _____

S. NO.	EQUIPMENT/APPLIANCE	DATE OF PURCHASE	BEE STAR RATING
1.			
2.			
3.			
4.			
5.			

The Bureau of Energy Efficiency (BEE) has established a comparative star-labelling system for indoor appliances such as tubular fluorescent lamps, refrigerators (frost-free and direct cool) and air conditioners. Other appliances include distribution transformer, induction motors, pump sets, ceiling fans, LPG, electric geysers and colour TV. The more the number of stars, the more is the energy efficiency of the appliance.

The system was launched in 2006 by the Ministry of Power with an objective to provide the consumer an informed choice about energy saving and thereby the cost-saving potential of the marketed household and other equipment.[2]

5.13 Do you have a policy for maximum and minimum temperature settings for air-conditioned spaces? If you do, support with requisite orders/initiatives.

Yes ☐ _____

No ☐ _____

The National Building Code defines thermal comfort in tropical India as 25–30°C, with the optimum condition at 27°C.[3] There are other criteria as well. Lower set point temperature has direct bearing on energy consumption of an HVAC system. Test results by Tokyo Electric Power Co. indicate that raising an air conditioner's thermostat from 26–28°C and using an electric fan can reduce electricity consumption by up to 22 per cent.

With the thermostat on 18°C, the compressor will have to operate for longer to bring the heat down from 45°C degrees to 17°C. This means more electricity is consumed. When the thermostat is set at 27°C, the air conditioner cools the room to that temperature and turns off the compressor until the room warms up again, saving electricity. 27°C is considered the most pleasant room temperature, in which one neither sweats nor does one feel cold.

5.14 Do you have solar, geothermal, biomass or other forms of renewable energy installed on your campus? If you do, kindly elaborate the share percentage of such installation of the total power demand.

Solar ☐

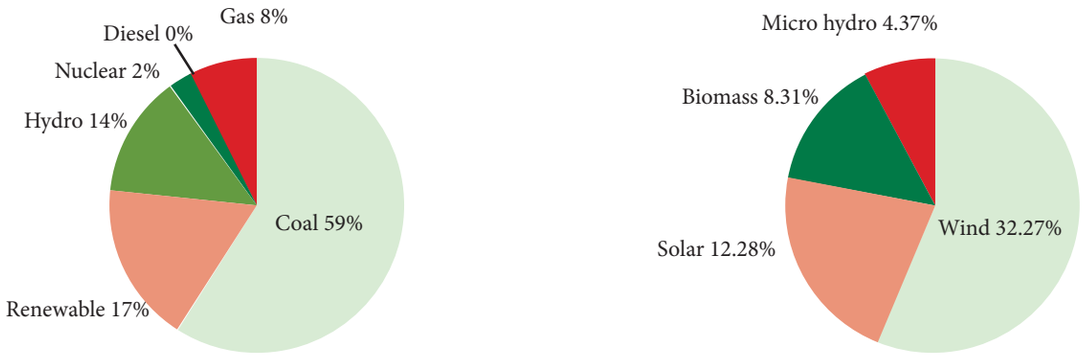
Geothermal ☐

Biomass ☐

Others (specify) ☐

India's installed power capacity as on 31 March 2017 was 326.8 GW, of which 57.25 GW was renewable as shown in *Figure 1: Indian power scenario (in GW); installed capacity of renewable sources (in MW)*.[4] In 2014, the country set a target of installing 175 GW renewable energy capacity by 2022. Currently, wind energy forms the highest proportion of installed renewable energy, but solar energy has great potential as we get 300 solar days per year on average. This advantage has enabled another target of meeting 8 per cent of India's total energy consumption through solar energy by 2022. Solar energy, at 100 GW, will comprise the largest wedge of the target of 175 GW power capacity. The installed capacity of renewable energy sources in India as on 31 March 2017 is given below:

Figure 3: Indian power scenario (in GW); installed capacity of renewable sources (in MW)



Source: Central Electricity Authority, 2017.

The government aims to achieve these renewable energy targets through mini-grids and micro-grids. This involves a shift from a central grid system to a decentralized renewable energy (DRE) system. DRE comprises smaller power plants that operate in standalone mode or in parallel with the central grid in case of emergency to supply a group of houses, offices or a campus. This decentralization provides the ability to isolate from a larger network and therefore a reliable and self-sustained source of energy to consumers.

5.15 Do you offer renewable energy lessons and programmes?

Yes ☐ _____

No ☐ _____

Box 5.3: Micro hydropower plants versus big dams

- Small hydropower plants need only a small amount of flow to generate electricity and therefore the stream need not be blocked by large concrete dams, which are very expensive, to build reservoirs of water. Maintenance too is not as costly as large hydro power plants. Large hydropower plant projects also require a long preparation time, involving substantial planning and testing because there is no standard and set procedure for constructing a dam. Micro hydropower plants, on the other hand, can be installed quickly.
- Micro hydropower plants do not require large reservoirs and consequently there is no submergence of huge tracts of land, no loss of flora and fauna and most importantly no displacement of a large number of people.
- Any breach of the dam can also cost lives of numerous humans, trees and animals. In contrast, a micro hydropower plant is a safe option.

Source: A. Sikdar et al. 2011. *Climate Change and Natural Resources*. Centre for Science and Environment, New Delhi.

Box 5.4: Green campus proposals

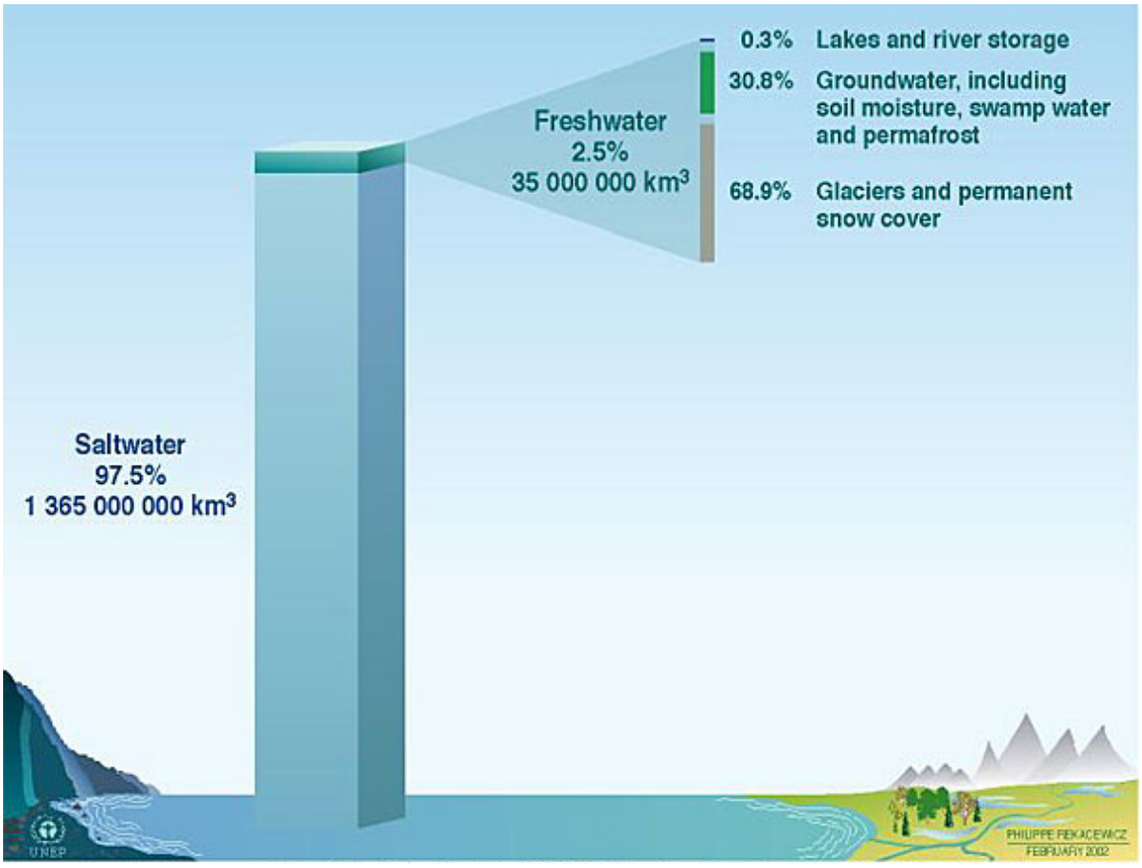
In 2016, the University Grants Commission suggested that all educational institutions develop green campuses. The suggestion involves preparation and submission of a proposal by institutions to reduce demand for conventional energy by 10 per cent and demand for fossil fuels by 25 per cent at the end of five years. Suggested measures include preparation of a master plan, energy and water audits for setting a baseline scenario and reduction targets, enhancing supply from renewable energy sources and energy-efficiency measures such as energy-efficient street lighting system, low-energy fixtures, energy-efficient pumping system, energy-efficient motors and use of star-rated equipment. The request is part of the Development of Solar Cities programme, launched by the Ministry of New and Renewable Energy in 2014. The programme provides financial assistance of up to Rs 5,00,000 for preparation of the master plan and detailed project report.

Source: University Grants Commission, 2016

6. Water

Water is one of the most precious substances on our planet and essential for survival. Though almost 70 per cent of the earth's surface is covered with water, there is still profound scarcity of water for consumption. This is because only 2.5 per cent of surface water is fresh, of which 70 per cent is frozen as ice caps and glaciers. The remaining 30 per cent is present in aquifers, followed by rivers, lakes and wetlands, leaving only a minuscule part (0.007 per cent) available for human consumption.[1]

Figure 4: Total global saltwater and freshwater estimates



Source: United Nations Environment Programme, 2006.

The problem that we are faced with globally with regard to water is that either it is available in great quantities or not available at all. While the Amazon River alone carries 16 per cent of the global runoff, the arid and semi-arid zones of the world that constitute 40 per cent of the land mass receive only 2 per cent of the global runoff.[2] This uneven distribution is not only responsible for changes in climate and ecosystem, but also conflicts ranging at local, regional and national level. The conflicts mainly result from the competition triggered by scarcity of the resource.

Box 6.1: Glaciers

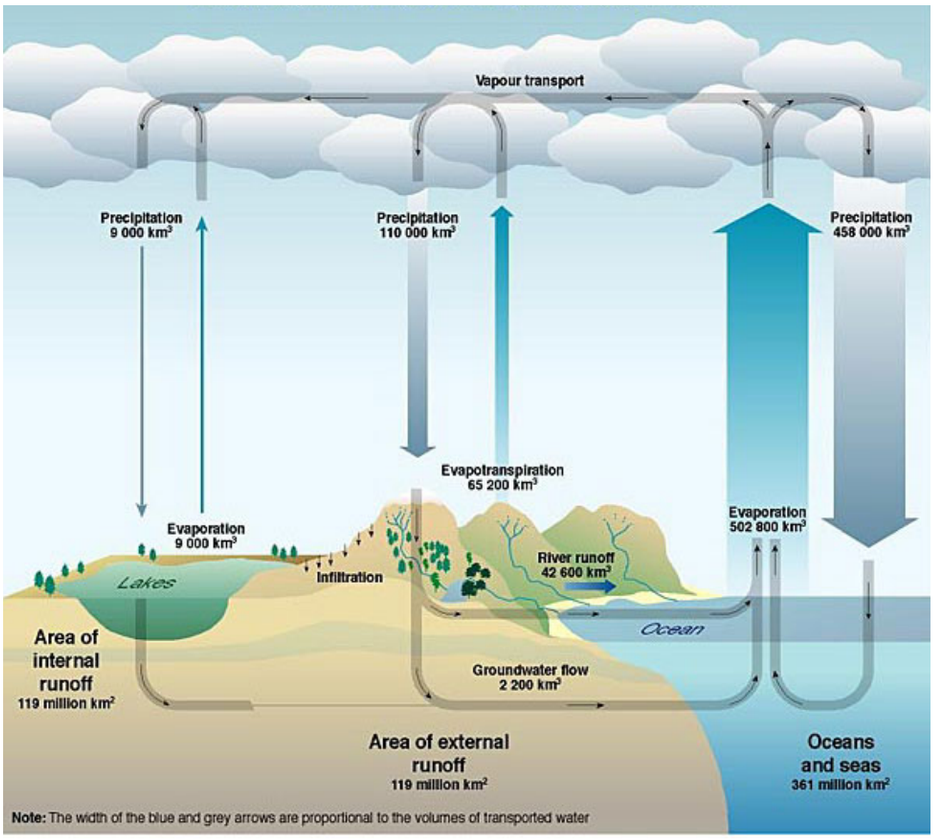
Glaciers are nature's marvel. They not only offer spectacular views on this planet, but also store 70 per cent of the world's freshwater within 10 per cent of world's land area. This great concentration of ice can only exist in low temperature which is found in polar regions and mountainous areas. Rising temperatures and changing climate are leading to melting of glaciers at an unprecedented rate. Humans have caused the disappearance of some ice caps, glaciers and even an ice shelf in this century!

