



Resilient India - Disaster Free India



Training Module On Solid Waste Management in Post -Disaster Situations

National Institute of Disaster Management
(Ministry of Home Affairs, Government of India)

Plot No. 15, Block B, Pocket 3, Sector 29, Rohini, Delhi 110042

Website: <https://nidm.gov.in>

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The training module is based on data and information available from a range of sources including published and unpublished literature, reports, etc. and their original sources are duly acknowledged. The team is only responsible for the interpretation and presentation of the inferences. The views are not necessarily of the government or any organizations. The contents of the training module can be freely cited, reproduced, translated with due acknowledgement to the original publication and the authors.

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Foreword

Among the various adverse impacts of disasters, the generation of large volumes of waste pose a significant challenge. The waste generated during and after disasters differ significantly from the waste generated during normal times, both in terms of volume and composition, posing complex challenges for stakeholders. Disaster waste can severely hinder rescue and response operations. Improper management of such waste can result to severe environmental degradation and public health concerns.

Proper management of disaster waste, particularly through a gender-responsive approach- contribute substantially to disaster resilience, environmental protection and regeneration of livelihoods in affected areas. There are considerable potential ways for reduction, reuse and resource recovery by applying circular economy principles and 5Rs - Reduce, Reuse, Recycle, Recover and Refuse - to disaster waste management. For effectively addressing the challenges of disaster waste, a two-fold approach would be essential: firstly, strengthening the existing solid waste management systems in cities, towns and rural areas and secondly, establishing efficient mechanism for managing disaster waste post-disaster scenarios. Both strategies would require proactive planning and robust institutional provisions.

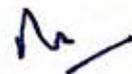
This training module has been developed drawing upon the research study undertaken by NIDM titled 'Solid Waste Management in Post-Disaster Situation' as well as various national &

international guidelines. It is designed to serve as a guide for organizing orientation and training programmes for stakeholders engaged in disaster management and solid waste management. The ultimate aim of this module is to support and contribute towards disaster-resilient communities through informed, inclusive and sustainable waste management practices in the country.

The module has been carried out as part of the NIDM-GIZ grant agreement on “Enabling Cities on Disaster Risk Reduction (DRR) and Climate Change Adaptation (CCA) for Sustainable Urban Development in India”, a sub-project under the Sustainable Urban Development – Smart Cities II (SUDSC-II) programme. This initiative is jointly implemented by GIZ and Ministry of Housing and Urban Affairs (MoHUA), Government of India on behalf of the German Federal Ministry for Economic Cooperation and Development (BMZ).

I hope that this work will encourage continued collaboration and commitment toward safeguarding India’s urban future from the risks of disasters.

I congratulate the entire team for their dedication and insightful contributions and encourage the cities to adopt and adapt these learnings to strengthen their disaster preparedness.



(Madhup Vyas)

Acknowledgement

I would like to express my deepest gratitude to Shri Madhup Vyas, IAS, Executive Director, NIDM, for providing encouragement, guidance, and unwavering support for successfully completing this module.

I would acknowledge the support of the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH under the sub-project 'Enabling Cities on Disaster Risk Reduction (DRR) and Climate Change Adaptation (CCA) for Sustainable Urban Development in India', of the Sustainable Urban Development Smart Cities II (SUDSC-II) project.

I would like to acknowledge the guidance and support of Shri Surendra Thakur, Former Joint Director, and Dr. Amir Ali Khan, Associate Professor and Head of the Resilient Infrastructure Division, NIDM. I would like to thank our consultant, Shri Vivekanand Gupta, for supporting us in preparing the module with a lot of dedication, creativity, and diligent work. I am grateful to officials of GIZ, mainly Ms. Shweta Dua, Technical Advisor, GIZ, for thoroughly reviewing the module and providing the valuable inputs at each stage of preparation of the module. I would like to thank all experts and stakeholders for their inputs during stakeholder consultations.

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(Garima Aggarwal)

Senior Consultant (Resilient Infrastructure)

NIDM

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List of Abbreviations

AI	Artificial Intelligence
C&D	Construction and Demolition
CBO	Community-Based Organization
CCA	Copper Chrome Arsenate
CPCB	Central Pollution Control Board
CPHEEO	Central Public Health and Environmental Engineering Organization
CPWD	Central Public Works Department
CSR	Corporate Social Responsibility
GHG	Greenhouse gas
DC	Deputy Commissioner
DDA	Delhi Development Authority
DUSIB	Delhi Urban Shelter Improvement Board
DW	Disaster Waste
DWM	Disaster Waste Management
ESF	Emergency Support Functions
ICT	Information and Communications Technology
IDP	Internally Displaced Persons
IoT	Internet of things
IRS	Incident Response System
MCD	Municipal Corporation of Delhi
MES	Military Engineering Services
MoEF&CC	Ministry of Environment, Forest and Climate Change
MOHUA	Ministry of Housing and Urban Affairs
MOPR	Ministry of Panchayati Raj
MORD	Ministry of Rural Development
MRF	Material Recovery Facility
NGO	Non-governmental Organisation
NIDM	National Institute of Disaster Management
RDF	Refuse-derived Fuel
SBM	Swachh Bharat Mission
SE	Superintending Engineer
SOP	Standard Operating Procedure
SPCB	State Pollution Control Board
SUP	Single Use Plastic
SWM	Solid Waste Management
UNDRR	United Nations Office for Disaster Risk Reduction
W-T-E	Waste-to-energy

Note: *This module has been designed as a guide for the facilitators. It is not intended to be a research report or a reference book on the subject. Though it attempts to touch on all of the important dimensions of the topic, it is not expected to be an exhaustive course book on the subject. The learnings covered in the sub-modules on disaster waste (mainly technical sessions 5, 7-9) should not be interpreted to be the officially recommended guidelines, regulations, or advisories. This module is based on information and data obtained from various published and unpublished sources. The original sources are duly acknowledged in the respective sections.*

1. Executive Summary

As a result of the devastating impacts of disasters, solid waste in large volumes is often generated, which also hinders relief and rescue efforts by blocking access. Unattended solid waste during and post-disaster may potentially cause a public health risk.

NIDM has published a research study titled 'Solid Waste Management in Post-Disaster Situations'. This training module is developed based on the above-said study and will act as a learning primer for conducting the training programs for the senior level and middle level government officers. The objectives of the training module include enhancing knowledge and awareness of solid waste management and disaster management, solid waste generated in a disaster situation, and providing a preliminary orientation on planning elements. The methodology for preparing the module predominantly covers literature review, articulation and designing interactive learning activities. Case studies are used as a key learning method in the module. The module is structured in a modular fashion, with sub-modules structured for incremental learning and to induce convergence and cross-learning. Pre-training assessment and feedback are other key features of the module.

There are three sub-modules, each with three sessions, for a total of nine technical sessions. Sub-module I covers the fundamental concepts of solid waste management; Sub-module II covers understanding of disaster management & disaster waste and Sub-module III focuses on planning strategies effective for waste management in disaster situations.

Session 1.1. (Technical Session 1) covers definition, types, characteristics, and quantity of waste generated; steps in solid waste management; the status of solid waste management in Indian cities; and legal, regulatory, and institutional frameworks for SWM in India. Two case studies are also part of this session. **Session 1.2. (Technical Session 2)** includes important concepts and guiding principles of solid waste management and issues and challenges in SWM service delivery in India. This session has an interactive learning activity on tracing the flow of solid waste in the city through a drawing activity in groups. **Session 1.3. (Technical Session 3)** covers existing scenarios, issues and good practices with respect to management of construction and demolition waste, plastic waste, biomedical waste, hazardous waste and sanitary waste. This session will cover five case studies on various specific types of waste.

Session 2.1. (Technical Session 4) includes definitions and concepts of disaster, disaster management, climate change, and disaster risk resilience; disaster management and gender; the vulnerability profile of India; stages of disaster management; and the global policy framework and institutional framework in India. It will also include an activity on listing key areas related to disaster risk reduction in the respective cities of the participants. **Session 2.2. (Technical Session 5)** attempts to explain how solid waste is generated as an impact of disasters, characteristics and quantities of waste pertaining to various types of disasters, and drivers of high waste generation. A group activity to understand the types of waste generated post-disasters through a card-matching game is included in this session. Three case studies on various aspects of disaster waste are also included in this session. **Session 2.3. (Technical Session 6)** covers the institutional framework and stakeholders for waste management during disasters in India and a brief on international guidelines. This session also has an interactive learning activity on stakeholder mapping.

Session 3.1 (Technical Session 7) covers the need for planning and cycle of disaster waste, conceptual frameworks and types of plans and key elements of contingency and implementation plans. This session also includes a case study on the use of circular economy principles in the management of disaster waste. **Session 3.2 (Technical Session 8)** focuses on planning and action methods and tools and covers disaster waste generation and need assessment, identification of urgent action points, prioritization or hazard ranking of disaster waste, temporary disposal site location, and pre-selection. A group activity in this session attempts to develop understanding of key aspects of a contingency plan for disaster waste management with the help of two sub-activities on initial estimates of waste volumes and hazard ranking. **Session 3.3 (Technical Session 9)** includes integration in plans and preparation of guidelines and SOPs, awareness generation, and building community resilience and capacity. A group activity on writing points on integration of disaster waste elements into city sanitation action plans and state disaster management plans is also part of this session.

A field visit to a waste processing plant is part of a five-day-long training program. This covers a briefing by the plant operator and a guided tour of the different parts of the plant, followed by noting down observations by the participants. The field visit will be concluded with an activity on writing the observations from the field visit. The valedictory session consists of capturing feedback from participants and assessments, an address by the dignitaries as per the protocol, and a formal vote of thanks.

The first option of a session plan for conducting a training program will be of three days duration, which will include nine technical sessions along with an inaugural and valedictory session, one assessment at the end of the training program and feedback capture at the end of the training program. The second option of a session plan will be of five days duration, consisting of nine technical sessions, divided across fourteen sessions along with inaugural and valedictory sessions and a site visit. In this option, there will be three assessments, one after each sub-module, and feedback capturing will be done three times at the end of each of the three sub-modules.

2. Introduction

2.1 Background

Disasters have devastating impacts on human lives, livelihoods, buildings and natural systems. Disaster impacts in multiple ways like deaths, injuries, destruction and damage to buildings, infrastructure facilities and other human-made or natural structures. India is prone to many hazards and has faced several earthquakes, floods, cyclones, landslides, fires, etc. in the past. Climate change is identified as one of the drivers of disaster risk. The United Nations¹ has identified gender inequality, along with environmental and climate emergencies, as the greatest development challenges of today's world. The G-20 Declaration advocates keeping gender equity at the core of climate action².

Many natural and built features over the land and below the water surface are either destroyed, blown away, displaced, broken, torn or washed away from various parts of cities and villages. Disasters like floods also transport many harmful and undesired substances, like carcasses, mud, silt, and garbage piles, to human settlements. The accumulation of disaster waste can also hinder relief, rescue, and reconstruction efforts by blocking access to houses and areas³.

The situation further worsens with the mixing of different types of solid waste and the contamination caused by the mixing of hazardous waste. The makeshift health-care facilities may not have sufficient facilities for handling bio-medical waste. Solid waste generated from temporary relief and rehabilitation camps requires specific attention and provisions. In addition to the waste generated directly as an impact of disasters like construction debris, the basic service provisioning of household waste collection and management also gets impacted due to interruptions caused by different stages of the solid waste management service chain. Since people of different genders and age groups are differently impacted or affected by disasters, their needs and capacities are critically important to building resilience.

Box 1: Magnitude of Solid Waste Generated as a Result of Some Recent Disasters Globally

Haiti earthquake 2010	23 -60 million tons
The Great East Japan Earthquake 2011	31 million tons
Nepal earthquake, 2015	14 million tons
Hurricane Katrina (USA) 2005	26.8 million tons
Super Typhoon Haiyan (Yolanda) (Philippines) 2013	19 million tons
Thailand floods 2011	100,000 tons

Source: Ministry of Environment, Japan (2018). DWM Guidelines for Asia and the Pacific. Page 5

The quantity of waste generated during a disaster is often overwhelmingly high and this imposes mammoth challenges for solid waste management and disaster management authorities. The Great East Japan Earthquake of 2011, Earthquake of Haiti in 2010 and Earthquake in Sichuan (China) in 2008, were estimated to generate disaster waste on the tune of 31, 23 and

20 million tons respectively. Srinagar floods of 2014 and Kerala floods of 2018 were reported to lead generation of over 35,000 MT solid waste individually.