The 30.2-km-long Gangotri Glacier and the neighbouring chain of glaciers are lifelines for the Ganga and Brahmaputra River basins. During 1842–1935, the Gangotri Glacier was receding at an average of 7.3 m every year and in 1985–2001 at about 23 m per year. Currently, the average retreat is at an alarming 28 metres per year. Other glaciers that feed the Ganga and Brahmaputra River basins face the same threat.

GLACIER	RETREAT OF SNOUT (M)	AVERAGE RETREAT (M/YEAR)
Triloknath Glacier	400	15.4
Pindari Glacier	2,840	135.2
Milam Glacier	990	13.2
Ponting Glacier	262	5.1
Bara Shigri Glacier	650	36.1
Gangotri Glacier	364	28.0
Zemu Glacier	194	27.7

Source: International Union for Conservation of Nature and Natural Resources, 2012.

Figure 5: Global precipitation, evaporation, evapotranspiration and runoff

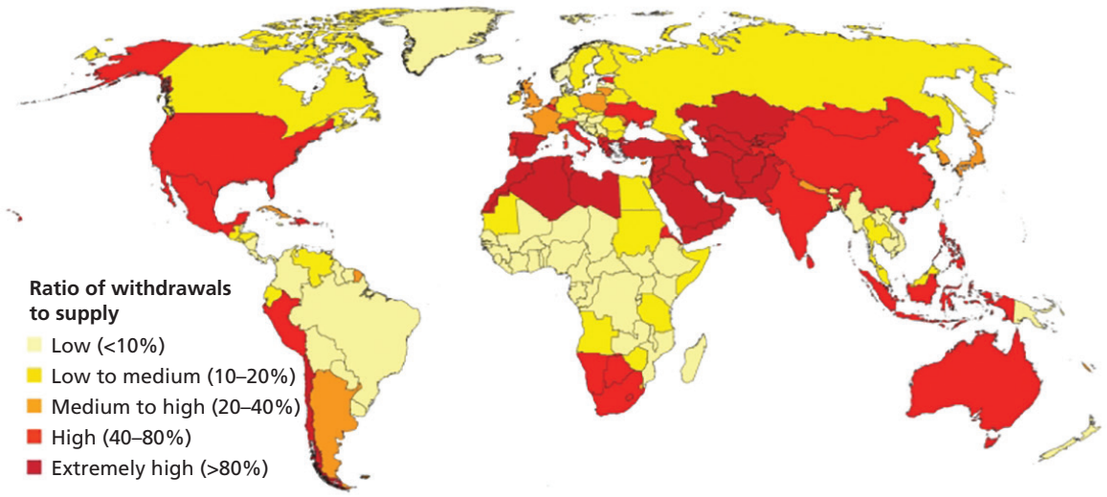


Source: United Nations Environment Programme, 2006

Developing countries are expecting their middle class to double by 2025. Rising affluence drives a larger water demand. Population growth pushes the demand for food up by 69 per cent and agriculture accounts for 70 per cent of water withdrawals globally. An increase of about 20 per cent in water withdrawal for energy production is also expected between 2010 and 2035. This water-intensive food production and electricity generation are estimated to raise water consumption by a dramatic 85 per cent.[3]

As shown in *Map 1: Country-wise water stress*, the Middle East and North Africa faces extremely high water-stress as estimated for the year 2040. Following are the US, China, India and Australia, which are estimated to have high water-stress.

Map 1: Country-wise water stress (2040)



Note:Projections are based on a business-as-usual scenario using SSP2 and RCP8.5

Source: A. Maddocks, R.S. Young and P. Reig, 2015. Ranking the world's most water-stressed countries in 2040.http://www.wri.org/blog/2015/08/ranking-world%E2%80%99s-most-water-stressed-countries-2040

India holds about 4 per cent of the world's water resources. It is estimated that the country receives around 4,000 billion cubic metres (BCM) of rainfall.[4] While rainfall is the country's primary source of freshwater, it varies widely across states, seasons and years. Rivers are present in large numbers but are not adequate for the rapidly rising water demand. Nine of India's 20 river basins, which support a population of 200 million, are already facing water scarcity.[5] Further, most of these rivers are polluted because every day millions of tonnes of industrial effluents, agricultural run-off—containing fertilizers and pesticides—and domestic wastes flow into them untreated. Even after 26 years of pollution abatement programmes, almost all the major river systems contain high levels of organic pollution, low oxygen levels for aquatic organisms, and bacteria, protozoa and viruses which have faecal origin and cause various diseases.

Further, the country depends on groundwater resources, and is the largest consumer of groundwater in the world. States like Punjab and Maharashtra have been withdrawing groundwater at an alarming 127 to 170 per cent of the available groundwater.[6] About 89 per cent of the groundwater extracted is used for irrigation, making agriculture the highest-category user in the country. This is followed by domestic use, which requires 9 per cent of the extracted groundwater, and industrial use, which requires 2 per cent of the groundwater. Almost 50 per cent of the urban water requirements and 85 per cent of rural domestic water requirements are fulfilled by groundwater. This huge dependence is leading the nation towards groundwater overuse as well as contamination. Excessive

or unscientific exploitation of groundwater, agricultural and industrial activities, poor sanitation and septage management, and solid waste disposal can contaminate aquifers. In parts of India, aquifers are contaminated by arsenic, fluoride, iron and nitrate, making them unsuitable for human use. Government data for shallow aquifers shows that Rajasthan has the highest concentration of fluoride, nitrate and iron, Delhi has its groundwater contaminated with nitrate, and West Bengal has the highest concentration of arsenic.

Exploitation of water resources through over consumption and pollution has left cities in India, which are growing exponentially, struggling to meet their water demand. The situation is more explicitly exhibited by the examples from two of the largest cities in India. In 2005, the official water demand for India's largest cities, Delhi and Mumbai, was a massive 3,973 and 3,900 million litres per day (MLD). Per capita demand was estimated at 268 litres per capita per day (LPCD) for Delhi and 307 LPCD for Mumbai, which is higher than the domestic average (see *Table 3: Average domestic water consumption in Indian cities*). Both cities faced a shortfall of about 600 and 900 MLD, respectively.[7] The situation is worsened by the fact that almost 30-40 per cent of water is lost during transmission and supply in almost every city in India. As a result, about 65 per cent of households across seven major Indian cities faced severe water deficiency in 2005.

Poor water management and diversion of water to cities has led to a series of violent protests, inter-state disputes and tensions at the city level, where neighbouring states do not want to share water and water supply is not equitable within the city.

Guiding principles

Clean water for all

- Reduce overall water demand by at least 25 per cent from current levels through water efficiency and conservation measures while maintaining quality of life.
- Ensure equitable access to clean water for all and prevent water guzzling.
- Promote decentralized wastewater treatment for reuse and recycling.
- Conserve rainwater and increase groundwater recharge in green areas, water bodies, nullahs etc. to augment local availability of water to meet daily water needs and reduce dependence on water supply from longer distances.

Table 3: Average domestic water consumption in Indian cities

USE	CONSUMPTION IN LITRES/DAY/PERSON
Drinking	5 litres
Cooking	5 litres
Bathing	55 litres
Washing clothes	20 litres
Washing utensils	10 litres
Cleaning the house	10 litres
Flushing latrines	30 litres
Total	135 litres

Source: National Building Code of India, 2016

The only solution to the crisis is water conservation and efficiency. Conservation begins with reducing water consumption at the users' end. Alongside, efficient water management augments the process of conservation. According to the American Water Works Association (AWWA), by installing more efficient water fixtures and regularly checking for leaks, daily per capita water use can be reduced by about 35 per cent.[8] The nature of such efficiency interventions for water management and their magnitude can be suggested by a water audit.

Water audit: A water audit is a qualitative and quantitative analysis of water consumption in a particular establishment or system. It supports the establishment to identify ways of reducing, reusing and recycling water to make building water use more efficient and also save money on otherwise unnecessary water use.

6.1 Have you done a water audit? If you have, support with a flow chart from source to discharge process with volume data marked on each stage, including storage volumes.

Yes ☐

No ☐

6.2 Do occupants know where the water on the campus comes from? Support with source information (such as groundwater, river, pond etc.) and percentage split if multiple sources are used.

Yes ☐

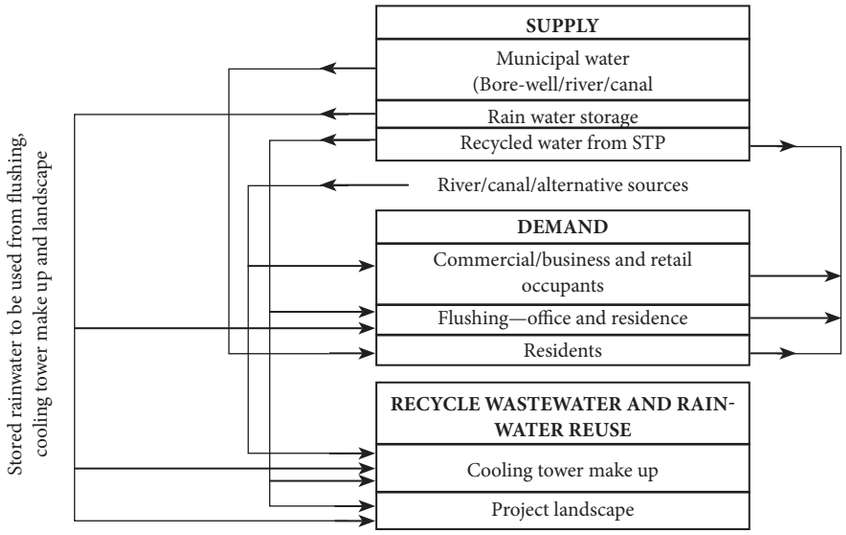
No ☐

S. NO.	SOURCE	PER CENT OF TOTAL SUPPLY
1.		
2.		
3.		
4.		
5.		

In India, water in cities is supplied by the municipal body/local authority through a water pipeline network. Unfortunately, this provision has not been able to catch the pace of rapid development and urbanization. A remarkable number of institutions, neighbourhoods and other areas in towns and cities have to arrange for water on their own. For instance, only two-thirds of residents of Gurugram, Haryana, have access to piped water, and the supply is irregular. Because of the demand-supply gap, 70 per cent of the residents—including a sizeable number of those with piped water connections—depend on groundwater .[9]

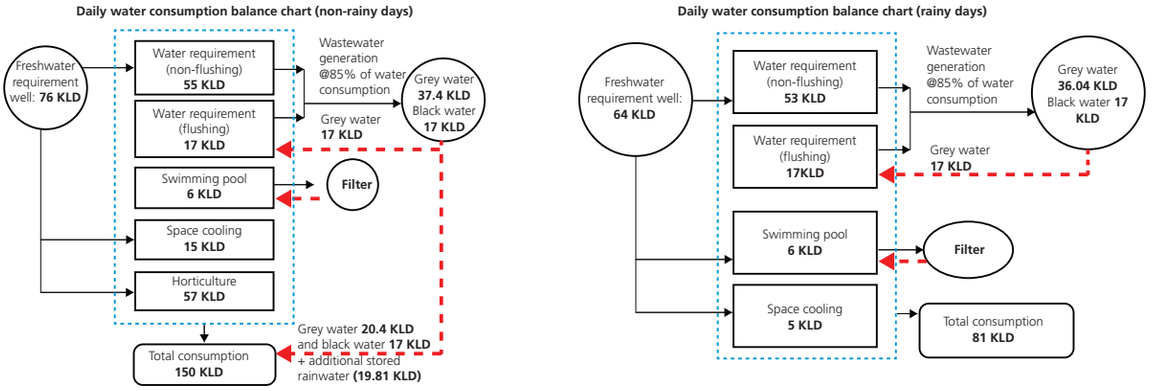
Groundwater is extracted through tube wells and bore wells. Other sources of water include supply tankers, rainwater harvesting, treated/untreated wastewater, etc. (see *Figure 1: A typical scheme showing general components of a water management system in a campus*).

Figure 6: A typical scheme showing general components of a water management system in a campus



6.3 Do you track your water use and cost source-wise, e.g. local authority, tankers, tube wells/bore wells, rainwater harvesting, treated/untreated wastewater, etc.?

Figure 7: Water balance cycle chart (in kilo litres per day [KLD]) at the Anil Agarwal Environmental Training Institute, Nimli, Alwar, Rajasthan



Support with the last five-year trend, with lowest possible distribution (if monitored).

Yes ☐ _____

No ☐ _____

S. NO.	SOURCE	2012		2013		2014		2015		2016	
		USE (KLD)	COST (INR)	USE (KLD)	COST (INR)	USE (KLD)	COST (INR)	USE (KLD)	COST (INR)	USE (KLD)	COST (INR)
1.											
2.											
3.											
4.											
5.											

6.4 If you are dependent only on groundwater, do you track your groundwater decline? (Attach the borehole log used for the drilling of the bore well.)

Yes ☐ _____

No ☐ _____

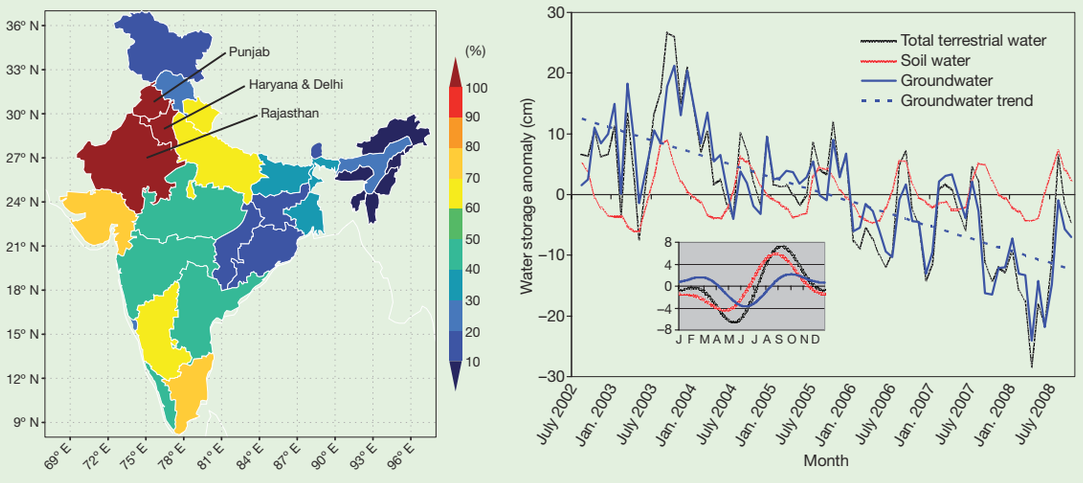
A borehole log is a detailed record of geologic formations penetrated by a borehole. It also includes information on water table level and water quality of the aquifer.

Figure 8 shows monthly time series of water storage anomalies in northwestern India (Rajasthan, Punjab and Haryana). Another study (2013) by the Central Ground Water Board (CGWB) identifies three regions where

Box 6.2: Declining levels of groundwater in India

A study using satellite-based estimation suggests that the groundwater decline in India is severe. Most states in the country are not able to recharge groundwater to even half the levels before extraction. The states of Rajasthan, Haryana and Punjab withdraw almost 100 per cent of the groundwater level after recharge. The three states have a semi-arid to arid climate, averaging about 50 cm of annual rainfall (see *Figure 2: State-wise groundwater withdrawals as percentage of recharge*).

Figure 8: State-wise groundwater withdrawals as percentage of recharge

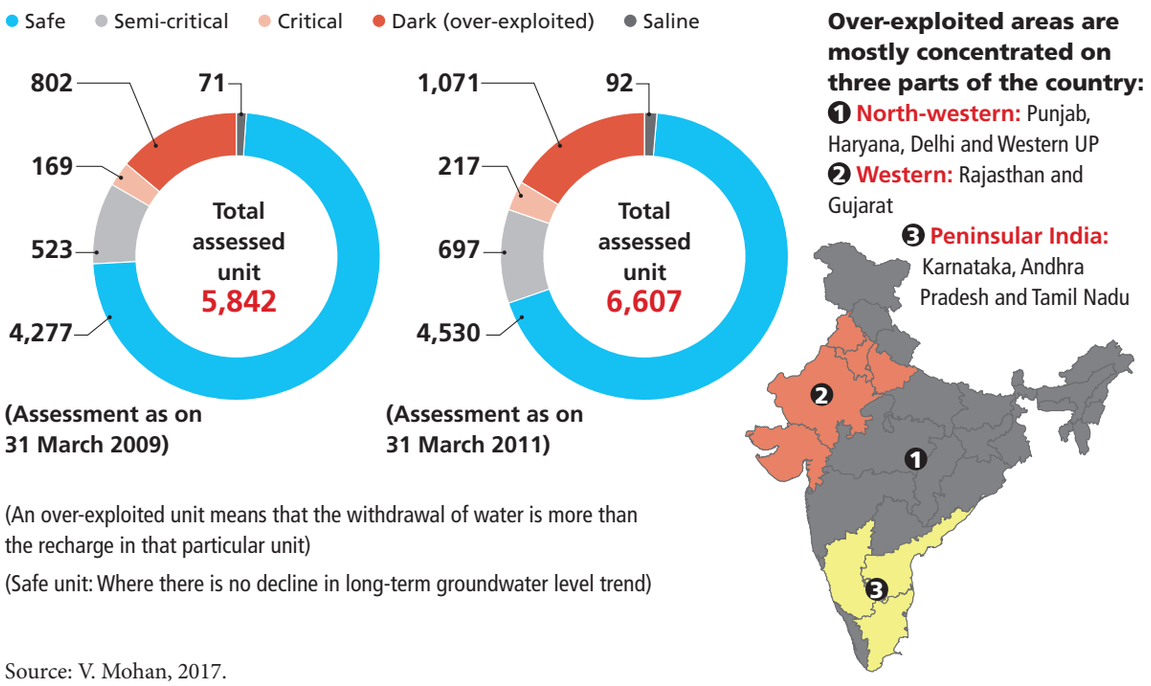


Source: M. Rodell et al., 'Satellite Based Estimates of Groundwater Depletion in India', *Nature* 460(7258): 999–1002. September 2009. DOI: 10.1038/nature08238

overexploitation of groundwater is taking place (see *Figure 3: Results of groundwater-level assessment conducted by CGWB*).[10]

1. North-western: Punjab, Haryana, Delhi and Western UP
2. Western: Rajasthan and Gujarat
3. Peninsular India: Karnataka, Andhra Pradesh and Tamil Nadu

Figure 3: Results of groundwater-level assessment conducted by CGWB



(An over-exploited unit means that the withdrawal of water is more than the recharge in that particular unit)

(Safe unit: Where there is no decline in long-term groundwater level trend)

Source: V. Mohan, 2017.

6.5 Do you have 24 x 7 or intermittent water supply? Is it a pressurized system or a gravity-based design? Support with the design scheme.

24 x 7 ☐

Intermittent ☐

Water is distributed using different systems to ensure the supply quality, quantity and pressure. A distribution system is selected depending upon the level of source, topography of the area where it is to be supplied and other local conditions. A pressurized system involves pumping of treated and stored water at a municipal facility directly to user ends. A gravity-based system supplies water by using the pressure granted by gravity. Generally, treated water is stored in an overhead tank, designed for a neighbourhood or campus, and is released to reach user ends.

6.7 Do you offer water conservation education lessons and programmes?

Yes ☐ _____

No ☐ _____

6.8 Do you encourage responsible water use via:

Policies ☐ _____

Education campaigns ☐ _____

Contests ☐ _____

Incentives ☐ _____

Awards ☐ _____

6.9 Do you monitor and immediately report leaks via work order? Support with measurement, inference process and relevant work orders.

Yes ☐ _____

No ☐ _____

6.10 What kind of faucets do you have installed in your campus? Provide details and specifications of selected options. Mark their saving potentials (via facilities/estates department).

Full turn faucets ☐

Faucets with flow restrictors ☐

Automatic faucets ☐

Faucet with aerators ☐

Full turn faucet: These are the regular taps that use a valve action to release and restrict water flow. The water flow depends on the line pressure and diameter of the outlet rim.

Flow restrictors: These are small control fixtures that deliver a precise volume of water in faucets, typically 5.6–8.3 litres per minute, irrespective of varying line pressure. These offer a saving potential of 80 per cent.

Automatic faucet: These faucets are installed with a sensor that limits the flow of water to only those times when it senses hands under the faucet. These faucets can achieve a reduction of water use by 75 per cent. It also reduces vandalism and damage because users cannot leave the water running.

Aerators: Aerators are water-saving tools that add air to the water stream to make the flow feel stronger. These can be designed for a water-flow rate from two to eight litres per minute, and offer a potential to reduce overall consumptions by up to 30 per cent.

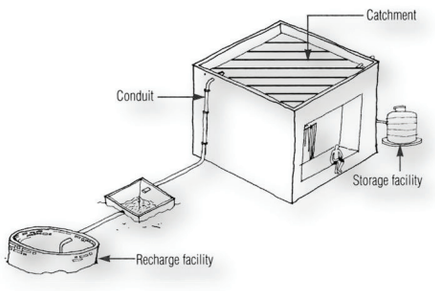
6.11 Do you use collected rainwater for on-site needs? If you do, support with the design scheme, detailing on structures and O&M scheme. (Include site potential to percentage harnessed supported by rainfall trends and soil and aquifer data.)

Yes ☐

No ☐

Rainwater harvesting: This is a mini-scale water resource project that collects and stores rainwater for productive use. This use could either be usage in daily activities or recharging of ground water table. The process needs adoption of structural measures for collecting, directing and storing rain water. The collected rainwater is generally used for non-potable uses like flushing, gardening and cleaning. Affordable technology these days allows for on-site treatment of stored rain water through a combination of processes, such as membrane filtration, disinfection using chlorination and UV light, ozonation and adsorption.

Figure 9: A typical rainwater harvesting system



It is important to get familiar with the term runoff when discussing rainwater harvesting. Runoff is the amount of rainwater that flows away after falling on a surface. It is different for paved and unpaved areas and varies according to the type of pavement (see *Table 4: Run-off coefficient and surface types*).

Table 4: Run-off coefficient and surface types

CATCHMENT VARIETY	SURFACE TYPES	RUNOFF COEFFICIENT
Roof catchments	Tiles	0.8-0.9
	Corrugated metal sheets	0.7-0.9
	Concrete	0.70-0.95
Ground surface covered with	Soil (slope <10%)	0.0-0.3
	Rocky material catchment	0.2-0.5
	Lawns, sandy soils having (slope 2%)	0.05-0.10
	Lawns, sandy soils having (slope 2-7%)	0.10-0.15
	Brick pavements	0.70-0.85
	Park/cemeteries	0.1-0.25
	Play grounds	0.2-0.35
	Asphalt and concrete pavement	0.70-0.95

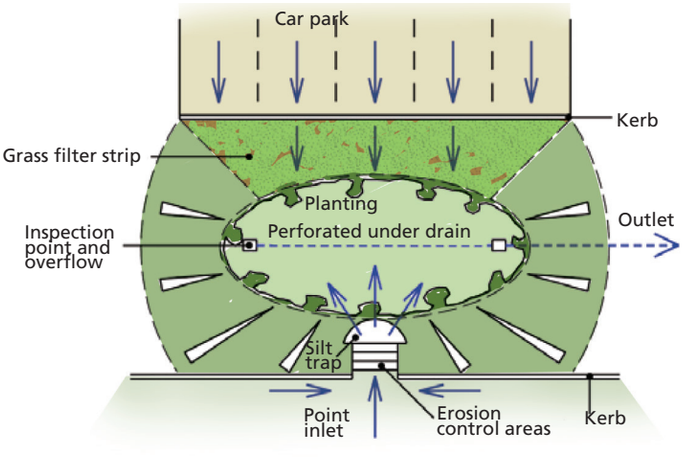
Source: National Building Code of India, 2016.

Quality of runoff from rooftop is the cleanest, followed by paved surface. Unpaved surface may lead to a contaminated run-off, therefore, is not advisable to be used for drinking water purposes.

There are several other techniques to channel, hold and/or absorb run-off with a view to manage and utilize rainwater productively. This broad approach is referred to as Sustainable Urban Drainage Systems (SUDS). These measures can be undertaken in open spaces, generally located outside the envelope of individual developments. Specific measures pertain to the design and characteristics of the site, their location within green spaces and other clearly defined utility areas that can manage storage and conveyance of surface water runoff. The measures could involve either a natural or artificial structures. A few SUDS measures are described below.

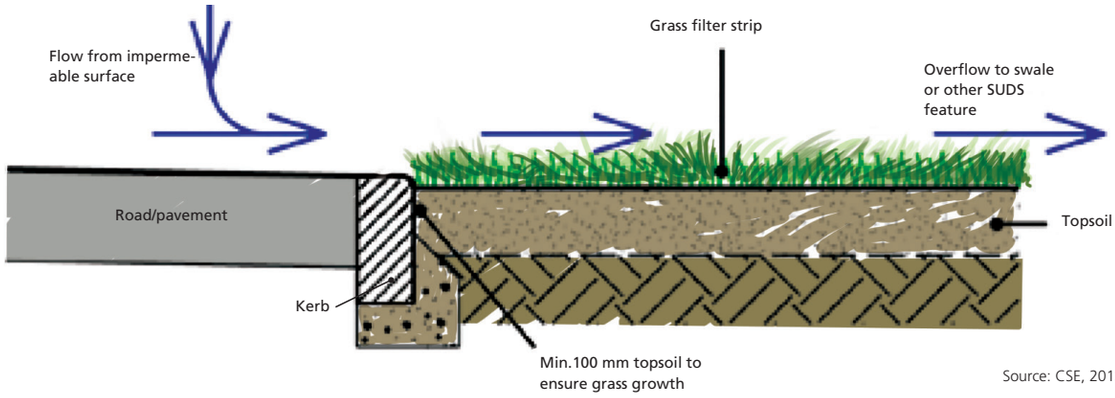
Rain garden is a landscape structure that gives aesthetic and functional advantage over a conventional garden. It is a shallow basin that can be installed on any unpaved surface to temporarily retain and absorb runoff. It can be planted with native shrubs, perennial flowers and other vegetation. It can remove up to 80 per cent of sediments from rainwater runoff and up to 90 per cent of nutrients and chemicals,[11] therefore preventing pollutants from entering into the soil and groundwater. It can allow for 30 per cent more absorption of water into the ground. A rain garden is not to be confused with a pond or marshy patch of land. A rain garden is dry most times and holds water during and after rain and that only for 12–48 hours.