2.2 Defining Solid Waste and Disaster Waste

Solid waste refers to any type of garbage, trash, refuse or discarded material⁴. In India, the Solid Waste Management Rules, 2016 has defined *“solid waste as solid or semi-solid domestic waste, sanitary waste, commercial waste, institutional waste, catering and market waste and other non-residential wastes, street sweepings, silt removed or collected from the surface drains, horticulture waste, agriculture and dairy waste, treated bio-medical waste excluding industrial waste, bio-medical waste and e-waste, battery waste, radio-active waste generated in the area under the local authorities and other entities mentioned in rule 2”*. In addition, construction and demolition waste and special waste types like plastic waste, bio-medical waste, electric and electronic waste (e-waste), battery waste and hazardous waste have been defined in the respective rules.

As defined in Joint UNEP/OCHA Environment Unit Guidelines⁵, *“Disaster waste is the waste that is generated by the impact of a disaster, both as a direct effect of the disaster as well as in the post-disaster phase as a result of poor waste management”*.

In the module, both of the above terminologies have been used. The expressions- 'solid waste management in disaster situations' and 'solid waste management in post disaster situations' intend to broadly cover both- 'solid waste' as well as 'disaster waste'.

2.3 Need of the Module

In light of the increasing trend of disasters in India, there is an emerging need for preparedness in all dimensions of the hazards. The linkage between solid waste management, health, and the environment is very well established. Incorporating solid waste management elements in all stages of disaster management—prevention, mitigation, preparedness, response, and recovery—is essential to ensure an effective response and avoid any ill effects on human health and the environment. Similarly, it is essential to integrate hazard management and risk resilience perspectives into the regular (peace-time) solid waste management systems in urban and rural areas with a gender responsive approach. Considering the criticality of these aspects, it is imperative that the human resources engaged in planning, management, service delivery, and disaster response are oriented and equipped with an understanding of various dimensions.

Knowledge and capacity-building resources for solid waste management are substantially available, which received a programmatic and regulatory push through the Swachh Bharat Mission (SBM) Urban and Rural launched in 2014 and the Solid Waste Management Rules in 2016. In India, we have rules and guidelines for handling various types of waste, like municipal waste, plastic waste, e-waste, bio-medical waste, hazardous waste, battery waste, etc. The Central Public Health and Environmental Engineering Organization (CPHEEO) revised the manual on solid waste management in light of SWM Rules 2016. In the disaster management domain, many capacity-building resources are available internationally as well as at the national level. NIDM has led the efforts in making available training resources and imparting training in the areas of different hazard types like earthquakes, fires, floods, cyclones, landslides, etc. However,

the existing training and knowledge resources do not cover the solid waste management aspect during or post-disaster categorically and with a nuanced approach.

Some international agencies have developed guidelines for the management of disaster waste, contributing to the knowledge and capacity-building resources in this domain. These organizations include the United Nations Environment Programme (UNEP), the United Nations Development Programme (UNDP), the Ministry of Environment, the Government of Japan, the Government of South Australia, the National Institute for Environmental Studies, Japan, etc. Recognizing the importance of disaster waste management, NIDM organized a national consultation on “Challenges and Solutions for Safe Utilization and Safe Disposal of Solid Waste Generated in the Post-Disaster Scenario” on November 11 and 12, 2021. The paper on this topic, titled ‘Solid Waste Management in Post-Disaster Situations’, has been published by NIDM.

2.4 Title of the Module and Training Program

The training program using this module is proposed to be named “Orientation Training on Solid Waste Management in Disaster Situations”.

2.5 About the Module, Aim, Objectives and Outcomes

The training imparted using the module aims to provide the participants with orientation, awareness, enhanced knowledge, and guidance on the planning and implementation of solid waste management in disaster situations to effectively respond and avoid any ill effects on human health and the environment. The training program using the module is envisaged to act as a learning primer on the topic of solid waste management in disaster situations. The key objectives of the training module are mentioned below:

- To enhance knowledge and awareness of solid waste management and disaster management for government departments and urban local bodies.
- To develop a clear understanding of disaster management and solid waste generated during and post-disaster situations, its volume, characteristics, and management concerns.
- To provide a orientation on various elements and processes of planning and taking actions to manage solid waste in disaster situations.

The training imparted using the manual is expected to develop more sensitized, oriented, and informed human resources capable of decision-making, planning, and organizing various activities pertaining to solid waste management in disaster situations. The module is prepared to act as a guiding document for the facilitators.

2.6 Target Participants

The target participants for training programs may include senior and middle level officials of the state disaster management authorities, district disaster management authorities, and district administration. It will also target the staff and service providers of urban and rural local bodies involved in the planning and delivery of solid waste management services. Senior and

mid-level functionaries will be the primary target groups for the training.

2.7 Approach to Learning and Methodology

Learning methodology: The training methodology is based on adult learning principles. Adult learning principals acknowledge the basic attributes of adult learners, which are different from those of children. The attributes of adult learners, as described by Malcom Knowles⁶ :

- Adults are autonomous and self-directed. Therefore, they must be actively involved in the learning process
- As adults have accumulated a significant amount of life experience and knowledge that must be recognized.
- Adults are practical and focus on the aspects of a lesson that are most useful to them and their work

Elaborating on the key principles of adult learning, Johan Goodlad has written that adult learning should be *practical and problem-focused, induce positive self-esteem, integrate the new learning with the existing knowledge, capitalize on their experience, and permit choice*.⁷

The module puts a lot of emphasis on engaging the participants in different interactive learning activities and provides avenues for their expressions so that their past experiences and knowledge are valued and used to induce peer learning. The basic mode of delivery for technical sessions will include a combination of PowerPoint- based deliberations and interactive learning activities. Some case studies and special lectures will be appropriately used to strengthen the delivery of the content.

Structure: The sub-modules are designed in such a way that some or all sub-modules can be used with little modification for shorter and more focused trainings targeting specific groups of participants. Such an approach will provide an opportunity to build a larger body of knowledge and skills in the area of waste management during disaster situations. This will also facilitate the availability of customizable training programs to be organized around the topic in the future.

Convergence and Cross-learning: The target audience for the training module is envisaged to be stakeholders from two domains: waste management and disaster management. Therefore, the module will attempt to shed light on both domains separately and induce *cross-learning* through common activities and assessments. In the later sub-modules, the focus will be on integrated planning and management to achieve convergence. The training imparted using the module will pre-dominantly adopt an 'orientation' approach.

Assessment and Feedback: To evaluate the understanding of participants, a continuous informal assessment approach will be adopted, which will mainly involve interactive learning activities. In addition to the informal assessments, formal assessments will be conducted through objective-type question-and-answer sessions at the end of each of the three sub-modules. A pre-training assessment will be conducted through an online questionnaire. Feedback of the participants will be captured after each session.

2.8 Scope and Limitations

The module covers various dimensions of solid waste management and disaster management in India in order to develop a clear understanding of solid waste generated in disaster situations. It covers waste types and quantities, prioritization, actions, plans, tools, and methods primarily drawn from international guidelines and resources. It also talks about the existing institutional framework and possibilities of integration in different types of plans for sensitization and orientation of the participants. The contents of this module are mainly drawn from an NIDM publication on solid waste management in disaster situations⁸, in addition to international guidelines, national provisions, and case studies. The module does not cover liquid waste, carcass, technical details, official protocols or regulatory requirements for handling and disposal of disaster waste, equipment specifications, or cost elements.

Box 2: Note for the Facilitators

Facilitators of the training sessions need to create a link with the knowledge imparted in the previous session to develop a gradual understanding of the subject. If required, concepts and practices earlier discussed should be rediscussed at the beginning of a new session. A recap of previous sessions at the beginning of the day should be used as an effective way to **connect the dots**.

2.9 Structure of the Module

The module is divided into three sub-modules, each with three sessions, for a total of nine technical sessions. Introductory and valedictory sessions will be added to these technical sessions to prepare the training program and session plans. The division and sequencing of the technical sessions are done to build a step-by-step understanding following a progression from basic to advanced learning.

Below is a glimpse of the broad structure of the module.

Sub-modules	Sub-module objective	Technical Sessions
Sub-module I : Basics of Solid Waste Management	To impart a basic understanding of solid waste management to a diversified set of participants, along with a nuanced understanding of waste types, that are crucial from a disaster risk resilience perspective.	<p>Session 1.1. Basics of Solid Waste Management</p> <p>Session 1.2. Solid waste management concepts and challenges in the existing solid waste management system</p> <p>Session 1.3. Dealing with the specific waste types (plastic waste, C&D waste, bio-medical waste, hazardous waste, and sanitary waste)</p>
Sub-module II. Understanding Disaster Management and Disaster Waste	To develop an understanding of hazards, vulnerabilities, and disaster management scenarios in India, along with the post-disaster waste situation and existing frameworks.	<p>Session 2.1. Disaster Management and Disaster Risk Resilience</p> <p>Session 2.2. Post disaster solid waste situation: Hazard- wise waste characteristics and quantities</p> <p>Session 2.3. Institutional and governance frameworks</p>

Sub-modules	Sub-module objective	Technical Sessions
Sub-module III. Planning for waste management in disaster situations	To equip the participants with an understanding of the types, needs, and roles of plans and how to prepare the key elements of the plans for managing solid waste in disaster situations.	<p>Session 3.1. Cycle of disaster waste management and types of plans</p> <p>Session 3.2. Planning and action methods and tools for disaster waste management</p> <p>Session 3.3. Strengthening institutional aspects, awareness generation, and capacity building</p>

The training program will have an inaugural session before the start of the first session under Sub-Module 1. Some of the technical sessions can be broken into two or more parts depending on the number of participants, availability of time, and resource persons. Two options for the session plans for training programs with three-day and five-day durations are provided in Chapter 8. A site visit to a solid waste processing plant is included in the five-day session plan option, aiming to provide on-site exposure to an established waste processing plant or a material recovery facility to the participants. After the end of all technical sessions, a valedictory session will be conducted.

2.10 Learning Resources

The study material for the participants will be in the form of notes, guidelines, and presentations used for the preparation of this module. All study resources will be compiled in soft copy format on an online drive and shared with the participants through a link.

2.11 Venue, Material and Resource Persons

The venue for conducting training using this module should have a seating arrangement of approximately 30–40 participants or more, along with facilities like projectors, pinning boards, etc. The venue should have a flexible seating arrangement, as some sessions require participants to sit in groups at a table. Activities under technical sessions will require printed sheets, cards, post-its, colored sketch pen sets, pencils, erasers, and sharpeners. It is expected that the participants will use their personal smart phones for calculations and other activities as required. A detailed list of the material required is given in the respective sections of the module. Considering the multi-disciplinary nature of the topic, domain-specific specialists in relevant areas of solid waste management and disaster management will be engaged.

3. Inaugural Session

Session Objective: to establish the need for the training program, introduction to the topic, participants and facilitators, and a quick appreciation of the level of knowledge and profile of the participants.

Duration: 100 minutes (1 hour 40 minutes)

Topics Covered, Duration and Method:

	Items/ topics	Duration	Method
1	<ul style="list-style-type: none"> - Welcome address - Key note address - About the training program and objectives - Vote of thanks 	40 minutes	Speeches PowerPoint Presentation
2	<ul style="list-style-type: none"> - <i>Meet and greet: Introduction of the participants and facilitators</i> - <i>Reflections on expectations</i> - <i>Pre-training assessment exercise</i> 	60 minutes	Writing activity on post-it or small cards Filling in the google forms or a printed form

Each participant will interact with one other participant and introduce him/ her to all the other participants. The introduction should cover key areas of work and hobby in addition to the name, designation, and place. Each participant is to mention at least one expectation from training on a post-it. All written post-it pieces will be pinned to a pin board. The facilitator will summarize the profiles of the participants and their expectations. A pre-training assessment exercise will be conducted to understand the current level of understanding of the participants on the contextual topics.