Figure 10: A typical rain garden plan



Source: CSE, 2016

Figure 11: A typical filter strip



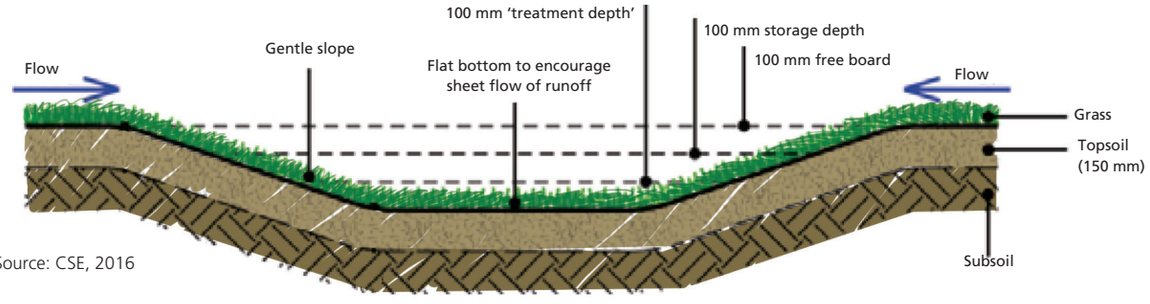
Source: CSE, 2016

Filter strip is a grassy or densely vegetated strip of land that collects surface water runoff as sheet flow from impermeable surfaces.

Berm is a raised bank or a barrier separating two areas. It is generally found along canals or rivers and is made to avoid flooding. In landscaping, it is used to retain water and add an aesthetic element.

Swale is a water-harvesting ditch used for retaining runoff. It can be constructed in a conduit form with contours or man-made levelling to move storm water from one place to another. If planted with vegetation, it can help in filtration and treatment of runoff to some extent. Since the movement of water is slow, it does not erode soil but instead allows passive seepage of water into the soil to further recharge groundwater aquifers.

Figure 12: A typical swale



Source: CSE, 2016

6.12 Have you installed any natural structures and/or vegetation to retain water on-site and minimize potable water use? If you have, support with the design scheme and percentage of augmentation and detailing on structures and O&M scheme.

Rain gardens ☐ _____

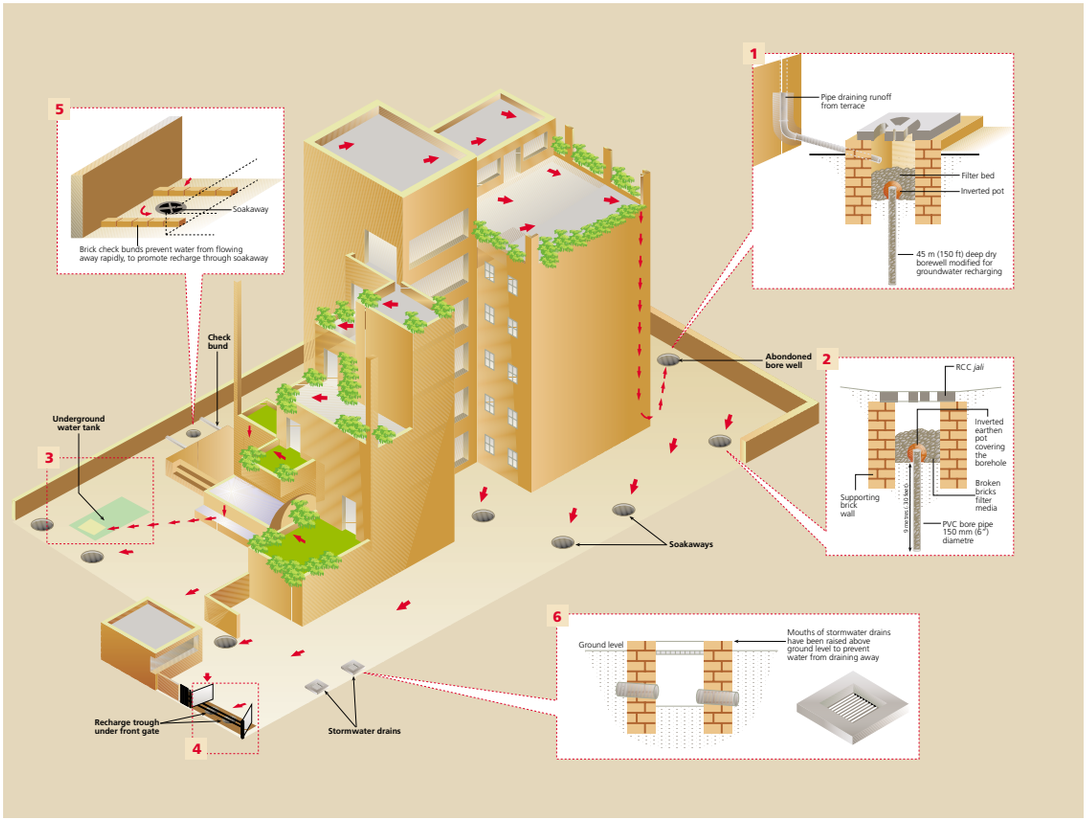
Berms ☐ _____

Swales ☐ _____

Filter strips ☐ _____

Other (specify) ☐ _____

Figure 13: Rainwater harvesting system at CSE, New Delhi



6.13 Do you monitor the impact of your rainwater harvesting structure? (Attach the trend of groundwater quantity and quality in last five years.) If the installed structure is new, what are the indications for increase in soil moisture?

Yes ☐ _____

No ☐ _____

6.14 Do you use native, drought-tolerant landscaping and grass? Do you have water-use zones (hydro-zones)? If yes, support by landscaping plan and percentage cover under such initiatives.

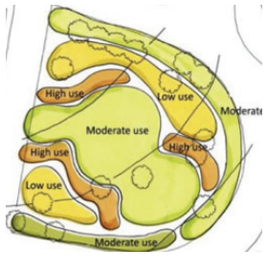
Yes ☐ _____

No ☐ _____

Drought tolerant plants can withstand extreme lack of rainfall and water. These are mostly the plants that are native to the region.

Hydro-zones: Different plants can be grouped according to their water needs to optimize the irrigation system. This approach to irrigation defines a hydro-zone, in which each zone supplies plants with the same water needs with appropriate amounts of water.

Figure 14: Hydro-zones



6.15 Have you optimized your irrigation system (if applicable) to:

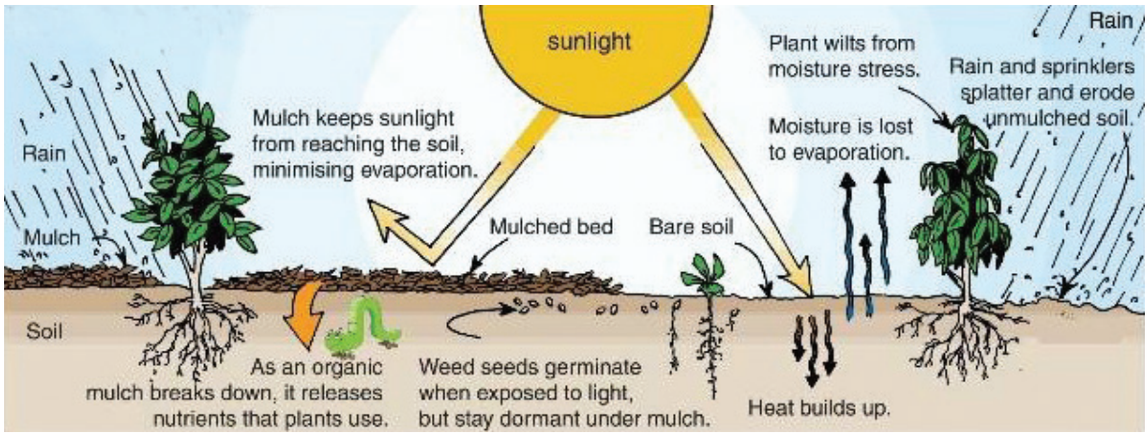
☐ Operate at night or early morning hours to minimize evaporation

☐ Water the minimum time and frequency necessary for the applicable vegetation

☐ Mulching or any other techniques

Mulching is application of a layer of material to the surface of soil to conserve soil moisture, improve fertility and health of the soil, reduce weed growth and enhance visual appeal of the landscape.

Figure 15: How mulch works



6.16 Do you use treated wastewater? If you do, provide details on percentage and type of water processed, technology type and output characteristics, including quality.

Yes ☐ _____

No ☐ _____

S. NO	TYPE OF WATER PROCESSED	PER CENT OF TOTAL WATER TO BE PROCESSED	TREATMENT TECHNOLOGY
1.	Waste (black) water		
2.	Grey water		

Details output characteristics here:

7. Air

According to Global Burden of Disease estimates, outdoor air pollution has emerged as the fifth largest killer in India. According to air quality data of the Central Pollution Control Board, close to half of Indian cities have air pollution levels that are classified as critical. While the level of tiny particles of size range less than 10 micron (PM10) and 2.5 micron (PM2.5) are the biggest concerns as these are very toxic and go deep inside our lungs and get mixed with blood stream, there are several other toxic gases in the air that add to toxic cocktail (see *Table 5: Air pollutants and their health impacts*).[1, 2]

Though there are national standards for pollutants, most cities are violating the standards. A large number of combustion sources and dust sources contribute to air pollution and require sustained action to be able to meet the ambient air quality target.

Table 5: Air pollutants and their health impacts

AIR POLLUTANTS	SAFE LIMIT	HEALTH IMPACTS
PM 2.5	60 µg/m³ (24 hours)	Cause cardiovascular diseases, stroke, respiratory problems including COPD, cancer and a range of other metabolic diseases including hypertension, diabetes, effect on foetus, adverse effect on brain function etc.
PM 10	100 µg/m³ (24 hours)	Prolonged exposure may lead to adverse responses in the lungs triggering an array of cardiopulmonary problems
SO_2	80 µg/m³ (24 hours)	Emitted from fuel combustion/coal burning. Affects human suffering from asthma and chronic lung diseases and exacerbates respiratory symptoms
NO_x	80 µg/m³ (24 hours)	Emitted from both petrol and diesel engine motor vehicles. Precursor of ozone formed in the troposphere. The toxic oxides are immune-toxic and increase susceptibility to respiratory tract infections such as influenza. Frequent exposure causes irritation of the lungs and consequent acute respiratory illnesses.
CO	02 mg/m³ (8 hours)	Toxic gas emitted from combustion processes as well as from emissions of petrol-fuelled vehicles. CO binds with hemoglobin and impairs transport of oxygen within the blood affecting cardiovascular and nervous systems.
PAHs		Emitted from combustion of petrol and diesel, more from diesel combustion. Inhalation of this semi- volatile particle can even carcinogenic.
VOCs	Benzene 10 ng/m³ (annual)	VOCs, released from petrol and diesel, as for e.g. benzene, are carcinogenic. Benzene is harmful for human health for its hematotoxic, neurotoxic, leukemogenic and carcinogenic effects.

Also from public health standpoint, exposure to toxic emissions from local sources in micro environments such as a campus or a neighbourhood can be very serious. It is important to eliminate or reduce exposure from local sources like waste burning, vehicles, construction activities, chulha pollution etc. in micro environments that emit directly within our breathing zone.

The Government of India has already notified the prescribed standards for pollutants under the Air Act that should be met for 98 per cent of the days. Based on this, targets should be set to meet clean air standards throughout the year. In addition, to reduce daily exposure from air pollution that can get aggravated by the weather conditions as in winter, the government has notified an Air Quality Index to show how dangerous or good the daily air quality is. This helps people take precautions as well as the government to take a graded response action.

Air Quality Index (AQI) is a tool used for communicating air quality status in simple terms. It converts complex air quality data of various pollutants in a single number. The AQI categories are Good, Satisfactory, Moderately polluted, Poor, Very poor and Severe, based on concentration of pollutants in atmosphere and their likely health impacts (see *Table 6: Air Quality Index and likely health impacts*).[3]

Table 6: Air Quality Index and likely health impacts

AQI category	AQI	Likely health impacts
Good	0–50	Minimal impact
Satisfactory	51–100	May cause minor breathing discomfort to sensitive people
Moderately polluted	101–200	May cause breathing discomfort to people with lung disease such as asthma and discomfort to people with heart disease, children and older adults
Poor	201–00	May cause breathing discomfort to people on prolonged exposure and discomfort to people with heart disease
Very poor	301–400	May cause respiratory illness to the people on prolonged exposure. Effect any be more pronounced in people with lung and heart disease
Severe	401–500	May cause respiratory effects even on healthy people and serious health impacts on people with lung and/or heart diseases. The health impacts may be experienced even during light physical activity.

Table 7: Category-wise recommendations detailed in graded response action plan

Severe + or Emergency When PM 2.5 levels cross 300 µg/m³ or PM 10 levels cross 500 µg/m³ (five times above the standard) and persist for 48 hours or more
Stop entry of truck traffic into Delhi (except essential commodities).
Stop construction activities.
Introduce odd and even scheme for private vehicles based on license plate numbers and minimize exemptions
Task force to take decision on any additional steps including shutting of schools
Severe When PM 2.5 levels are above 250 µg/m³ or PM 10 levels are above 430 µg/m³
Close brick kilns, hot mix plants, stone crushers.
Shut down Badarpur power plant and maximize generation of power from existing natural-gas-based plants to reduce operation of coal-based power plants in the NCR.
Intensify public transport services. Introduce differential rates to encourage off-peak travel.
Increase frequency of mechanized cleaning of road and sprinkling of water on roads. Identify road stretches with high dust generation.
Very poor When PM 2.5 levels are 121–250 µg/m³ or PM 10 levels are 351–430 µg/m³
Stop use of diesel generator sets.
Enhance parking fee by three to four times.
Increase bus and metro services by augmenting contract buses and increasing frequency of service.
Stop use of coal/firewood in hotels and open eateries.

Residential Welfare Associations and individual house owners to provide electric heaters during winter to security staff to avoid open burning by them
Alert in newspapers,TV, radio advising respiratory and cardiac patients to avoid polluted areas and restrict outdoor movement.
Moderate to poor Poor—When PM 2.5 levels are 91–120 µg/m³ or PM 10 levels are between 251–350 µg/m³ Moderate—When PM 2.5 is between 61–90 µg/m³ or PM 10 is between 101–250 µg/m³
Stringently enforce/stop garbage burning in landfills and other places and impose heavy fines on person responsible.
Close/stringently enforce all pollution control regulations in brick kilns and industries.
Stringently enforce pollution control in thermal power plants through PCB monitoring.
Do periodic mechanized sweeping on roads with heavy traffic and water sprinkling also on unpaved roads every two days.
Strict vigilance and no tolerance for visible emissions—stop plying of visibly polluting vehicles by impounding or heavy fine.
Strict vigilance and enforcement of PUC norms.
Stringently enforce rules for dust control in construction activities and close non-compliant sites.
Deploy traffic police for smooth traffic flow at identified vulnerable areas.
Strictly enforce Supreme Court order on diversion of non-destined truck traffic and ensure only trucks registered after 2005 are allowed entry into Delhi.
Strictly enforce Supreme Court ban on firecrackers.
Ensure fly ash ponds* are watered every alternate day during summer months (March–May).
Information dissemination social media, mobile apps should be used to inform people about the pollution levels, contact details of control room, enable them to report polluting activities/sources to the concerned authorities, and actions that will be taken by government based on the level of pollution.

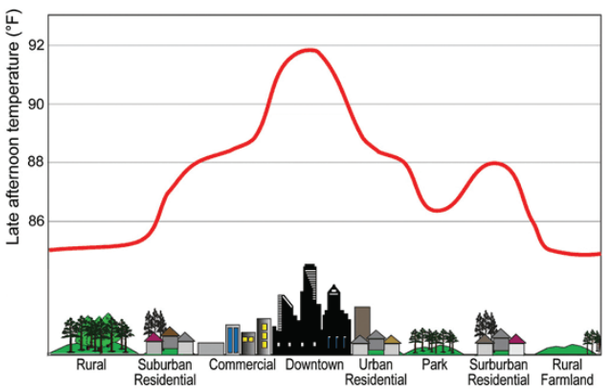
Take an integrated approach to address outdoor and indoor pollution to reduce overall exposure: From public health standpoint it is not right to address indoor and outdoor air pollution in isolation. According to the Global Burden Disease study for India, indoor air pollution contributes about 25 per cent of outdoor air pollution

Climate co-benefits: Action on air pollution is also expected to provide climate benefits by reducing heat trapping gases like carbon dioxide. Improvement in emissions control technologies need to be conjoined with energy efficiency measures that are expected to reduce energy guzzling and green house gases and heat trapping black carbon in particulate matter.

Urban heat island: In the past few decades, India has been facing problems related to unpredictable climate pattern and extreme weather conditions. Our cities feel burnt in temperatures that are 3–4 degrees higher than the average for the time of year because of the magnified effect of paved surfaces and a lack of tree cover. This is known as the urban heat island effect (see *Figure 10: Urban heat island effect*).

In India, a 'heat wave' is declared on when the

Figure 16: Urban heat island effect



Source: https://nca2009.globalchange.gov/urban-heat-island-effect/index.htm

temperature is 5 degrees or more than the average temperature recorded over past three decades. As per research, in the near future, the number of heat wave days may vary from about 5 to 30–40 every year. In 2015, around 2,000 people have died due to the heat wave across India. The effect gives rise to extreme weather events and eventually natural calamities. Several cities are facing abnormal UV indices, which is a serious menace carrying medium to high health risks. It is essential to build up resilience through climate change adaptation.

Indoor air quality in buildings: Indoor air quality is the quality of air in and around a building, which affects health, stress, frustration and overall comfort of building occupants. Persistent exposure to the polluted air as well as asbestos and radon may not cause immediate symptoms but can lead to lung diseases and cancer after many years. The health and comfort of inhabitants are major factors that contribute to their learning, productivity, performance and achievement. Therefore, it is essential to maintain indoor air quality to maintain health and the wellbeing of citizens.

Develop action plan for each source of air pollution: Broadly, the key sources of air pollution in a campus are expected to be vehicles, waste burning, construction activities and eateries. These are sources of highly toxic emissions.

Guiding principles

Clean air for all

- Meet the national ambient air quality standards for all pollutants in a time-bound manner to protect public health.
- Map the exposure levels and local pollution sources across the city for stronger local action to reduce public health risk.
- Take an integrated approach towards controlling outdoor air pollution sources as well as indoor pollution sources such as biomass chulhas as these also contribute hugely to outdoor pollution.

7.1 Provide details on air quality and action on air quality for benchmarking.

1. Trend in air quality based on the air pollution data from the nearest air pollution monitoring stations or the known trend in your city:

---

2. Inventory of air pollution sources in the campus (if you have carried out one):

---

3. Nature, type and number of air polluting sources inside the campus, for example, waste burning, vehicles (petrol, diesel, CNG/LPG), construction activities:

---

4. Nature, type and number of air polluting sources outside the campus within a radius of 500 m:

---

5. Estimation of trend in pollution from different sources or any known study in your local area on air pollution:

Guiding principles

Sustainable and affordable mobility for all

- Ensure that at least 90 per cent of daily motorized travel trips are carried by affordable, reliable and modernized public transport systems, efficient para-transit and extensive non-motorized transport.
- Eliminate traffic fatalities and road injuries.
- Make commuting safe and accessible for women.
- Promote universal road design for the differently abled.
- Promote compact city design to reduce distances and vehicle-km travelled and increase public transport and walking.
- Preserve and build open public spaces and enable equitable access.

A *transport audit* is a systematic analysis of any transport infrastructure provided for convenient movement of people in a given area. It ensures the sustainability of transport system and safe design of infrastructure.

7.2 Have you done a transportation audit for any campus?

Yes ☐ _____

No ☐ _____

7.2 Are vehicles (buses, cars, trucks, motorcycles, golf carts and other electric vehicles, etc.) allowed in your campus? Provide details.

S. NO	VEHICLE	FLEET SIZE	VEHICLE KM TRAVELLED (VKT)	FUEL TYPE (BS III, BS IV, EURO IV, ETC.	YEAR OF REGISTRATION
1.					
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					
10.					

7.3 Do you encourage green transportation options via:

Policies ☐ ----------

Education campaigns ☐ ----------

Contests ☐ ----------

Incentives ☐ ----------

Awards ☐ ----------

7.4 Do you provide green transportation infrastructure such as:

Safe, connected, and accessible walkways and pathways ☐

Bike paths and/or lanes ☐

Bike racks ☐

Electric vehicle charging points ☐

Green vehicle priority parking (fuel efficient, alternative fuel, carpool) ☐

Sustainable/green transportation refers to a broad subject of transport, which involves a movement system that does not emit toxic emissions, therefore resulting in any negative impact on human health and environment. It also incorporates the criteria of health and focuses on effective use of resources, modifying our transport structure. The culture emphasizes on walking, cycling, and using non-motorized transport systems and electric vehicles along with public transport system. The system discourages any use of private vehicles and encourages production of vehicles which utilizes renewable sources of energy such as solar, bio-fuel, (micro) hydroelectricity, etc.

7.5 Have you calculated your carbon footprint?

Box 7.1: Carbon footprint

Carbon footprint is defined as sum total of all greenhouse gas emissions caused by direct or indirect human activities, in a given period of time, expressed in equivalent tons of carbon dioxide (CO_2). Carbon footprint is usually calculated for a time period of a year.

For example, 1 litre of diesel is equivalent to 2.7 kg of carbon dioxide. Therefore, if your diesel car drives 300 km, consuming 7.5 litre diesel per 100 km (7.5 x 3 x 2.7), 6.075 kg CO_2 is your personal carbon footprint.

Yes ☐ _____

No ☐ _____

7.6 Do you encourage bus drivers and parents etc. to not idle their engine during pick-up/drop-off?

Yes ☐ _____

No ☐ _____

7.7 Is there any provision/policy of accessibility and mobility inside the campus?

Yes ☐ _____

No ☐ _____

Indicators for indoor air quality

There are four major elements involved in development if indoor air contamination as given below:

Sources of air pollution in the surroundings of building: This includes air contamination due to pollen, dust, fungal spores, exhaust from vehicles moving near adjacent roads, any exhaust from neighbouring buildings, unsanitary debris, use of pesticides, excess microbial growth on rooftops after rainfall crawlspace etc.

Active equipment used within building: This includes both HVAC and non-HVAC equipments. From HVAC system, dust/dirt in ductwork, humidifiers, improper use of biocides, emissions from sealants or cleaning compounds, improper venting of combustion products, refrigerant leakage, etc. disturbs air quality. Similarly from non-HVAC equipments, VOC/ozone emissions contaminate indoor air. Moreover, emissions from office equipments, shops, emissions from solvents, toners, ammonia used in labs, cleaning processes of elevator motors and other mechanical systems add to the above.

Human activities: Various human activities can also contribute to indoor air pollution. These account for:

- Personal activities, which include smoking, cooking, body odour, cosmetic odours etc.
- Housekeeping activities, which include cleaning materials and procedures, emissions from stored supplies or trash use of deodorizers and fragrances, airborne dust or dirt etc.
- Maintenance activities, which include microorganisms in mist from improperly maintained cooling towers, airborne dust or dirt volatile organic compounds from use of paint, caulk, adhesives, pesticides from pest control activities, emissions from stored supplies etc.

Building components and furnishings: Building furnishing elements, including paints, varnishes, aerosol sprays and wood preservatives etc., cause VOC/inorganic compound emissions, which contribute to contaminating indoor air. Similarly, carpets, curtain and other fabrics with textures surfaces, damages asbestos in aged furniture emits dust particles. Unsanitary conditions in water-clogged areas lead to microbial growth, poorly designed drain and sewer systems etc. also contribute in local air pollution in surroundings of a building.

7.8 Do you use toxic-free cleaning products? Supplement with policy or any other supporting data

Yes ☐ _____

No ☐ _____

7.9 Do you use low-VOC paints? Supplement with policy or any other supporting data.

Yes ☐ _____

No ☐ _____

Volatile organic compounds are carbon-containing compound emitted as gas from certain solids and liquids. In household applications, during painting, certain VOCs get released into the air as the paint dries. (Other products emit solvents, including adhesives, cleaning supplies, and even some home furnishings.) These readily vapourizable compounds react with other elements when they are released into the air to produce ozone, which causes air pollution and a host of health issues.

7.10 Do you practise integrated pest management, with natural, non-polluting treatment methods?

Yes ☐ _____

No ☐ _____

Integrated pest management, also known as integrated pest control (IPC), is an effective and environmentally sensitive approach that integrates practices for economic control of pests with least possible impact for people, land and environment. The approach aims to suppress pest populations below the economic threshold. The UN's Food and Agriculture Organization defines IPM as 'the careful consideration of all available pest control techniques and subsequent integration of appropriate measures that discourage the development of pest populations and keep pesticides and other interventions to levels that are economically justified and reduce or minimize risks to human health and the environment'.

7.11 Do you practise regular housekeeping routine to minimize dust and allergens? Elaborate methods.

Yes ☐ _____

No ☐ _____

8. Waste

The problem of waste is outsizing across the globe. Waste is the residual of our daily consumption and production processes and includes discarded items. Population growth, rapid urbanization, economic growth and rising affordability are together accelerating this cycle of consumption and production, and resulting in waste as a huge problem. High vulnerability with regard to waste management is attached to developing countries as they try to cope with burgeoning populations, scarce financial resources and smaller capacities. Improper and insufficient management of waste not only contaminates natural resources such as soil and water (both surface- and groundwater), but exposes a substantial population to diseases and unsafe and unsanitary living conditions. It also contributes to greenhouse gas emissions by production of methane. Post-consumption waste is estimated to account for almost 5 per cent of total global greenhouse gas emissions.