4. Sub-module 1: Basics of Solid Waste Management

Sub-module objective: To impart a basic understanding of solid waste management to a diversified set of participants along with a nuanced understanding of waste types, crucial from a disaster risk resilience perspective.

4.1 Session 1.1 (Technical Session 1): Basics of Waste Management

Session objective: to develop an understanding of the basic attributes of solid waste management, like definition, types, characteristics, quantity, current status and prevailing regulatory frameworks.

Duration: 90 minutes (1.5 hours)

Topics covered, duration and method:

Items/ topics	Duration	Method
1 - Definition, types, characteristics and quantity of waste generated, Steps in solid waste management - Status of solid waste management in Indian cities	70 minutes	PowerPoint Presentation Case study Special lecture
2 - Legal, regulatory and institutional frameworks for SWM in India	20 minutes	PowerPoint Presentation Special lecture

The 2016 Solid Waste Management Rules define the meaning and constituents of solid waste (refer Section 2.2 for the definition). The solid waste generated in urban areas is also termed 'municipal waste'. Below is a broad typology of municipal waste.

Biodegradable	Recyclable	Insert	Domestic and Hazardous Waste
<ul style="list-style-type: none"> • Kitchen Waste and Food Waste • Vegetable Waste Non-Vegetarian Waste • Garden waste 	<ul style="list-style-type: none"> • Paper • Plastics • Wood, Board, Chips, Cardboards • Metal, Glass, Rubber, Rags 	<ul style="list-style-type: none"> • Sand • Pebbles • Dirt and Gravels • Construction and Demolition Waste 	<ul style="list-style-type: none"> • Napkins, Bandages • Aerosol cans • Expired medicines, paints, nail paint remover, batteries, cleaning agents, detergents, perfumes etc

Figure 1: Broad Typology of Municipal Waste

Source: Ministry of Housing and Urban Affairs (2017). 'Waste To Wealth'. Page 15 and other sources

SWM Rules of 2016 define various types of solid waste. As per the rules, "biodegradable waste" means any organic material that can be degraded by micro-organisms into simpler stable compound. "Combustible waste" means non-biodegradable, non-recyclable, non-reusable, non-hazardous solid

waste having minimum calorific value exceeding 1500 kcal/kg and excluding chlorinated materials like plastic, wood pulp, etc. "Domestic hazardous waste" means discarded paint drums, pesticide cans, CFL bulbs, tube lights, expired medicines, broken mercury thermometers, used batteries, used needles and syringes and contaminated gauge, etc., generated at the household level. "Dry waste" means waste other than bio-degradable waste and inert street sweepings and includes recyclable and non-recyclable waste, combustible waste and sanitary napkin and diapers, etc. "Inerts" means wastes which are not bio-degradable, recyclable or combustible street sweeping or dust and silt removed from the surface drains. "Non-biodegradable waste" means any waste that cannot be degraded by microorganisms into simpler stable compounds while "sanitary waste" means wastes comprising of used diapers, sanitary towels or napkins, tampons, condoms, incontinence sheets and any other similar waste. More types of waste like construction and demolition waste, plastic waste, bio-medical waste, electric and electronic waste,⁹ battery waste and hazardous waste have been defined in the respective rules notified by MoEF&CC.

The composition of solid waste is affected by many factors like geographic location, seasons, collection frequency, population diversity, extent of recycling, people's attitudes, legislation, etc. As per a study conducted by NEERI in 2004–05, the total compostable matter in municipal solid waste in India is 40%–60% and the recyclable fraction is 10%–25%. It has a moisture content of around 30%–60%. The municipal solid waste in India has a carbon-to-nitrogen (C/N) ratio of 20–40¹⁰.

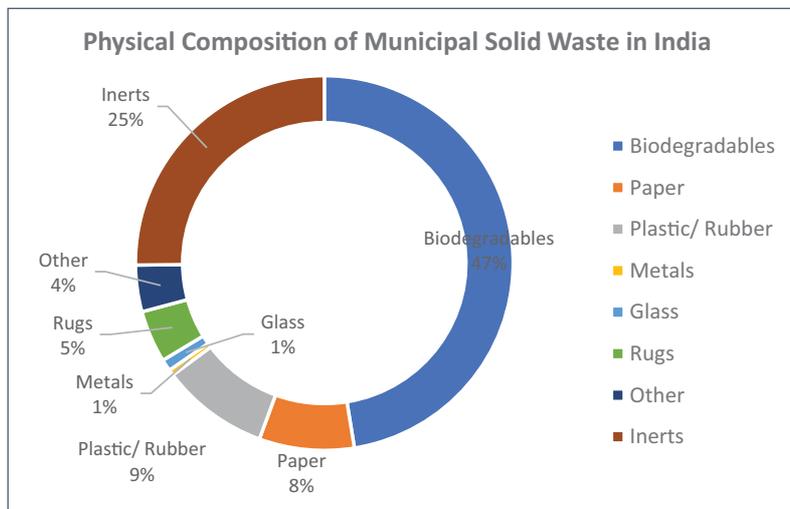


Figure 2: Physical Composition of Municipal Solid Waste in India

Source: CPHEEO (2016), 'Manual on Municipal Solid Waste Management' Part II, Page 43

Table 1 gives an idea of the variation in the generation of solid waste across different sizes of cities, which varies from 200 to 600 grams per capita per day. The per capita generation in rural and urban areas also has significant variations. The quantity of total waste generation in some of the states is given in Table 2.

Table 1: Per Capita Waste Generation in Urban Areas

Urban Population	Municipal solid waste generation (gm/capita/day)
Population below 2 Lakh	200-300
Population 2 Lakh – 5 Lakh	300–350
Population 5 Lakh – 10 Lakh	350–400
Population above 10 Lakh	400–600

Source: CPHEEO (2016), 'Manual on Municipal Solid Waste Management' Part II, Page 44

Table 2: Quantity of Total Waste Generation in Some of the States

States/ UT	Total solid waste generation per capita (Grams/day)
Andhra Pradesh	125.47
Telangana	242.39
Assam	35.06
GNCT of Delhi	448.75
Gujarat	158.3
Kerala	96.86
Karnataka	170.83
Odisha	48.39
Tamil Nadu	189.33

Source: Central Pollution Control Board (2020- 21). Annual Report on Solid Waste Management, Page 141- 153

Physical Characteristics of Municipal Waste

Density is one of the key physical characteristics of solid waste. The density of waste is the determinant of storage and transportation requirements. In India, municipal solid waste's density is typically around 450–500 kg/m³. The next important physical characteristic of solid waste is **moisture content**, which is usually expressed as the weight of moisture per unit weight of wet material. Its typical range is 20–45%. **The calorific value** is defined as the amount of heat generated from the combustion of a unit weight of waste (kJ/kg). Chemical characteristics of solid waste include pH; nitrogen, phosphorus, and potassium (N-P-K); C/N ratio; and biochemical characteristics: carbohydrates, proteins, natural fibre, etc. Toxicity in solid waste is characterized by heavy metals, organic pollutants, pesticides, and insecticides¹¹.

Steps in Management of Solid Waste

The prevailing practice of solid waste management involves multiple stages. These stages are depicted in the figure below. A further detailed description of the steps is depicted in Figure 5.



Figure 3: Stages of Solid Waste Management

As per the CPHEEO's manual, storage of waste at the source is the first essential step of solid waste management. The waste should normally be stored at the source of generation until collected for processing and treatment. Segregating waste at its source decreases the chances of contamination. It also optimizes waste processing and treatment technologies. As per the SWM Rules 2016, various components of solid waste should be segregated and separately stored:

- Biodegradable wastes, including agriculture and dairy waste
- Non-biodegradable wastes, including recyclable waste
- Non-recyclable, combustible waste
- Sanitary waste
- Non-recyclable inert waste
- Domestic hazardous wastes
- Construction and demolition waste¹²

At the household level, dry waste (waste other than bio-degradable waste, inert street sweepings, recyclable, non-recyclable, combustible waste and sanitary napkin and diapers), wet waste (biodegradable wastes), and domestic hazardous waste (discarded paint drums, pesticide cans, CFL bulbs, tube lights, expired medicines, broken mercury thermometers, used batteries, used needles and syringes and contaminated gauge, etc.) should be stored in separate garbage bins. Green colour bin for wet waste and white bin for dry waste is specified in the SWM Rules. For streets and public places, waste bins for separate storage of dry and wet waste should be provided. Waste collection bins for streets and parks should be provided at 25m to 250m distance depending on the locality¹³. Typical waste collection bins for households and public places are shown in Figure 4.



Figure 4: Typical Waste Collection Bins

Source: CPHEEO (2016), 'Manual on Municipal Solid Waste Management' Part II, Page 147- 148

Transfer Stations: In large cities where disposal sites are more than 15 km or 30 minutes away from the collection area, transfer stations help save on the cost and time involved in transportation. At the transfer stations, solid waste is transferred to larger vehicles or containers from a vehicle at the upper level of a ramp. They are recommended for large cities. Transfer stations can be equipped with material recovery facilities to recover recyclable waste before sending it for further processing or disposal¹⁴.

Pre-processing and sorting of mixed solid waste aims to prepare the segregated or partly segregated solid waste for further treatment and processing. Mechanical volume reduction is undertaken for compaction. Compactors (low-pressure and high-pressure compactors) are mainly used for volume

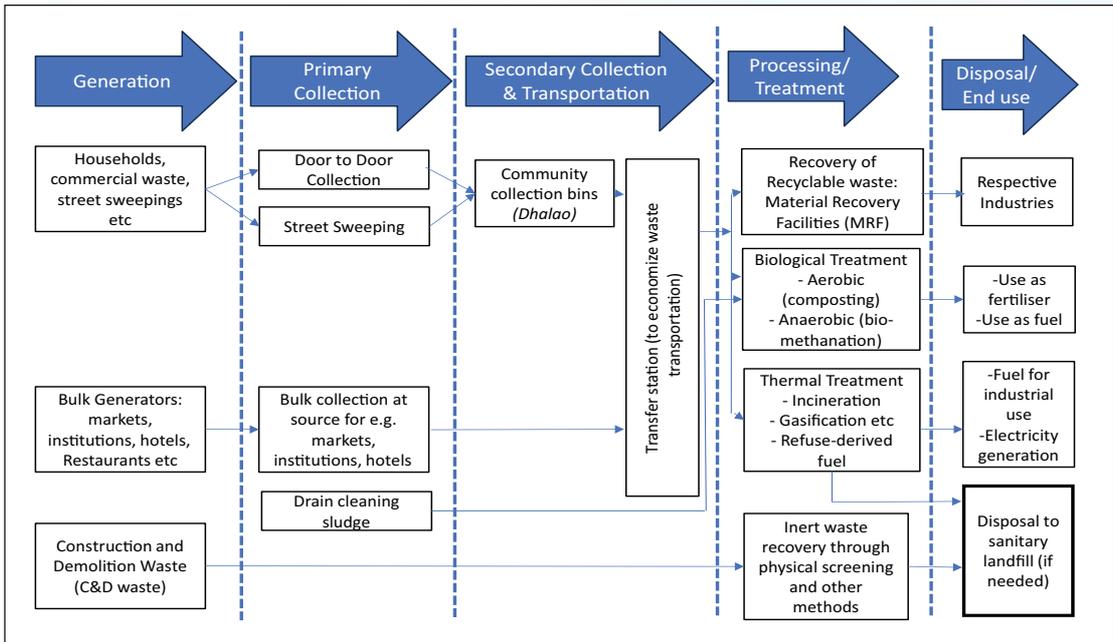


Figure 5: Various Activities and Processes Under Stages of Solid Waste Management

Source: Prepared based on Ministry of Urban Development (2014), 'Urban and Regional Development Plans Formulation and Implementation- URDPFI Guidelines Volume I, Page 343

reduction, while grinders, chippers, hammer mills, crushers, etc. are used for size reduction or shredding of waste. **Screening of waste** is generally undertaken using hand-sorting or previewing, inertial separation, and optical sorting. Air separation and magnetic separation are generally used for component separation. **Drying and dewatering** are also used to prepare solid waste for further treatment. Some of the technologies used for sorting mixed municipal solid waste feedstock include screening (for plastics, paper, cardboard, and metal), magnetic separation (for ferrous metal), eddy current separation (for nonferrous metal), and ballistic separation (for plastic, paper, glass, and gravel)¹⁵.