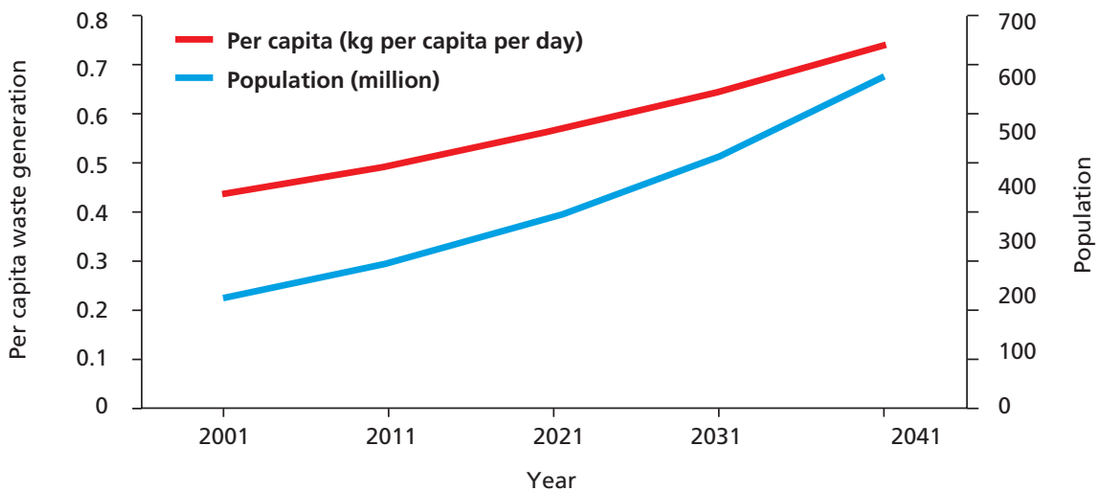
Figure 17: Types of waste as classified by the World Bank

Source	Typical Waste Generators	Types of Solid Wastes
Residential	Single and multifamily dwellings	Food wastes, paper, cardboard, plastics, textiles, leather, yard wastes, wood, glass, metals, ashes, special wastes (e.g., bulky items, consumer electronics, white goods, batteries, oil, tires), and household hazardous wastes (e.g., paints, aerosols, gas tanks, waste containing mercury, motor oil, cleaning agents), e-wastes (e.g., computers, phones, TVs)
Industrial	Light and heavy manufacturing, fabrication, construction sites, power and chemical plants (excluding specific process wastes if the municipality does not oversee their collection)	Housekeeping wastes, packaging, food wastes, construction and demolition materials, hazardous wastes, ashes, special wastes
Commercial	Stores, hotels, restaurants, markets, office buildings	Paper, cardboard, plastics, wood, food wastes, glass, metals, special wastes, hazardous wastes, e-wastes
Institutional	Schools, hospitals (non-medical waste), prisons, government buildings, airports	Same as commercial
Construction and Demolition	New construction sites, road repair, renovation sites, demolition of buildings	Wood, steel, concrete, dirt, bricks, tiles
Municipal Services	Street cleaning, landscaping, parks, beaches, other recreational areas, water and wastewater treatment plants	Street sweepings; landscape and tree trimmings; general wastes from parks, beaches, and other recreational areas, sludge
All of the above should be included as municipal solid waste. Industrial, commercial, and institutional (ICI) wastes are often grouped together and usually represent more than 50% of MSW. C&D waste is often treated separately: if well managed it can be disposed separately. The items below are usually considered MSW if the municipality oversees their collection and disposal.		
Process	Heavy and light manufacturing, refineries, chemical plants, power plants, mineral extraction and processing	Industrial process wastes, scrap materials, off-specification products, slag, tailings
Medical waste	Hospitals, nursing homes, clinics	Infectious wastes (bandages, gloves, cultures, swabs, blood and body fluids), hazardous wastes (sharps, instruments, chemicals), radioactive waste from cancer therapies, pharmaceutical waste
Agricultural	Crops, orchards, vineyards, dairies, feedlots, farms	Spoiled food wastes, agricultural wastes (e.g., rice husks, cotton stalks, coconut shells, coffee waste), hazardous wastes (e.g., pesticides)

The World Bank estimates the amount of municipal solid waste (MSW) will almost double by the year 2025 from the current 1.3 billion tonnes per year (2012) (see *Figure 11: Types of waste as classified by the World Bank*). The figures give a current footprint of 1.2 kg per person per day and 1.42 kg per person per day in 2025. The annual global cost to manage this amount of waste then also climbs from the current US $205 billion to USD 375 billion.[1] Waste is the only sector in which decisions are directly taken by the municipal body. Effective waste management is expensive and constitutes 20–50 per cent of municipal budget in countries around the globe. Ineffective waste management further increases this cost. For instance, improper waste disposal may lead to diseases or infections that will require further municipal investment in clinics and hospitals.

The costs to manage waste is projected to increase four-times for low-middle income countries like India, where waste management is highly ineffective and inefficient.

Figure 18: Daily per capita waste generation in India and projections as per population growth

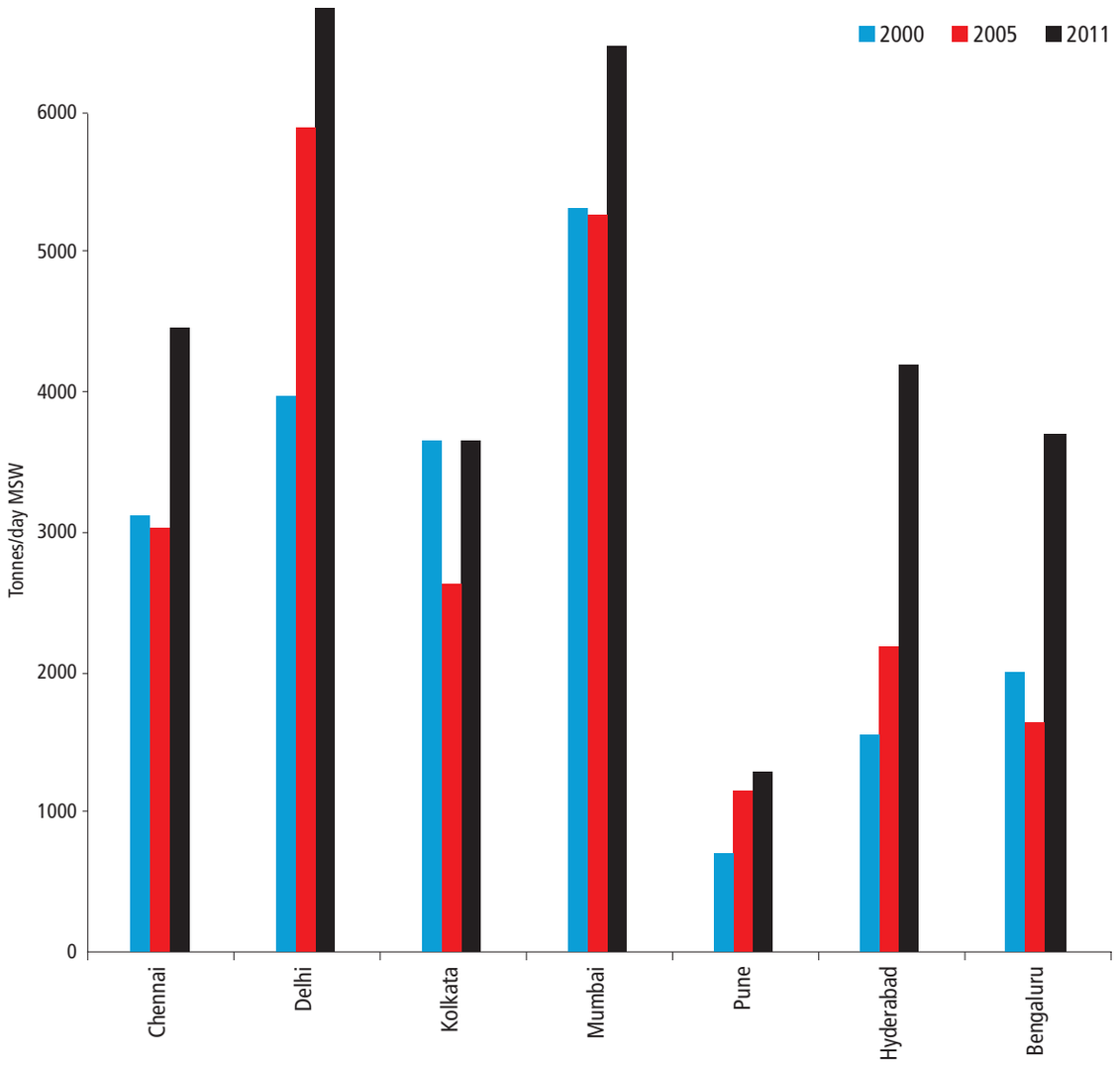


Source: Sunita Narain and Swati Singh Sambyal. 2016. *Not in My Backyard*. Centre for Science and Environment, New Delhi.

About 170,000 tonnes, i.e. 17,000,000 kg, of MSW is generated every day in the India. Per capita waste generation in major cities is 0.4–0.6 kg per day.[2] These numbers are relatively small in comparison to the global average, but considering the incapacity of municipal bodies to manage waste, the figures may not be trivial at all (see *Figure 12: Daily per capita waste generation in India and projections as per population growth*).

Municipal collection efficiency is 70–90 per cent in major metro cities and is below 50 per cent in small cities. Of this incomplete collection, only 10 per cent goes for treatment and a remarkable 90 per cent is dumped in the landfill without any treatment.[3] This indiscriminate and insensitive dumping fills the dumping sites with e-waste, toxic waste and biomedical waste. The consequence is that municipal bodies are running out landfill sites. In addition, the absence of scientific and safe disposal poses a great threat to the health and wellbeing of the rapidly increasing number of city inhabitants as well as the environment.

Figure 19: Largest waste generators in the country



Source: Sunita Narain and Swati Singh Sambyal. 2016. *Not in My Backyard*. Centre for Science and Environment, New Delhi.

The steep climb in waste generation in Hyderabad and Bangalore from 2005 to 2011 suggests that newly developing cities, i.e. cities with population above 100,000, need to be prepared the most with effective safeguards and efficient waste management systems in place (see *Figure 13: Largest waste generators in the country*).[4]

The situation becomes financially daunting when this hazardous waste management is spent with Rs 500 to Rs 1500 per tonne[5] by the municipal bodies. This means that Delhi and Mumbai spend between Rs 70,00,000 and Rs 10,500,000 per day on waste management. About 60–70 per cent of this amount is spent on street sweeping and (sub-par) waste collection, 20–30 per cent on transportation and less than 5 per cent on final disposal of waste. Waste management involves 30–50 per cent of municipal staff.

Proper waste management in the country needs addressing at almost all stages of the life-cycle of waste, i.e. generation, collection, transportation, treatment and disposal.

Citizens have the central role

Since cities and city managers are accountable for global waste and waste management respectively, citizens have a primary role in the process. A role that begins with reducing the amount of waste generated. This means adopting a lifestyle inherent with 'waste-free' or 'less-waste' habits. It involves preferring recycled products or products that come with less wastage. From a functional perspective, this ensures a smaller amount of waste going for collection, treatment and disposal (see *Figure 14: Approach to waste management* and *Figure 15: Process of waste collection, transportation and disposal*). As a consequence, resources are saved at each stage and there is a substantial increase in process efficiency [6] (see *Figure 16: Waste-to-revenue approach*).

Waste management the individual level begins with segregation at source. Segregation of waste offers a variety of solutions for recycling, reusing and reducing waste first at the individual level, which aggregates substantially at the city level. The level of segregation varies from city to city. It generally depends on the availability of treatment facilities. Segregation categories can range from dry and wet, biodegradable and non-biodegradable, organic, glass, paper, metal, plastic and hazardous etc.

Figure 20: Approach to waste management

Wrong: The current approach to waste management

Right: The expected approach

The Solid Waste Management Rules, 2016, of India suggest segregation of waste in three separate streams, namely biodegradable, non-degradable and domestic hazardous wastes.[7] The rules were notified by Ministry of Environment, Forests and Climate Change replacing the Municipal Solid Waste (Management and Handling) Rules, 2000. The ministry also notified management rules for plastic, e-waste, biomedical waste and construction and demolition waste around the same time. These new rules indicate the urgency attached with waste management in the country and attempt to provide a holistic framework towards increasing effectiveness and efficiency of the processes.

Guiding principles

Promotion of zero landfill development—minimize and reuse solid waste:

- Aim for near zero-landfill development with not more than 10 per cent of waste to go to landfill sites.
- Promote mandatory decentralized segregation and collection in all residential colonies and institutions, and composting sites at colony and ward levels.
- Promote properly designated and operated construction and demolition waste sites and recycling facilities that are well audited.