Materials Recovery Facility: As per the SWM Rules 2016, "Materials Recovery Facility" (MRF) is a facility where non-compostable solid waste can be temporarily stored to facilitate segregation, sorting, and recovery of recyclables from various components of waste. The recovery of recyclables can be undertaken by authorized informal sector waste pickers, informal recyclers, or any other work force engaged by the local body or responsible entity¹⁶.

Processing and treatment of solid waste can be broadly categorized into three categories: biological processing (composting and biomethanation), thermal processing, or waste-to-energy processing and processing for reuse (especially for C&D waste, plastics in road construction, etc.). Windrow composting, vermi composting, aerated static pile composting, in-vessel composting, pit composting, and mechanized organic waste converters are some of the popular methods of composting. Waste-to-energy technologies include incineration, gasification, and refuse-derived fuel (RDF).

Decentralized waste management systems are one of the approaches to sustainable waste management. Such systems have the advantage of reducing the volume of solid waste to be transported over long distances and processing key elements in smaller community-managed facilities in place of large centralized facilities. Another important element in solid waste management systems is the integration of informal waste pickers and traders, as they play an important role in the collection and channelization of recyclable waste¹⁷.

Sanitary landfill: Sanitary landfilling is the controlled disposal of waste. It minimizes the contact between waste and the environment. Its basic function is 'containment' and not treatment. In an ideal situation, following sustainability principles, nothing should be sent to the landfill. However, the rejected substances after the processing of waste and inert materials are required to be finally disposed of. Only 10–20% of waste that is inert in nature should be sent to sanitary landfill sites. A sanitary landfill facility consists of liners for protection of surrounding soil, runoff control, leachate control and treatment, monitoring wells, final cover, etc. The steps adopted for the design, implementation, and operation of a municipal sanitary landfill site include site selection, sanitary landfill design, construction of a sanitary landfill, sanitary landfill operation, closure, and a post-closure plan. Identifying suitable land for sanitary landfill sites is an important step in their planning and design. As per the norms, sanitary landfill sites should not be located in coastal regulation zones, wetland, critical habitat areas, sensitive eco-fragile areas, flood plains (as recorded for the last 100 years), or flood-prone areas. A buffer of 100 m, 200 m, 30 m, and 500 m should be maintained from rivers (from the flood plain), water bodies (ponds, lakes, etc.), non-meandering water channels (canal, drainage, etc.), highways or railway lines, and habitation, respectively¹⁸.

Present Status of Solid Waste Management in Indian Cities

Below is a glimpse of the status of solid waste management in select Indian cities, covering collection, processing, and final disposal.

Table 3: A Glimpse of the Status of Solid Waste Management in Select Indian Cities: Collection

S. No.	City	Number of wards	Generation (TPD)	Status of collection, segregation and processing		
				Wards with 100% door to door collection	Wards with 100% Source Segregation	Processing %
1	Bhubaneswar	67	405	100%	67	100%
2	Coimbatore	100	995	99%	98	98%
3	Guwahati	60	550	100%	24	18%
4	Greater Hyderabad	150	6,510	100%	150	100%
5	Kochi	74	225	100%	74	40%
6	Mangalore	60	292	100%	60	100%
7	Manikonda	20	40	100%	20	100%

Source: <https://sbmurban.org/swachh-bharat-mission-progress>, accessed on April 2, 2024

Note: Numbers are rounded off.

Table 4: A Glimpse of The Status of Solid Waste Management in Select Indian Cities: Processing

S. No.	City	Availability of processing and treatment facilities (No. and designed capacity in TPD)				
		Composting plants	Biomethanation plants	C& D waste processing plants	Waste to Energy	MRF facilities
1	Bhubaneswar	37 (211 TPD)	0	1 (25 TPD)	0	24 (250 TPD)
2	Coimbatore	10 (145 TPD)	0	0	0	3 (25 TPD)
3	Guwahati	0	1 (5 TPD)	0	0	1 (10 TPD)
4	Greater Hyderabad	1 (8,000 TPD)	0	2 (1,000 TPD)	1 (2,500 TPD)	1 (20 TPD)
5	Kochi	0	0	1 (10 TPD)	0	5 (91 TPD)
6	Mangalore	2 (400 TPD)	1 (10 TPD)	1 (50 TPD)	0	1 (100 TPD)
7	Manikonda	2 (30 TPD)	0	0	0	1 (20 TPD)

Source: <https://sbmurban.org/swachh-bharat-mission-progress>, accessed on March 28, 2024

Note: Numbers are rounded off.

Table 5: A Glimpse of the Status of Solid Waste Management in Select Indian Cities: Final Disposal

S. No.	City	Final disposal of solid waste and legacy waste				
		Total no. of dumpsites	Dumpsite area (in acre)	Dumpsite area reclaimed (in acre)	Quantity of legacy waste (in Lakh Tonne)	Quantity of remediated waste (in Lakh Tonne)
1	Bhubaneswar	1	62	0	19	0
2	Coimbatore	2	70	50	15	7
3	Guwahati	1	40	1	15	6
4	Greater Hyderabad	2	395	395	121	121
5	Kochi	1	47	5	5	1
6	Mangalore	1	42	0	9	0
7	Manikonda	-	-	-	-	-

Source: <https://sbmurban.org/swachh-bharat-mission-progress>, accessed on March 28, 2024

Note: Numbers are rounded off.

Legal, Regulatory and Institutional Frameworks for SWM in India

The key acts related to environment and waste management in India are the Water (Prevention and Control of Pollution) Act 1974 and the Environment (Protection) Act 1986. 'Solid Waste Management Rules, 2016' (SWM Rules 2016) is a key regulatory provision in the solid waste management domain. SWM Rules 2016 have defined the responsibilities of various stakeholders. The duties of waste generators and authorities (including related central ministries) are defined in the rules. Waste generators are defined as households, event organizers, street vendors, RWAs and market associations, gated communities having more than 5000 sq m, hotels and restaurants, etc. Timelines for the implementation of key elements of the rules and monitoring mechanisms are defined under the SWM Rules 2016. As per the rules, local bodies are required to frame bye-laws for levying spot fines for persons who violate these rules¹⁹.

Informal waste pickers play a significant role by collecting, sorting, processing, and selling recyclable waste, which also generates livelihoods for many poor people²⁰. As per SWM Rules 2016, informal waste collectors include individuals, associations, or waste traders who are involved in the sorting, sale, and purchase of recyclable materials. Local authorities are responsible for recognizing informal waste collectors and their organizations to facilitate their participation in the provision of solid waste management services²¹.

Other rules related to solid waste management include Plastic Waste Management Rules, 2016, Plastic Waste Management (Amendment) Rules, 2022 and 2024: Guidelines on Extended Producer Responsibility for Plastic Packaging, Bio-Medical Waste Management Rules, 2016, E-Waste (Management) Rules, 2022, Construction and Demolition Waste Management Rules, 2016, Battery Waste Management Rules, 2022, and Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016. Many cities have also prepared solid waste management bylaws. CPCB has prepared many guidelines based on the provisions of SWM Rules 2016, including one on sanitary waste management.

The Ministry of Urban Development introduced the National Urban Sanitation Policy in 2008, emphasizing the need for preparing integrated city-wide sanitation plans, institutional strengthening, awareness generation, and behavioral changes. Swachh Bharat Mission-Urban (SBM-U) and Swachh Bharat Mission-Grameen

Box 3: Global Case Studies on the Role of the Informal Sector in Solid Waste Management

In Peru, an NGO named Alternativa collaborated with the municipality and established many microenterprises for solid waste collection.

In Egypt, the informal sector has traditionally played an important role in waste collection. Followed by taking over waste collection services by international agencies, informal waste collectors were hired under a sub-contract to continue waste collection and were allowed to sort out recyclables.

In Belo Horizonte, Brazil, informal waste pickers created a cooperative called ASMARE. After many years of discussions, in 1993, a partnership was established with the city hall, recognizing its contribution.

Source: GIZ (2016), 'Basic Training on Municipal Solid Waste Management for Urban Local Bodies: A training course for elected representatives, decision makers and operative staff-Text- and Workbook for Participants', Page 178- 180

(Rural), launched in 2014, marked the first centrally sponsored schemes dedicated to sanitation and waste management. SBM 2.0 was launched in 2021. Many advisories and reference resources have been issued under SBM 2.0.

Box 4: Use of Information and Communication Technology in Solid Waste Management

Technologies like robotics, AI, IoT, data analytics, and cloud computing have a lot of potential to make solid waste management smart and efficient. Such innovative uses include push notifications, scheduling collection, automated or robot-driven sweeping, collection bin management, route planning and tracking of waste transport vehicles, market platforms, and monitoring of landfill sites and dumping grounds through drones.

ICT have been utilized by many cities to bring efficiency to various stages of solid waste management, like collection and transportation. Many cities have implemented smart bins and GIS-based systems under the Smart Cities Mission. Kabadiwalla Connect and ExtraCarbon are some of the Indian start-ups that have created a solution focusing on informal waste pickers with the help of AI and digital technologies.

Source: <https://www.esri.in>, <https://blogs.iadb.org/> and other websites

Table 6: Advisories and Reference Resources Issued Under SBM 2.0

Advisories	On-Site and Decentralized Composting of Municipal Organic Waste. Advisory on Material Recovery Facility (MRF) for Municipal Solid Waste. SBM Advisory on Landfill Reclamation.
Ready Reckoner documents	C&D Waste Ready Reckoner. Waste to Wealth: ready reckoner for selection of technologies for management of municipal waste.
Tool-kits	Preparing City Solid Waste Action Plan- Managing biodegradable waste. Preparing City Solid Waste Action Plan - Managing non-biodegradable waste. Tool-kit on Legacy Waste Management and Dumpsite.
Guidelines and Guidance documents	Guidelines on Usage of RDF in various industries. Guidance on Efficient Collection and Transportation of Municipal Solid Waste. Bulk waste generators: a Step-by-Step Guidance for Urban Local Bodies to implement the Solid Waste Management Rules, 2016. Biodegradable Waste Management at home: A Guidebook.
Model frameworks	Model framework for source segregation.
Compendiums	Waste-Wise Cities: Compendium of Best Practices in Municipal Solid Waste in India. Plastic recycling decoded. Towards Lakshya Zero Dumpsite: Collection of Case Studies.
Standard Operating Procedures (SOPs)	SOPs on Swachh Neighbourhood, Clubs, Hospitals, Offices, Parks, Railway Stations, Roads, RWAs, Schools, Volunteering.
Other resources	Plastic waste management in India: Issues, Solutions & Case Studies. Sanitary waste management - challenges and agenda.

Source: <https://sbmurban.org/technical-advisories>, accessed on 12.04.2024

Financing of solid waste management services in India is mainly through the central government's funding (through SBM 2.0), the state government's and ULB's funds, the private sector, and public-private partnerships.

4.2 Session 1.2 (Technical Session 2): Solid Waste Management Concepts and Challenges in the Existing Solid Waste Management System

Session objective: to develop an understanding of the concepts and guiding principles in solid waste management along with an appreciation of status, Issues and challenges

Duration: 90 minutes (1.5 hours)

Topics covered, duration and method:

S. No.	Items/ topics	Duration	Method
1	<ul style="list-style-type: none"> - Important concepts and guiding principles in solid waste management (circular economy, zero waste, EPR etc.) - Issues and challenges in SWM service delivery in India 	60 minutes	PowerPoint Presentation Guest lectures Case studies
2	- Activity on tracing the flow of solid waste in the city. Participants will be engaged in a drawing activity in groups	30 minutes	Reflections Drawing activity in group

Circular Economy Concept

Materials in a circular economy are reused, in contrast to materials in a linear economy, where waste is created after the use of materials. A circular economy aims to reduce pollution and waste, circulate materials, and regenerate nature, whereas in a linear economy, a higher quantity of waste is generated due to the unsustainable use of fresh resources²². The circular economy is considered to be one of the key elements in achieving sustainable development goals (SDGs). A report by Accenture has suggested circular economy business models in the form of circular supply chains, recovery and recycling, potential life extension, sharing platforms, and product as a service. It has estimated the economic potential of the circular economy in India at approximately half a trillion dollars by 2030²³.