8.1 Do you segregate waste at source into wet, dry and hazardous waste?

Yes ☐ _____

No ☐ _____

Box 8.1: Waste segregation in Hamburg

The colour-coding scheme for waste segregation at source is followed differently in cities and countries. For instance, Hamburg, Germany, follows:

1. Green bin for organic waste like compostable kitchen waste and garden rubbish. The waste from the green bin goes to the compost plant directly.
2. Blue bin for paper waste. The paper is collected by a private company from the municipal body and sold to the recycling companies.
3. Yellow bin for lightweight packaging, plastics and metal. This waste first goes in a sorting facility and then for recycling according to respective material. The waste that goes into yellow bin is part of a national policy wherein manufacturers have to pay a fee for their packaged products to the government.
4. Grey bin for all kinds of residual waste that is neither compostable nor recyclable, such as sweepings, sanitary articles and other household waste.

Source: https://www.stadtreinigung.hamburg/

8.2 Do you follow colour-coded bins for segregation?

Yes ☐ _____

No ☐ _____

NOTE:

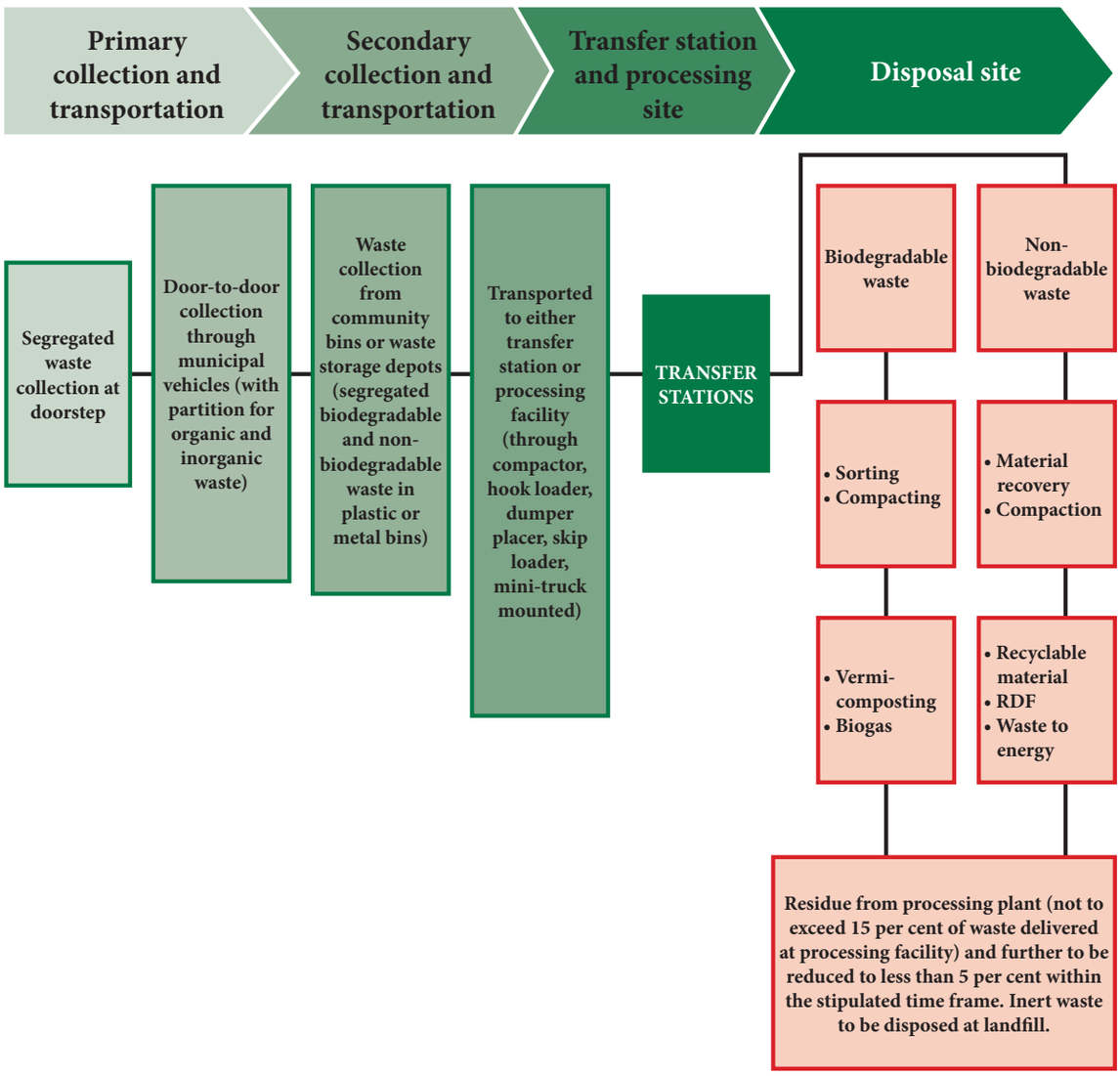
The Government of India mandates to segregate waste at source into:

a. Biodegradable (in green bins): Leftover food items, vegetable and fruit peels, egg shells, meat, fish, etc.

b. Non-biodegradable (in blue bins): Disposable cups, plates, cardboard, metal containers, paper, non-infectious plastics and other recyclables and combustible objects.

c. Domestic hazardous wastes (in black bins): Insecticides, disinfectants, fumigants, chemical containers, broken thermometers, expired medicines and other chemicals.

Figure 22: Process of waste collection, transportation and disposal



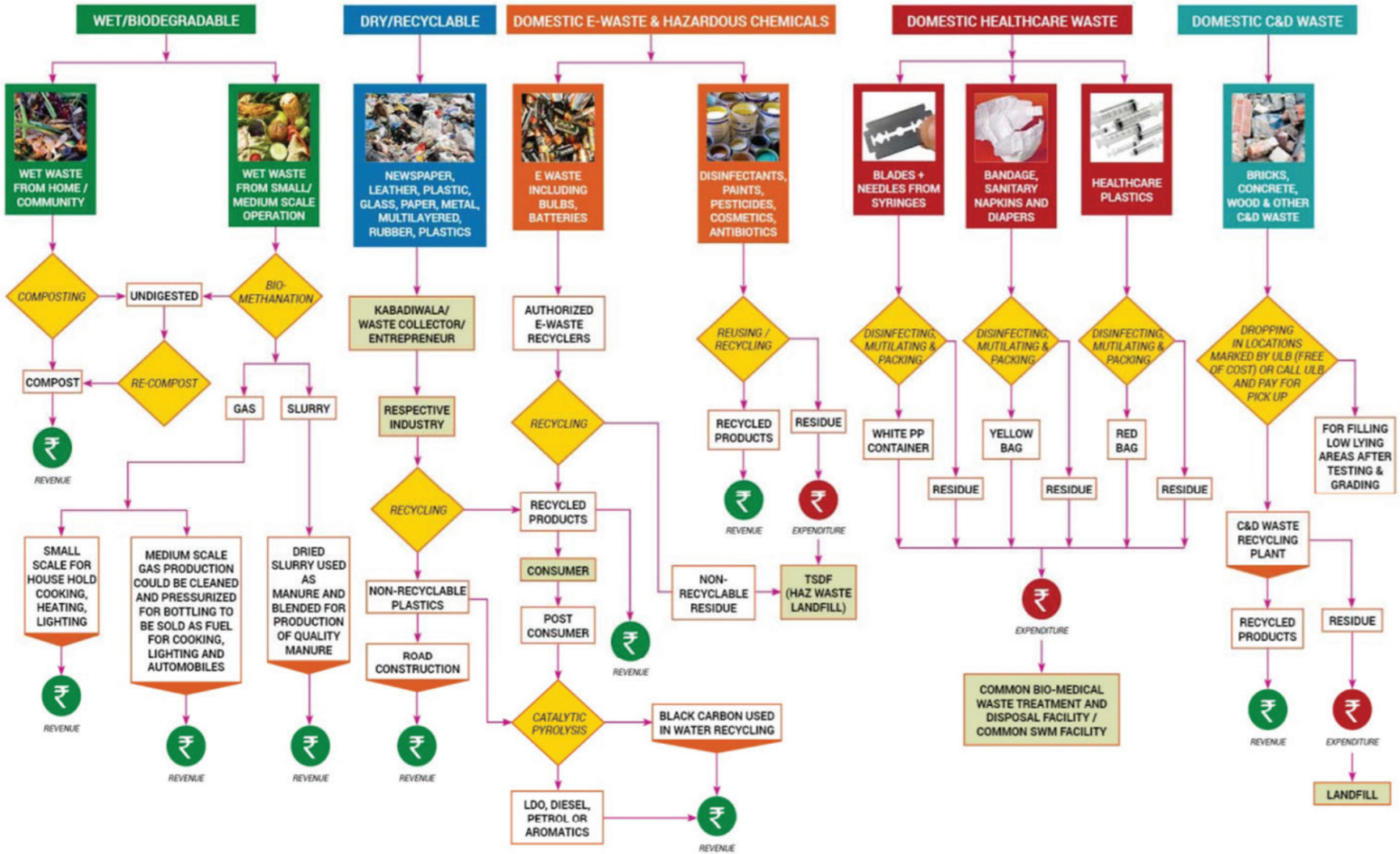
Source: *Municipal Solid Waste Management Manual*, 2016.

8.3 Do you track the waste that goes out of your campus?

Yes ☐ _____

No ☐ _____

Figure 23: Waste-to-revenue approach



Source : http://www.cseindia.org/userfiles/ShyamalaMani.pdf

In India, waste is not segregated, but recyclables are removed by waste-pickers prior to collection, during the collection process, and at disposal sites. When recyclables are picked during the (secondary) collection stage or at disposal sites, it exposes the pickers to high risk of injury, disease and hazardous environment. Disposed waste contains needles, broken glass and other sharp objects. The job of disposing of waste is executed by the informal sector without safety equipment. Segregation at later stages also affects the amount and quality of recycling. Recyclables recovered from mixed waste may be contaminated and therefore reduce marketing possibilities.

8.4 Are you registered with authorized recyclers/vendors for plastic waste and other recyclables? If you are, support with time-based trends, certificate, manifesto, etc.

Yes ☐ _____

No ☐ _____

Waste composition: The composition of waste varies by location in a building or campus. It is different for administrative blocks, classrooms, hostels, canteen/mess, laboratories, workshops, halls/auditoriums, sports complex, etc. This variation is primarily due to the specific characteristics of the materials used, which are specific to different locations. For instance, messes/canteens produce more organic waste, classrooms produce higher quantities of paper waste, and laboratories and workshops tend to produce more plastic and e-waste.

On a national level, the composition of MSW at generation sources and collection points consists a large amount of organic matter (40–60 per cent), ash and fine earth (30–40 per cent), paper (3–6 per cent) and plastic, glass and metals (each less than 1 per cent). The Indian government suggests landfill sites should be used only as a last resort in the waste management process. Landfill dumping should not exceed 20per cent of the total MSW generated. All biodegradables and recyclables to be recovered fully prior to land filling. Only inert materials such as ash (from incineration), silt and soil recovered from street sweeping should end into the landfill.

Being informed on the composition of waste is crucial in determining processing and treatment technologies. It enables the organization or campus:

1. To formulate a waste reduction strategy
2. To be informed of the recycling potential
3. To create awareness about waste on campus
4. To finally reduce the campus contribution to MSW and landfill

Characteristics of waste are determined by:[8]

Density: The density of waste (mass per unit volume, kg/m^3) determines the storage and transportation volume requirements. Density of MSW in India is typically 450–500 kg/m^3. Only low density wastes, such as packaging material, plastic waste, etc., can be hauled efficiently with compactors, where a compaction ratio as high 2.5:1 is achievable. High density waste such as street sweeping or inert waste are not cost-effective when hauled with compactors.

Moisture content: It is expressed as [(Wet weight-Dry weight)/Wet weight] * 100. Moisture content is generally high in waste comprising a higher proportion of food waste. It typically is 20–45 per cent depending on arid climate and wet season.

Calorific value: It is the amount of heat generated from combustion of a unit weight of the waste, expressed as kilojoule per kilogram (kJ/kg). Calorific value determines the potential for recovering refuse derived fuel (RDF) from waste and its utilization (through incineration) in cement, power, and waste to energy plants. The value is

determined by using a bomb calorimeter, in which the heat generated from the combustion of a dry sample is measured at a constant temperature of 25°C. Since the test temperature is below the boiling point of water, the combustion water remains in the liquid state. However, during combustion, the temperature of the combustion gases remains above 100°C so that the water resulting from combustion is in the vapour state.

These characteristics can be identified in an organization or campus through a waste audit. Waste audit systematically determines the amount and type of waste generated.

8.5 Have you done a waste audit? Provide details.

Yes ☐ _____

No ☐ _____

S. NO	LOCATION/ BLOCK	VOLUME	DENSITY	COMPOSITION (PER CENT)			
				BIODEGRADABLE	RECYCLABLE	INERT	OTHER (SPECIFY)
1.							
2.							
3.							
4.							
5.							
6.							
7.							
8.							
9.							
10.							

8.6 Do you have collection points from where municipal truck can pick up the rejects? If you do, mention the size of the container.

Yes ☐ _____

No ☐ _____

The number and capacity of containers to store waste before collection depend on the volume of waste (as resulted by the waste audit) and frequency of collection. An additional 100 per cent storage is kept to avoid spilling in case of delay in collection.

8.7 Do you reduce waste via:

☐ Promoting reusable trays, plates, bowls, cups/bottles, and serving-ware

☐ Minimizing use of products with excess packaging

☐ Engaging occupants to properly sort waste

☐ Engaging occupants to reduce packaging waste and single-serve containers

☐ Other practice/s (specify):

_____

_____

_____

_____

8.8 Do you encourage a zero-waste culture via:

☐ Policies _____

☐ Education campaigns _____

☐ Contests _____

☐ Incentives _____

☐ Awards _____

A *zero-waste* ideology encourages a lifestyle that makes sure all products are reused and no waste ends into landfills or incinerators.

8.9 Do you practice creative reuse, on-site treatment? Support by examples detailing volumes of waste reused and methodologies (such as vermin-composting, burial, mechanical composting, etc.)

☐ Recycling _____

☐ Composting _____

☐ Other (specify): _____

8.10 Are all stakeholders engaged in campus zero-waste efforts and practise proper recycling and composting? Define broad roles.

☐ All _____

☐ A few _____

☐ None _____

8.11 Do you have a disposal provision/facility/policy for:

☐ Cleaning products _____

☐ Grease _____

☐ Strippers _____

☐ Batteries _____

☐ Biomedical waste _____

☐ Fluorescent lighting _____

☐ E-waste _____

☐ Other potentially hazardous products, specify: _____

Fats, oils and grease (FOG) may not be harmful in liquid form but can pose a great problem as they harden and congeal in the waste. FOGs are produced at food service establishments. Proper plumbing system provides grease traps in such establishment to prevent FOGs from entering into the sewage system. Absence of grease traps affects the entire sewage system adversely and presents a high cost to environment and the municipal body. But once FOGs are collected in grease traps they need proper treatment and should end into landfills. Improper disposal forms toxic products, coats plants and animals and suffocates them by oxygen depletion, catches fire in presence of ignition and reduce degradability of otherwise degradable materials.

The E-waste (Management) Rules, 2016, define e-waste as 'electrical and electronic equipment, whole or in part discarded as waste by the consumer or bulk consumer as well as rejects from manufacturing, refurbishment and repair processes'. This equipment could be computer, computer peripherals and accessories, kitchen appliances, household electronics, laboratory equipment, phones, cables, circuit boards, etc. E-waste can contain heavy metals such as lead, copper, cadmium, arsenic, mercury, nickel and flame retardants. Such toxic substances pose a threat of leaching into the soil and water at landfills and contaminating the environment. E-waste also prematurely fills the landfill sites due to its large volume. The only way to dispose of e-waste as per the rules is to recycle or process at authorized dismantlers, recyclers, manufacturers and refurbishers. Processing at an authorized facility ensures extraction of the mineral trapped inside the e-waste in a safe and controlled environment.

India has emerged as world's second largest mobile phone market. It has become the fifth largest producer of e-waste with about 18,50,000 tonnes produced annually.[9] Generation of e-waste is directly related to affluence, hence growing cities are largest producers of e-waste. Sixty per cent of the annual e-waste is generated by 65 cities in India. Mumbai tops this list, followed by Delhi and Bengaluru. State-wise, Maharashtra, Tamil Nadu, Telangana, Uttar Pradesh, West Bengal, Delhi, Karnataka, Gujarat, Madhya Pradesh and Punjab are large producers of e-waste.

Currently, 95 per cent of e-waste produced in the country is handled by the entrepreneurial informal sector, which may not be equipped to handle the bulk of e-waste generated in the country. Taking note of the issue, the E-waste (Management) Rules, 2016, set up an e-waste collection target of 30 per cent for electronics manufacturers under extended producers' responsibility.

8.12 Is the e-waste going to an authorized recycler?

Yes ☐ _____

No ☐ _____

8.13 How do you handle compostable wastes such as food, garden/horticulture? Support by current scheme of operations.

Yes ☐ _____

No ☐ _____

Campuses produce large quantity of food waste due to the presence of at least one mess/canteen. The volume of food waste is even larger if there is an accommodation facility within the campus. This food waste can make up a substantial share of total campus waste considering the largest proportion of MSW in India is made of organic materials. A higher presence of organic matter in waste means higher methane emissions as it decomposes not only at landfills but also at local waste collection points, storage facilities and transfer stations. Methane from landfills represents 12 per cent of total global methane emissions. This scenario presents a need to utilization of reduction and reuse methods at source like composting.

Composting: This is a biological waste treatment process that involves decomposing of solid wastes by the action of micro-organisms such as bacteria, yeast and fungi. The process yields fertilizer, known as compost, for plants. It prevents transfer of organic waste to landfills and hence the uncontrolled release of methane. It also reduces dependency on chemical fertilizers for agricultural purposes. There are various types of composting methods that need different balance in chemical properties of waste in order to be processed.

Chemical properties:[10]
Moisture: Microbes need moisture for survival and growth. As the particles decompose, the moisture tends to occupy the free air space between them. Thus, when the moisture content is very high, it prepares anaerobic conditions.

Aeration: The process of composting requires adequate supply of oxygen for natural degradation by micro-organisms. Under aerobic conditions, decomposition rate is 10–20 times faster than anaerobic conditions. Turning or mixing the waste piles at regular intervals ensures ample oxygen supply and aeration.

Carbon to nitrogen (C/N) ratio: The ratio between carbon and nitrogen elements of the waste has to be maintained around 30:1 to allow good decomposition. Carbon comes from brown matter (like wood chips, saw, dust, paper, etc.) and nitrogen from green matter (like food scraps, leaves, etc.). C/N ratio below 25:1 results in production of foul smell and a higher C/N ratio will result in production of ammonia, thus hampering the decomposition process.

Temperature: in aerobic composting, temperatures can rise up to 70°C. Increased temperature results in increase biological activity, provided the materials are stabilized. High temperature helps in destruction of some common pathogens and parasites.

Particle size: Microbes need enough surface area for microbial activity and enough void space to allow air circulation for microbial respiration. Therefore, optimum particle size needs to be ensured for the process.

Vermicomposting: This type of composting involves casting of earthworms into the compost pit. A particular species of earthworm breaks down the organic matter and helps in culturing vermicompost. Vermicompost is a nutrient-rich natural fertilizer and soil conditioner that is richer in plant nutrients compared with normal compost prepared from similar material. The earthworm species often used include *Eudrillus eugineae*, *Eisenia foetida* or *Lumbricus rubellus*. The species are not suited for waste that is hard and has excessive acidity and alkalinity. These chemical characteristics come from high oil, spice and salt content in food. Moisture content

preferred ranges from 40–55 per cent. Vermicomposting can be done in a tank with dimensions 4m x 1m x 0.5 m for waste input of 10 kg/day of semi decomposed waste (see *Table 7: Potential problems of vermicomposting, causes and solutions*).

Table 8: Potential problems of vermicomposting, causes and solutions

ISSUES	CAUSES	SOLUTIONS
Foul odour	Overfeeding	Remove the excess food, remove meal or remove daily products if any
	Not enough air circulation or anaerobic conditions	Fluff up or loosen bedding
	Bed too wet	Add bedding to absorb moisture
Flies	Waste exposed	Bury the waste completely
Ant infestation		Immerse the base or feet of the vermin bed in water
		A barrier of chalk or petroleum jelly may repel the ants.
		If bedding seems dry, add water
Mite infestation		Avoid adding foods with high moisture
Dead worms or escaping worms	Bed too wet	Do not water till it reaches appropriate moisture
	Bed too dry	Sprinkle water till it turns moist
	Excess temperature, not enough air, not enough food.	Sprinkle water till it turns moist, temperature drops, add waste appropriately
	Bed packed tightly	Turn bed and make it fluffy

Figure 24: Windrow composting

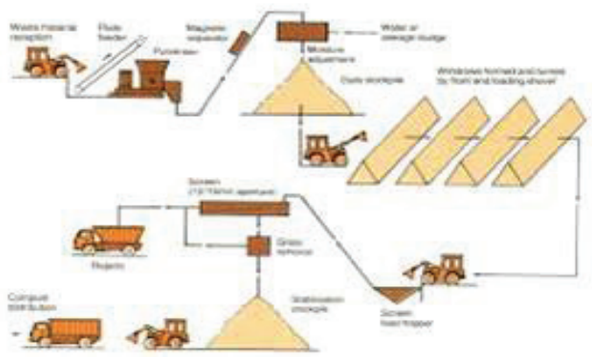
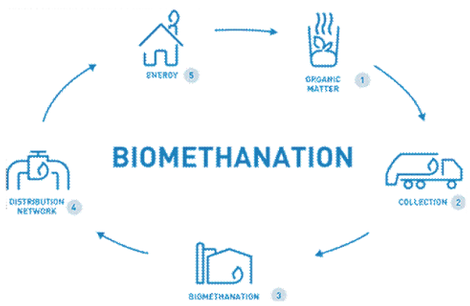


Figure 25: Typical bio-methanation cycle



Windrow composting: The process involves aerobic biodegration of organic material. It requires placing of pre-sorted feedstock in long narrow piles called windrows (3–6 m high). The placement gap is normally 1–3 m. These windrows are turned on a regular basis to boost porosity and passive aeration.

Bio-methanation: It is a process involving anaerobic digestion of organic matter in presence of micro-organisms. It produces methane and carbon dioxide rich biogas, also known as biowaste-derived fuel, suitable for energy production and hence, is a renewable energy source. The nutrient-rich solids left after digestion can be used as a fertilizer. The organic matter should not be fibrous as the anaerobic microorganisms do not easily break down woody molecules such as lignin, cellulose, hemicelluloses, etc. Preferred C/N ratio for the process is 25–30:1 and the moisture content should be greater 50 per cent, which provides better feed, gas production, system type, system efficiency. Area requirement for bio-methanation is approximately 25 m^2.

8.14 Do you use the compost produced for horticulture purposes? If you do, specify.

Yes ☐ _____

No ☐ _____

8.15 Has the campus banned use of plastic?

Yes ☐ _____

No ☐ _____

Plastic is a hefty cause of environmental breakdown. It does not degrade and produces harmful dioxins that release in the air and contaminate the soil. The pigments and colours used in plastic contain harmful toxic metals like chromium and copper. Plastic then directly impacts plants and animal life in both the land and the sea. While the statistics are incomplete, some conservationists estimate that at least 100,000 mammals and birds die from them each year even as more plastic is produced and consumed around the world.

Plastic bags have become a major part of our daily life. Bags of less than 25 microns are a greater hazard. They cannot be recycled but they have a shorter life span and hence are disposed of quickly. The plastic waste management rules, 2016 have mandated the minimum thickness for plastic carry bags and sheets to be 50 microns.

In India, 15,000 tonnes of plastic waste is generated every day, of which only 9,000 tonnes is collected and processed.[11] The plastic waste management rules, 2016 promote use of plastic waste for road construction as per Indian Road Congress guidelines. Other uses include energy recovery, waste to oil, etc.

8.16 Have any initiatives been taken in the campus to promote upcycling of plastic?

Yes ☐ _____

No ☐ _____

Box 8.2: Recycling waste in Princeton University

At Princeton University, two students collected 5,000 plastic cups and repurposed them to creative lighting fixtures, durable chairs and other aesthetic elements in their campus. They used easily available materials such as glue gun and fish-net wires to run through the cups making holes. Their initiative is called cUpcycle!

Source: https://sustain.princeton.edu/news/cupcycle

9. Open and green spaces

Landscape features in a campus leave a first impression in a prospective or new student's mind. Open and green spaces also reduce the environmental footprint of a campus.

To optimize resource use on campus, appropriate plant materials and proper irrigation techniques—done through a landscape plan in accordance with the natural features of the campus—are crucial.

Guiding principles

To protect and expand forests and green areas :

- Earmark at least 10 per cent of the land area as forests.
- Earmark another 15 per cent as additional green areas, such as tree cover, parks, roadside green belts etc.
- Protect at least 5 per cent as community or conservation reserve.
- Earmark wastelands as forests to increase forest cover.

This will help sequester greenhouse gas emissions, trap toxic pollution and prevent heat islands, help recharge groundwater and revive aquifers, protect local biodiversity and meet community requirements.

9.1 Have you taken action to green your campus through implementation of:

- ☐ On-site composting
- ☐ Rain gardens, berms, swales or natural drainage features
- ☐ Rain barrels and other rainwater collection systems
- ☐ Food gardens
- ☐ Native and drought-tolerant landscaping
- ☐ Ponds
- ☐ Tree planting and care
- ☐ Natural elements, such as wood benches, etc.
- ☐ Any other sustainable/greening initiative. Please specify.

_____

_____

_____

_____

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