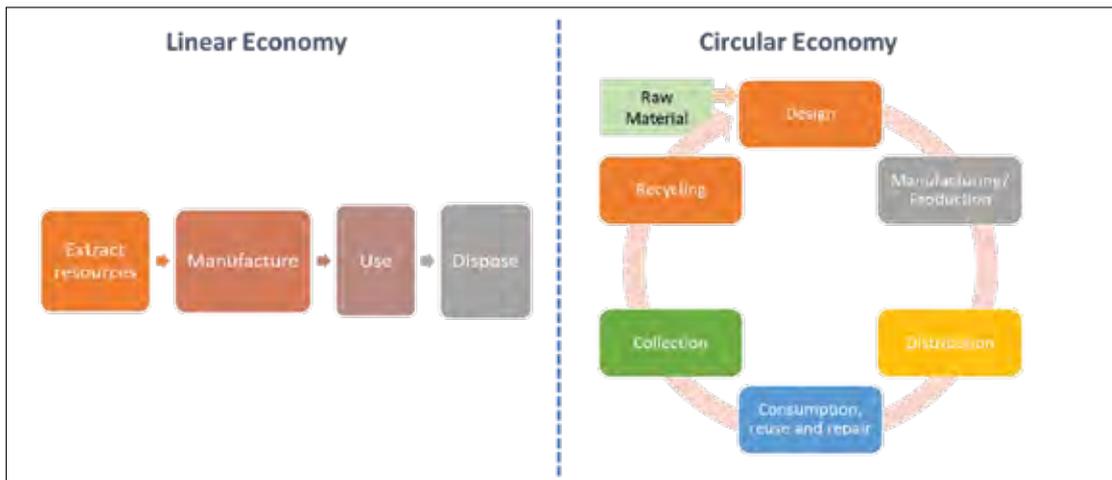


Figure 6: Linear Economy and Circular Economy

Source: Presentation by NITI Aayog on 'India's Mission Circular Economy' dated 09.02.2023, Slide 6

Circular Economy in Solid Waste

There is a great opportunity for resource recovery from three types of solid waste, namely dry waste, wet (organic) waste, and construction and demolition waste, using the principles of circular economy.

Table 7: Circular Economy in Solid Waste: Key Potential Areas

Waste type and contents	Economic Potential	Key potential areas
Dry Waste - plastic, paper, cardboard, glass & ceramic, metals, textiles, tyres & rubber etc.	Rs. 11,836 crores per annum	- MRF facilities can generate employment - Important role in mitigation of GHG emissions - Rapid implementation of existing EPR rules and provisioning for other dry waste types
Wet Waste - biodegradable waste covering food waste, fruits, vegetables flowers, garden waste etc.	Rs. 2,044 crores per annum	- Use of bio-methanation which is more profitable than composting - Creating market for end product
Construction and demolition waste - concrete, soil, steel, wood, plastics, bricks and mortar etc.	Rs. 416 crores per annum	- Reduction in virgin construction material - Reducing waste and cost reduction in construction

Source: Compiled from- Ministry of Housing and Urban Affairs (2021), 'Circular Economy in Municipal Solid and Liquid Waste'

Policy provisions and challenges pertaining to Plastic waste and C&D waste have been discussed in a greater depth in the next technical session.

Integrated Solid Waste Management (ISWM) is closely linked to the 3R approach (reduce, reuse, and recycle). It suggests the most preferred and least preferred practices for the management of solid waste. As depicted in Figure 7, source reduction and reuse are the most preferred practices, whereas landfilling is the least preferred. Recycling, composting, and converting waste to energy are the other preferred options in the order of preference²⁴.

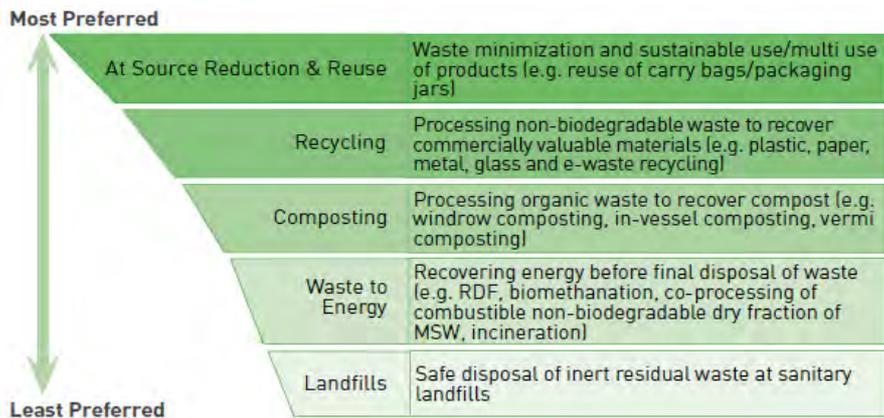


Figure 7: Integrated Solid Waste Management (ISWM) Hierarchy

Source: CPHEEO (2016), 'Manual on Municipal Solid Waste Management' Part II, Page 209

5-R concept focuses on five aspects of refuse, reduce, reuse, repurpose and recycle. Refuse indicates saying no to single-use plastics, leaving unnecessary packaging at stores while repurposing aims transforming an old article for a new use using upcycling²⁵. **Zero-waste** is a concept and approach in the direction of sustainable waste management. As defined by the Zero Waste International Alliance (ZWIA), it is “the conservation of all resources by means of responsible production, consumption, reuse, and recovery of products, packaging, and materials without burning and with no discharges to land, water, or air that threaten the environment or human health.” The zero-waste approach targets to transform the whole economic system so that no waste is incinerated, sent to landfills, or disposed of in the oceans by using a more circular approach to the way resources are manufactured, used, and disposed of²⁶. In a circular economy, materials are collected and reused instead of generating waste after use in a linear economy²⁷.

Extended Producer Responsibility (EPR)

CPHEEO’s manual defines Extended Producer Responsibility (EPR) as a “policy approach wherein a producer is held responsible for the post-consumer stage of a product, typically for defined tasks of separate collection (e.g., for e-waste or hazardous waste components), reuse (e.g., disposal-refund systems for bottles), recycling (e.g., for used cars), and storage and treatment (e.g., for batteries)”²⁸. In India, EPR has been made mandatory for waste types like plastic packaging, e-waste, and battery waste through the rules pertaining to these specific waste types.

Issues and Challenges in Solid Waste Management

Issues and challenges in solid waste management under its key stages of management (refer Figure 5) are mentioned below:

Generation, Segregation and Primary Collection: As per CPCB’s annual report²⁹, a marginal decrease has been observed in per capita solid waste generation over the last six years. Only two states, or UTs—Chhattisgarh and Andaman and Nicobar—have been reported to practice 100% segregation of waste. Lack of efforts for waste reduction and segregation at source remain major hurdles in the effective processing and treatment of solid waste.

Secondary Collection and Transportation: In many smaller towns and villages, solid waste is transported in uncovered vehicles or trollies, which causes littering. In the absence of decentralized waste processing facilities, many cities spend a significant amount on transportation.

Processing and treatment: As per CPCB’s annual report in 2021, the percentage of total solid waste processed was 49.9 percent, which indicates a huge gap in processing. However, the percentage of processing has increased from 19 percent in 2015-16 to 49.96 percent in 2020-21³⁰.

Disposal/End Use: In the absence of scientific landfill facilities, in most of the cities and villages, solid waste is being dumped in open dumping sites. Out of a total of 3,184 dumpsites, only 234 have been reclaimed, and 8 sites have been converted to landfill sites³¹. It is estimated that more than 10,000 hectares of urban land are locked in these dumpsites in India. Open dumping of mixed-waste is directly associated with many severe environmental impacts. Due to anaerobic decomposition, methane and other landfill gases are continuously generated. Such gases contribute to global warming and air pollution. Dumpsites often witness fires causing the release of hazardous gases as a result of the burning of mixed waste, including plastic, rubber, etc. Leachate produced mainly due to the decomposition of waste causes pollution of groundwater³².

Human resource, gender and livelihood issues: Many cities and towns face issues related to sanitation workers exposed to hazardous waste and not equipped with proper protective gear. Informal waste pickers (rag pickers) often collect recyclable waste from mixed waste dumps in unsafe conditions. It has been reported that informal waste pickers include a significant number of women working in unhealthy and hazardous situations. In many Indian cities, women form a major frontline workforce for the collection of solid waste as sanitation workers, whose working conditions are a matter of concern³³.

Financial issues: Service level benchmarks for solid waste management suggest efficiency in collection of SWM Charges as 90%³⁴. However, several local bodies struggle to collect user charges for the collection and processing of solid waste.

Box 5: Good Practices for Addressing Livelihood and Gender Issues in Solid Waste Management in India

Under the Advance Locality Management (ALM) Program of the Municipal Corporation of Greater Mumbai, initiated in 1997, co-operatives of women waste pickers, supported by an NGO, Stree Mukti Sanghatna, undertook waste management work in housing complexes and campuses, etc. The Solid Waste Collection and Handling (SWaCH) program in Pune city grew out of an informal waste pickers union run by women. With approximately 3,500 members, it handles 70,000 tonnes of recyclable waste annually, providing its members with steady sources of income. Some of the other initiatives include reCharkha’s work on plastic waste recycling at Dadra Nagar Haveli, Hasiru Dala’s work at Bengaluru, and Haritha Karmasena in Kerala.

Source: 1) National Institute of Urban Affairs (2015), 'Compendium of Good Practices: Urban Solid Waste Management in Indian Cities', Page 23- 29. and 2) Ministry of Housing and Urban Affairs (2023), 'Women-Led Sanitation Stories of Change', Page 11, 13, 18 and 19

**Activity 1: Activity on Tracing the Flow of Solid Waste in the City:
What Happens to the Waste Generated**

Activity objective	To develop an appreciation of the current status of the management of various types of solid waste in the city by attempting to answer the question, what happens to the solid waste generated in the city?
Time Duration	30 mins
Mode	Drawing on sheets, discussions, reflections
Material Requirements	<ol style="list-style-type: none"> 1. Printed sheets (A0 or A1 size) showing waste types and the corresponding desired and undesired disposal options 2. PowerPoint slides for briefing (1- 2 slides) 3. Bold markers/ Sketch pens of red and green colour (30- 40 nos, one of each colour marker for two participants)
Step-wise process	<ol style="list-style-type: none"> 1. The facilitator briefs about the activity, divides the participants into 3-5 groups based on their respective cities/districts, followed by the distribution of 1 printed sheet to each group. (5 mins) 2. Drawing activity in group (20 mins) Each group to discuss and show desired and undesired practices prevailing in the city by marking red and green lines The facilitator goes around to facilitate drawing 3. Briefing through PowerPoint slides (5 mins)

4.3 Session 1.3 (Technical Session 3): Dealing with the Specific Waste Types (Construction and demolition waste, plastic waste, biomedical waste, hazardous waste, sanitary waste and e-waste)

Session objective: to develop a deeper understanding of the waste types, which are relatively critical from a disaster perspective in terms of higher generation, processing complexities, and hazard potential.

Duration: 90 minutes (1 hour 30 minutes)

Topics covered, duration and method:

S. No.	Items/ topics	Duration	Method
1	<ul style="list-style-type: none"> - Construction and demolition waste: existing scenario, issues and good practices - Plastic waste management: existing scenario, issues and good practices - Biomedical waste, hazardous waste and sanitary waste: existing scenario and issues 	90 minutes	PowerPoint Presentation Special lectures

Construction and Demolition (C&D) Waste

Construction and Demolition (C&D) Waste Management Rules 2016 define C&D waste as “any waste comprising building materials, debris, and rubble resulting from the construction, remodelling, repair, and demolition of any civil structure is classified as C&D waste”³⁵. In 2001, a study by the Technology Information, Forecasting, and Assessment Council (TIFAC) reported the estimated generation of approximately 12–15 million metric tonnes per year in India. According to a report by BPMTTC, the average annual generation of C&D waste was estimated to be in the range of 100 million metric tonnes³⁶. The composition of C&D waste varies as per the construction methods and materials used in construction in each region. For plain areas of northern India, the major constituents of C&D waste are soil, sand, and gravel (26%), bricks and masonry (32%), and concrete (28%). Other constituents include metal (6%), wood (3%), and others (5%)³⁷. As per a report by Godrej Properties, for every one million square feet of residential building construction, approximately 3,648 metric tonnes of construction waste are generated³⁸.

Box 6: Case Study on Construction and Demolition Waste Processing plant at Burari, Delhi

North Delhi Municipal Corporation, along with IL&FS, set up a C&D waste processing plant in 2019 with a 500 TPD capacity, which was expanded to 2,000 TPD. At the plant, the waste is segregated as per size, and unrecyclable materials like plastic and wood are sent to the W-T-E plant in Okhla. The products of the plant include ready-mix concrete, kerb stones, cement bricks, pavement blocks, hollow bricks, and manufactured sand.

Source: MoHUA (2017), 'Waste to Wealth', Page 73

Issues with C&D Waste Management: Some of the major issues associated with C&D waste are described below:

Absence of segregation of C&D waste poses a major risk of contamination of municipal waste, as C&D waste contains substantial hazardous substances like paints and asbestos sheets.

Open dumping of C&D waste may pollute land as well as groundwater due to the leachate generated.

It occupies large areas in dumping grounds and landfills, resulting in reduced space for municipal waste.

It may lead to damage to ecosystems and water bodies if disposed of in waste bodies.

- C&D waste disposed of on or along the road causes traffic and mobility obstructions.
- C&D waste is one of the causes of air pollution.
- It may cause flooding, as C&D waste disposed of in storm water drains blocks the flow of water.³⁹
- Inadequate capacity of C&D waste processing plants.⁴⁰

Regulatory and Programmatic Provisions for C&D Waste:

- SWM Rules 2016 state that separate storage of construction and demolition waste, as and when generated, is the responsibility of the waste generator.
- Construction and Demolition Waste Management Rules, 2016 were notified on March 29, 2016.
- Key stakeholders in these rules are waste generators, service providers (authorities that provide services like water, sewerage, electricity, telephone, roads, drainage, etc.), urban local authorities, MoHUA, MoEF & CC, MoRD, MoPR, the Bureau of Indian Standards, and the Indian Roads Congress.
- These rules define the responsibilities of generators as to segregate the C&D waste into concrete, soil, and other parts, ensure no mixing with other wastes, and store it within his premises.
- Generators of 20 tons of C&D waste or more in one day or 300 tons per project in a month are required to segregate the waste into four types: concrete, soil, steel, wood, plastics, bricks, and mortar.
- They are also required to submit a waste management plan and get appropriate approvals from the local authority⁴¹.

Plastic Waste

Plastic has become a major item in our day-to-day lives. It's multiple usages as packaging, building and furnishing material, wrappers, carry bags, bottles, appliances, etc. have made it an extensively used material. The annual global production of plastic is estimated to be over 150 million metric tons per year⁴². Plastic waste is defined as any plastic discarded after use or after its intended use is over.

“plastic” means material that contains as an essential ingredient a high polymer such as polyethylene terephthalate, high-density polyethylene, vinyl, low-density polyethylene, polypropylene, polystyrene resins, and multi-materials like acrylonitrile butadiene styrene, polyphenylene oxide, polycarbonate, and polybutylene terephthalate⁴³. As per a MoHUA report, plastic waste generated in 2017–18 was 9.4 million metric tons per year, which is equivalent to around 26,000 tons per day⁴⁴.

Issues in Plastic Waste and its Management

- The generation of plastic waste is increasing at a very rapid pace. As per the CPCB report, per capita plastic waste generation has increased almost 2.5 times over the last five years (from 2015-16 to 2020-21)⁴⁵.
- About half of the plastic in India is discarded as waste after a single use. This is a major cause of plastic waste generation and also leads to an increase in demand for products made of virgin plastic⁴⁶.
- The burning of plastic waste causes the emission of extremely harmful chemicals, which are associated with many health hazards like cancer, immune deficiency, neurological damage, birth defects, asthma, and child growth disorders, etc.
- Plastic waste dumped inappropriately breaks down slowly into smaller pieces into microplastics, polluting soil and water sources, including groundwater. Plastic waste is one of the biggest threats to the marine ecosystem. It is estimated that by 2050, there will be more plastic waste than fish in the oceans⁴⁷.
- Poor management of plastic waste is often cited as one of the causes of urban flooding, as it causes the blocking of drains.
- There is a lack of recycling of plastic. It is estimated that 60% of plastic is recycled, but it is mostly done by the informal sector. Recyclable plastic waste is often found to be mixed with other food or wet waste, making it unsuitable for recycling⁴⁸.
- Some issues in achieving a circular economy of plastic waste include a lack of comprehensive methods for plastic waste management, limited collection and recycling of single-use plastic, and the use of unscientific methods of recycling by the informal sector⁴⁹.

Box 7: Managing Single Use Plastic (SUP) in India

India banned single-use plastic items through an MoEFCC notification with effect from July 1, 2022. Nonetheless, a number of issues, such as the widespread usage of prohibited single-use plastic products, an undeveloped market for plastic substitutes, a lack of enforcement and awareness, etc., continue to be causes for concern. Some of the suggested pathways for effectively managing SUP include enforcement of the law, mandatory public disclosure of environmental compensations and penal actions, banning carry bags of all thicknesses, and investing in the SUP alternative market.

Source: <https://www.downtoearth.org.in/news/india/how-bad-is-india-s-single-use-plastic-crisis--94667>

Regulatory and Programmatic Provisions for Plastic Waste

The Plastic Waste Management Rules, 2016, came into force on March 18, 2016. These rules have been amended in 2018, 2021, 2022 and 2024. The Plastic Waste Management Rules of 2016 are applicable to all waste generators, urban local bodies, gram panchayats, producers, importers, and brand owners. Key authorities related to these rules are the central pollution control board (CPCB) and state pollution control boards. The development and setting up of infrastructure for the management of plastic waste and framing bye-laws are the responsibility of the local bodies.

Primary responsibility for the collection of used multi-layered plastic sachets, pouches, or packaging lies with *producers, importers, and brand owners*. They are also responsible for establishing a system for collecting back the plastic waste generated by their products⁵⁰.

Guidelines on extended producer responsibility (EPR) were introduced through the Plastic Waste Management (Amendment) Rules 2022. These guidelines are applicable to producers, importers, brand owners, recyclers, and waste processors. As per the regulations, producers, importers, brand owners, and plastic waste processors shall register on the centralized portal of the CPCB. EPR targets and obligations for recycling, end-of-life disposal, and use of recycled plastic content are defined for producers, importers, and brand owners⁵¹.

Bio-Medical Waste

'Bio-medical waste' is defined as any waste that is generated during the diagnosis, treatment, or immunization of human beings or animals, or research activities pertaining thereto, or in the production or testing of biological or health camps, including the categories mentioned in Schedule I to the Bio-medical Waste Management Rules, 2016⁵².

As per the CPCB's report, the total quantum of bio-medical waste generation was 774 tons per day in 2020. 15% of the total bio-medical waste was generated due to COVID 19. Over 91 percent of the bio-medical waste was treated and disposed of safely by common bio-medical waste treatment facilities (CBWTFs) and captive treatment facilities⁵³.

The key stakeholders in the Bio-medical Waste Management Rules, 2016 are MoEF, State Pollution Control Boards and Committees, urban local bodies, and gram panchayats, the central and state Ministry of Health and Family Welfare, the central and state ministries for animal husbandry and veterinary, etc. As per the rules, the state's department is responsible for providing a suitable site for the

Box 8: Good Practices for Plastic Waste Management in India

Bhopal Municipal Corporation has streamlined the collection and sale of plastic waste to recyclers with the help of local organizations. This practice has been replicated in many other cities. In Surat city, Ecovision operates nine MRFs and handles 65 to 70 MT of plastic waste daily. It is working with 400 waste pickers and ensuring linkages to social protection schemes. In Panaji, the ULB has collaborated with recycling companies and the UNDP to connect with bulk waste generators and introduced a buy-back mechanism for dry waste to provide incentives for practicing 16-way segregation.

Source: NITI Aayog and UNDP (2021), 'NITI Aayog – UNDP handbook on sustainable urban plastic waste management', Page 16- 24

establishment of a common bio-medical waste treatment and disposal facility. Major duties of the occupiers cover proper storage, pre-treatment of specific wastes, training of the staff, etc., while the operator of a common bio-medical waste treatment and disposal facility is required to ensure that the collected bio-medical waste is transported, handled, stored, treated, and disposed of⁵⁴.

Box 9: Good Practices in Management of Hazardous Waste: Collection of Hazardous Waste in Nuremberg, Germany

Nuremberg municipality has set up a mobile collection facility for the collection of hazardous waste from households, which is available free of charge. The facility is spread throughout the city's six Material Recovery Facilities (MRF) in regular one-week rotations. The municipality prepared a communication brochure covering key features of the facility, like the type of hazardous waste to be brought to the mobile facility and to be brought to the MRFs, guidance on reducing waste generation, a schedule for the mobile facility, etc.

Source: GIZ (2016), 'Basic Training on Municipal Solid Waste Management for Urban Local Bodies', Page 121

Hazardous Waste

SWM Rules 2016 define "domestic hazardous waste" as discarded paint drums, pesticide cans, CFL bulbs, tube lights, expired medicines, broken mercury thermometers, used batteries, used needles and syringes, contaminated gauges, etc., generated at the household level. As per the rules, it is the responsibility of the waste generator to keep it in a segregated manner and hand it over to the authorized waste collector or agency. Establishing waste deposition centers and ensuring safe storage and transportation for domestic hazardous waste is the responsibility of local authorities and gram panchayats⁵⁵.

"Hazardous waste" is defined as any waste that, by reason of characteristics such as physical, chemical, biological, reactive, toxic, flammable, explosive, or corrosive, causes danger or is likely to cause danger to health or the environment. As per the 'Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016', the key stakeholders for hazardous waste include the occupiers, hazardous waste generators, the state's department of industry, CPCB, SPCBs, MOEF, importers and exporters, recyclers, pre-processors, co-processors, users, the Directorate General of Foreign Trade, and port authorities⁵⁶. As per the CPCB's annual report, during 2017–18, total hazardous waste generated was 9.44 million metric tonnes. There are 66,914 hazardous waste-generating industries in India⁵⁷.

Sanitary Waste

Proper management of sanitary waste, including sanitary napkins and towels, is crucial in order to achieve a gender-responsive solid waste management system. As per the SWM Rules 2016, waste generators are required to segregate it at source, wrap it securely, and keep it in the dry waste bin for collection. Local bodies are mandated to create awareness about the segregation and wrapping of sanitary waste for its proper management. CPCB's guideline on sanitary waste has identified throwing them unwrapped or wrapped into fields, outside rooftops, etc. as a common unsafe practice. Small-scale incinerators (community or school level) and burning in health clinics or municipal waste management systems are the safe treatment and disposal options for sanitary waste⁵⁸. The

Box 10: Strategic Options for Improving the Management of Sanitary Waste

A report by the Centre for Science and Environment (CSE) has identified ways for improvement in sanitary waste management. Below are the highlights:

- Comprehensive assessment of sanitary waste generated and dash boards for monitoring. A separate EPR portal for sanitary product brand owners and manufacturers.
- Existing rules and guidelines need to be strengthened, incorporating them into ULB's by-laws. The terminology and the respective broad category of solid waste need to be clearly defined.
- Redesign and augment sanitary waste management facilities.
- Information, education, and communication should be strengthened. The roles of all stakeholders should be defined, and all stakeholders should be engaged effectively.

Source: Atin Biswas and Shailshree Tewari, 2022, Sanitary Waste Management in India: Challenges and Agenda, Centre for Science and Environment, New Delhi, Page 44-52

incinerators are required to comply with the emission standards.

E-Waste

'E-waste' is defined as electrical and electronic equipment, including solar photo-voltaic modules, panels, or cells, whole or in part discarded as waste, as well as rejects from manufacturing, refurbishment, and repair processes⁵⁹. As per a MeitY report, e-waste generation in India was about 3.2 million metric tons in 2019, making India the third-highest e-waste-generating country. Out of the total generation, only 10 percent of the e-waste is collected. The collection and management of e-waste is a key challenge for authorities and stakeholders⁶⁰.

Generally, e-waste consists of various metals, plastics, cables, cathode ray tubes, printed circuit boards, etc. Many heavy metals and toxic substances, such as mercury, lead, beryllium, and cadmium, may be present in e-waste that pose a risk to the environment and health. If the e-waste is scientifically processed, valuable metals like copper, silver, gold, and platinum can be recovered⁶¹.

E-waste management rules 2022 define the roles and responsibilities of various stakeholders. These rules were amended in 2023 and 2024. These rules are applicable to manufacturers, producers, refurbishers, dismantlers, and recyclers of e-waste or electrical and electronic equipment. Major government agencies involved are CPCB, the Department of Industry, and the Department of Labor of the state's or UT's. The rules define the responsibilities of manufacturers, producers, and refurbishers under the EPR Framework.

5. Sub-Module 2

Understanding Disaster Management and Disaster Waste

Sub-module objective: To develop an understanding of hazards, vulnerabilities, disaster management scenarios in India, and solid waste generated in disaster situations.

5.1 Session 2.1 (Technical Session 4): Disaster Management and Disaster Risk Resilience

Session objective: to develop an understanding of hazards, risks, vulnerabilities, climate change, and disaster management with their dimensions, stages, and institutional frameworks.

Duration: 90 minutes (1.5 hours)

Topics covered, duration and method:

S. No.	Items/ topics	Duration	Method
1	<ul style="list-style-type: none"> - Defining disaster and disaster management - Disasters, Climate Change, and Disaster Risk Resilience - Disaster Management and Gender - Vulnerability profile of India - Global policy framework and Institutional framework in India - Stages of Disaster Management 	70 minutes	PowerPoint Presentation Special lecture
2	Activity on disaster risk reduction measures: listing of key areas related to disaster risk reduction in the respective cities of the participants	20 minutes	Reflection writing activity Briefing through PowerPoint slide

Defining Disaster

The Cambridge dictionary defines disaster as '(an event that results in) *great harm, damage, or death, or serious difficulty*'⁶². The Disaster Management Act 2015 gives a comprehensive definition: "disaster" means a catastrophe, mishap, calamity, or grave occurrence in any area, arising from *natural or man-made causes, or by accident or negligence*, which results in substantial loss of life or human suffering or damage to, and destruction of, property, or damage to, or degradation of, the environment, and is of such a nature or magnitude as to be beyond the coping capacity of the community of the affected area⁶³. This definition highlights the types of causes, the impacts, and their seriousness. The definition given by UNDRR is: 'A serious disruption of the functioning of a community or a society at any scale due to hazardous events *interacting with conditions of exposure, vulnerability, and capacity*, leading to one or more of the following: human, material, economic, and environmental losses and impacts'⁶⁴. The UNDRR's definition points out aspects like exposure, vulnerability, and capacity.



Figure 8: Risk, Hazard, Exposure and Vulnerability

Source: Prepared using information from <https://www.preventionweb.net/understanding-disaster-risk/component-risk/disaster-risk>

As illustrated in Figure 8, **disaster risk** is a product of the hazard (frequency and severity), the people, assets, and resources exposed to it, and their level of vulnerability. A **hazard** is a phenomenon, process, or activity that can cause damage or disruption to health, the economy, or the environment. **Exposure** indicates the situation of settlements, facilities, economic activities, and environmental features located in hazard-prone areas. **Vulnerability** indicates the susceptibility of an individual, a community, or facilities and assets to the impacts of hazards, which depends upon a number of factors like social, economic, cultural, physical, and environmental⁶⁵.

As per the Disaster Management Act 2015, “disaster management” means a *continuous and integrated process of planning, organizing, coordinating, and implementing* measures that are necessary or expedient for—(i) *prevention* of danger or threat of any disaster; (ii) *mitigation* or reduction of risk of any disaster or its severity or consequences; (iii) *capacity-building*; (iv) *preparedness* to deal with any disaster; (v) prompt response to any threatening disaster situation or disaster; (vi) assessing the severity or magnitude of effects of any disaster; (vii) *evacuation, rescue, and relief*; (viii) *rehabilitation and reconstruction*⁶⁶.

Disasters, Climate Change, and Disaster Risk Resilience

Many studies across the globe have shown that with climate change, the risk of disasters is increasing. As per the UNDRR, climate change can alter the frequency and impacts of disasters and increase their vulnerability and exposure. Though the impact of climate change on disaster risk is not certain, it is projected that it can impact droughts, sea level rise, infectious diseases, wildfires, and cyclones⁶⁷.

UNDRR has defined resilience as “the ability of a system or a community to resist, absorb, accommodate, adapt to, transform, and recover from the effects of a hazard in a timely and efficient manner”. Disaster risk resilience targets preventing the risk of new disasters and reducing the risk of existing disasters to achieve and strengthen resilience⁶⁸.

Disaster Management and Gender

The impacts of disasters vary for different socio-demographic classes and genders. These

differentiations can worsen the already prevailing gender inequality linked to various socio-cultural factors. The disproportionate impacts on women may be in various forms like reduced life expectancy, livelihood and asset losses, re-entry to occupation, exposure to gender based violence triggered in emergency situations. Disasters may impact boys and girls differently. The financial distress caused by the disaster, may lead to withdraw of girls from school and early marriage while boys may be pushed to labour force depriving them from schooling⁶⁹. Some of the interventions to tackle gender specific impacts include communicate with affected women and men, boys and girls, using participatory methods, ensuring the physical security and integrity of women and men, integrating gender equality into the recovery framework and protecting the livelihoods of women⁷⁰.

Taking into account the differential needs of different genders, boys and girls, in the planning and implementation of interventions under different disaster management phases like preparedness, response, recovery, and mitigation is crucial to building disaster risk resilience.

Vulnerability Profile of India

India is vulnerable to many disasters, which can be classified into five main categories. The below table gives a list of 31 disaster types identified by the high-powered committee on disaster management (tsunami was added later).

Table 8: List of Disaster Types in India

Water and Climate related disasters	1) Floods and drainage management, 2) Cyclones, 3) Tornadoes and Hurricanes, 4) Hailstorms, 5) Cloud burst, 6) Heat wave and Cold wave, 7) Snow avalanches, 8) Droughts, 9) Sea erosion, 10) Thunder and lighting, 11) Tsunami
Geological related disasters	12) Landslides and mudflows, 13) Earthquakes, 14) Dam failure/Dam bursts, 15) Mine disasters
Chemical, industrial and nuclear related disasters	16) Chemical and industrial disasters, 17) Nuclear disasters
Accident-related disasters	18) Forest fires, 19) Urban fires, 20) Mine flooding, 21) Oil spills, 22) Major building collapse, 23) Serial bomb blasts, 24) Festival related disasters, 25) Electrical disasters and fires, 26) Air, road and rail accidents, 27) Boat Capsizing, 28) Village fire
Biological related disasters	29) Biological disasters and epidemics, 30) Pest attacks, 31) Cattle epidemics, 32) Food poisoning

Source: NIDM (2014), 'Country Profile of India', Page 7-8

Below is a glimpse of key facts about India's vulnerabilities as described in the National Policy on Disaster Management (NPDMD).

- 59 percent of the landmass is prone to earthquakes of moderate to very high intensity.
- Over 40 million hectares (12 percent of land) are prone to floods and river erosion.
- Close to 5,700 km of coastline (76 percent) is prone to cyclones and tsunamis.
- 68 percent of the cultivable area is vulnerable to drought.
- Hilly areas are at risk from landslides and avalanches⁷¹.

The Sendai Framework, adopted at the 2015 Third UN World Conference on Disaster Risk Reduction in Sendai, Japan, aims to reduce disaster risk and its impacts and recognizes the shared responsibilities of the state, local governments, private sector, and other stakeholders. Four priorities defined under this framework include understanding disaster risk, strengthening disaster risk governance to manage disaster risk, investing in disaster risk reduction, and enhancing disaster preparedness for effective response. The Sendai Framework has synergy with the Paris Agreement on Climate Change and the Sustainable Development Goals⁷². The Paris Agreement, adopted in 2015, is an international treaty aiming to hold the rise in global average temperature to well below 2°C above pre-industrial levels and continue the efforts to limit the rise to 1.5°C⁷³.

The Prime Minister's 10-point agenda for disaster risk reduction emphasizes using principles of disaster risk management, risk coverage for all, the leadership of women, global risk mapping, leveraging technology, building local capacity, and bringing greater cohesion to international response⁷⁴.

The Disaster Management Act 2005 was notified on December 23, 2005. This Act provides a governance framework at the central, state, and district levels in the form of the National Disaster Management Authority, the State Disaster Management Authority, and the District National Disaster Management Authority and fixes the responsibilities of each stakeholder. The preparation of disaster management plans is provisioned under the Act⁷⁵.

The National Disaster Response Force (NDRF), the National Response Fund, the National Disaster Mitigation Fund, and the National Institute of Disaster Management (NIDM) are other key institutions for disaster management in India. A national policy on disaster management was launched in 2009. The Disaster Management Act 2005 also provides provisions for the establishment of funds by state governments. In addition, there is a provision for the allocation of funds by ministries and departments. The Fifteenth Finance Commission has recommended a fund allocation methodology and funding structure⁷⁶.

Disaster management typically involves three key stages: pre – disaster, during disaster and post-disaster. Major operational and administrative activities include: Prevention, Mitigation, Preparedness, Response, Recovery and Rehabilitation⁷⁷.

Activity 2: Activity on Disaster Risk Reduction Measures

Activity objective	To develop an understanding of disaster risk reduction measures
Time Duration	20 mins
Mode	Writing on the given sheet, discussions, and reflections
Material / Venue Requirements	<ol style="list-style-type: none"> 1. Post-it- 1 or 2 packets (around 50 stickers) 2. Pens or pencils- 30- 40 no. (one for each participant)
Step-wise process	<ol style="list-style-type: none"> 1. The facilitator gives a brief introduction of the activity (5 minutes). 2. Each participant writes one or two key areas related to disaster risk reduction in his or her city on Post-it and hands it over to the facilitator (10 minutes) 3. The facilitator reads out the post-its and summaries (5 minutes).

5.2 Session 2.2 (Technical Session 5): Post Disaster Solid Waste Situation: Hazard- Wise Waste Characteristics and Quantities

Session objective: to develop an understanding of the generation of solid waste during and after a disaster with its magnitude and characteristics.

Duration: 120 minutes (2 hours)

Topics covered, duration and method:

S. No.	Items/ topics	Duration	Method
1	-What happens when disaster strikes: glimpses from past disasters	20 minutes	PowerPoint Presentation Slide show of photographs Video screening
2	-Characteristics of waste pertaining to various types of disasters -Quantities of waste generated from previous disasters, drivers of high waste generation	60 minutes	PowerPoint Presentation Case study Special lecture
3	Group activity on type of waste generated post different disasters through card matching game in groups	40 minutes	Card based game Briefing through PowerPoint slides

Disasters and Solid Waste Dynamics

Different types of disasters lead to numerous devastating activities, due to which many structures, goods, articles, and natural features are converted into waste. Some of the phenomena during and after the disaster are described below:

- Dismantling, collapsing, or breaking of buildings -> mainly caused by earthquakes, landslides, fire, floods, cyclones, and tsunamis
- Breaking, collapsing, or destruction of infrastructure facilities -> mainly caused by earthquakes, landslides, fire, floods, cyclones, and

Box 11: Case Studies on the Generation of Solid Waste in Past Earthquakes in India

Approximately 109 lakh metric tonnes of debris that was cleared after the Bhuj (Gujarat) earthquake in 2001. For the process of debris removal, over 1,700 excavators, bulldozers, and 2,800 trucks were used (World Bank & ADB, 2001).

After the 2011 Sikkim earthquake, collapsed buildings and landslides generated the majority of the waste, which included mud, cement mortar, and flat or sloping roofs constructed of galvanized iron sheet, thatch, reinforced cement concrete, and reinforced brick concrete or wood (DMMC, 2012).

Source: Aggarwal, G., Ratnoo, R., Bindal, M.K., Raman, D. and Kumar, S. (2023). Solid Waste Management in Post-Disaster Situations, National Institute of Disaster Management, Delhi, Page 41-43

tsunamis

- Movement of harmful and undesired substances like carcasses and waste heaps - > mainly caused by floods, cyclones, and tsunamis
- Converting articles, goods, or natural features into dysfunctional or useless forms (including burning) - > mainly caused by fire, floods, cyclones, tsunami
- Displacing, uprooting, and blowing natural forms, biomass, and plants -> mainly caused by landslides, floods, cyclones, and tsunamis
- Disruption in the routine service delivery of basic services-> caused by all hazards
- Creation of temporary staying and boarding areas -> caused by most of the hazards
- Killing and hurting humans and animals -> caused by most of the hazards

Most of the above phenomena cause the generation of solid waste and disruptions in the routine provision of solid waste management services. The quantity and type of waste generated are also dependent on the stages of disaster management.

Table 9: Quantity and Type of Waste Generated Under Different Stages of Disaster Management

Types of solid waste generated	Additional Waste Types Generated in Disaster Situation (Disaster Waste)		
	During disaster Response	Post disaster	
		Recovery	Rehabilitation
<ul style="list-style-type: none"> • Household waste (organic, inorganic, sanitary and domestic hazardous waste) • Construction and Demolition waste • Electrical or electronic waste • Bio-medical waste • Hazardous waste • Industrial waste • Agriculture waste • Other waste 	<ul style="list-style-type: none"> • C&D waste (buildings and interiors) • Infrastructure and other and human- made structures/ installations • Plant (green) waste • Plastic waste • Other inorganic waste (packaging and left relief material) • Carcass • Silt and mud • Automobiles, other vehicles and boats • Containers, drums • Solid waste from relief camps (temporary) 	<ul style="list-style-type: none"> • Solid waste from relief camps (temporary) 	<ul style="list-style-type: none"> • Household waste from rehabilitation localities • Construction waste (C&D waste) from reconstruction sites

Source: Compiled from various sources

Characteristics of Waste Generated Due to Disasters

The composition and quantity of the waste generated in a disaster situation depend upon factors like:

- Type and magnitude of the disaster
- The area or part of the settlement affected
- The status of development in impacted areas
- Nature of the response⁷⁸

Waste generated during disaster situations possesses some specific characteristics that are different from those generated during peacetime. Firstly, it is extremely difficult to estimate, considering the unpredictable nature of disasters. Secondly, the amount generated is phenomenal. As per the Ministry of Environment, Japan guidelines, the amount of disaster waste can equal tens of years' worth of regular municipal waste⁷⁹. Thirdly, the waste generated is often mixed, which makes it difficult to collect, store, process, or treat. The nature and quantities of various types vary during different stages of the disaster cycle⁸⁰. Details of disaster-time waste from past disasters in Japan and its comparison with regular waste generation are given in Table 10.

Box 12: Case Studies on the Generation of Solid Waste in Past Floods in India

After the Kerala floods in August 2018, huge piles of plastic waste were spread across roads, bridges, and agricultural land. Tonnes of plastic waste were also washed into the Idukki Hydel reservoir, the Periyar river banks (Raman, 2018), and the Malayattoor-Kodanad bridge in Ernakulam (Jayarajan, 2018).

During the Srinagar, Jammu & Kashmir Floods (2014), as the flood waters receded, tons of garbage, silt, mud, and slurry, rotten food items, sewage waste, and collapsed buildings lay bare on roads and streets, blocking lanes and drains (Ashiq, 2014).

Source: Aggarwal, G., Ratnoo, R., Bindal, M.K., Raman, D. and Kumar, S. (2023). *Solid Waste Management in Post-Disaster Situations*, National Institute of Disaster Management, Delhi, Page .38-39, 44- 45

Table 10: Estimated Amount of Waste Generated During Various Disasters in the Past Globally

Disaster and year	City	Quantity of waste generated (Thousand ton)	Time (in years) required for generation of routine municipal waste of equivalent quantity
The Great East Japan Earthquake, 2011	Iwate Prefecture	4,233	56-79 years
	Miyagi Prefecture	11,530	3.7-95 years
	Sendai city	1,369	3.7 years
	Ishinomaki ward	5,265	95 years

Disaster and year	City	Quantity of waste generated (Thousand ton)	Time (in years) required for generation of routine municipal waste of equivalent quantity
Flood and land slide, 2014	Hiroshima	584	1.6 years
Flood, 2015	Joso	52	3 years

Source: Ministry of Environment, Japan (2018). DWM Guidelines for Asia and the Pacific. Page 5

The estimated waste generated due to some recent disasters in India is given in Table 11.

Table 11: Estimated Waste Generated Due to Some Recent Disasters in India

S. No.	Hazard Name and Place	Year	Approximate Quantity of waste generated
1	Srinagar floods	2014	37,275 metric tonnes
2	Kerala floods	2018	35,717 metric tonnes
3	COVID 19 pandemic	2020- 2021	45,954 tonnes (COVID waste)

Source: 1- Ashiq, P. (2014, October 13). Floods filled Srinagar with record garbage. Srinagar, Jammu & Kashmir, India. Hindustan Times; 2- Jacob, J. (2018, September 7) After the flood, Kerala battles mounds of waste piled up on streets. India Today; 3- Centre for Science & Environment India (2021, June 30) COVID-19 will place India's biomedical waste management under terrible strain⁸¹

Types of Solid Waste Generated During Different Disasters Types

The types of solid waste generated and their relative volumes during a disaster vary as per the type of disaster. It also varies depending on various factors like the severity of the disaster, locations, settlement's characteristics, demographic profile of the region, infrastructure facilities, land cover and land form, vegetation, rescue and recovery efforts, etc.

Table 12: Types of Solid Waste Generated During Different Disasters: Indicative Relative Volumes

Waste Type/ Hazard type	Earthquake	Flood	Cyclone	Fire	Pandemic
Damaged buildings and other structures					
- Construction and demolition inert waste (bricks, concrete, rubble, etc.)	High	Low to Medium	Low	Medium to High	-
- Asbestos-containing material	High	Low to Medium	Low	Medium to High	-
- Hard waste (including furniture, carpets, etc.)	Medium	Medium to High	Low to Medium	Medium	-
- Metal waste	Medium	Low	Medium	Medium	-
- Domestic hazardous waste	Low to Medium	Low to Medium	Low to Medium	Low to Medium	-

Waste Type/ Hazard type	Earthquake	Flood	Cyclone	Fire	Pandemic
- Mixed waste	High	Low to Medium	Low	Medium to High	-
- Electrical and electronics waste	Low to Medium	Medium to High	Low to Medium	Low to Medium	-
Green (vegetative) waste (fallen trees and/or other damaged vegetation)	Low	Medium to High	High	Low	-
Damaged and/or displaced vehicles	Low to Medium	Low to Medium	Low to Medium	Low to Medium	-
Displaced soil and sediment	Low to high	Medium to High	Low to Medium	Low	-
Spoiled perishable food (supermarkets, restaurants, and households)	Low to Medium	Low to Medium	Low to Medium	Low	-
Health care waste (including bio-medical waste)	Low to Medium	Low to Medium	Low to Medium	Low to Medium	High
Plastic waste (SUP, water bottles and packaging)	Low to Medium	Medium to High	Low to Medium	Low	-

Source: Compiled from 1) Government of South Australia (2021). *Disaster Waste Management Guidelines*, page 11 and 2) Ministry of Environment, Japan (2018). *DWM Guidelines for Asia and the Pacific*. page 6

Note: In addition to the above major type of disaster waste, there may be other types of waste like agriculture waste, empty chemical drums, industrial packaging, expired goods, ashes, etc., depending upon the locality impacted and the type and intensity of the hazard.

It is clear from the above table that composition and quantity vastly vary as per the type of hazard. The above waste types can be broadly characterized based on chemical and physical characteristics. The handling (collection, transportation, processing and disposal) should be prioritised based on its characteristics. Indicative processing or disposal options for each type of disaster waste is given in Table 13.

Box 13: A Case Study on Challenges Faced in the Management of Disaster Waste During Past Disasters in India

After the 2001 earthquake in Gujarat, a lack of readily available equipment like concrete breakers, gas cutters, and bulldozers and trained operators immediately after the disaster further delayed rescue and debris removal. Waste was removed earlier during the rescue and relief operations or was later left unattended to be dealt with by people or during the reconstruction phase. A lot of concrete and rubble waste was dumped on open grounds, road sides, lake sides, and river banks (Mishra, 2004)

Source: Aggarwal, G., Ratnoo, R., Bindal, M.K., Raman, D. and Kumar, S. (2023). *Solid Waste Management in Post-Disaster Situations*, National Institute of Disaster Management, Delhi, Page 42-43.

Table 13: Indicative Processing or Disposal Options for each Type of Disaster Waste

Primary Characterises	Waste Type	Indicative processing or disposal option
Biodegradable (organic)	<ul style="list-style-type: none"> • Fallen trees and/or other damaged vegetation • Spoiled perishable food (supermarkets, restaurants, and households)- partly 	Composting, Bio-methanation
Recyclable	<ul style="list-style-type: none"> • Construction and demolition waste (bricks, concrete, rubble, concrete pipes, damaged roads and bridges etc.)- partly • Hard waste (including furniture, carpets, etc.) • Metal waste (including steel beams, trusses, frames, roofs, metal pipes, poles etc) • Damaged and/or displaced vehicles – partly • Plastic waste (SUP, water bottles and packaging)- partly • Electronic waste and whitegoods (Computers, televisions, refrigerators etc.) 	Recycling by recycling companies/ plants
Combustible	<ul style="list-style-type: none"> • Hard waste (including furniture, carpets, etc.)- partly • Plastic waste (SUP, water bottles and packaging) partly 	Waste to energy plants, road construction, RDF etc
Inert	<ul style="list-style-type: none"> • Displaced soil and sediment • Construction and demolition waste (bricks, concrete, rubble, etc.)- partly 	Filing of low laying areas, road construction
Others	<ul style="list-style-type: none"> • Asbestos-containing material • Domestic hazardous waste • Mixed waste 	Specially designed Landfilling
	<ul style="list-style-type: none"> • Health care waste (including bio-medical waste) 	Incineration/ Specially designed Landfilling

Source: Compiled based on 'Government of South Australia (2021). 'Disaster Waste Management Guidelines'

Activity 3: Activity on Type and Magnitude of Waste Generated During Different Disasters

Activity objective	To develop an understanding of types and relative magnitude of waste generated during different disasters through an interactive game
Time Duration	40 mins
Mode	Card game, discussions, reflections
Material / Venue Requirements	1. Two sets of printed cards – one each of disaster types (type I) and disaster waste (type II). 8- 10 sets of each type, depending on the number of participants 2. PowerPoint slides for the briefing (1- 2 slides) 3. Tables (preferably round) for placing cards and seating arrangements in groups

Step-wise process	<ol style="list-style-type: none"> 1. The facilitator briefs about the activity, and divides the participants into groups, each with 3–4 members, followed by the distribution of 2 card sets (one of each type) to each group (10 mins) 2. Card matching activity in groups (25 mins) <ul style="list-style-type: none"> -Each group to discuss and match cards of type I set to cards of type II set, making matched groups of cards. - The facilitator goes around to facilitate matching cards 3. Briefing through PowerPoint slides (5 mins)
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5.3 Session 2.3 (Technical Session 6): Institutional and Governance Frameworks

Session objective: to develop an understanding of the institutional framework, governance systems, and stakeholders involved in the Indian context with an overview of international guidelines.

Duration: 110 minutes (1 hour 50 minutes)

Topics covered, duration and method:

S. No.	Items/ topics	Duration	Method
1	-Institutional framework for waste management during disasters in India and stakeholders - Brief on international guidelines	60 minutes	PowerPoint Presentation Special lecture
2	- Activity on stakeholder mapping	50 minutes	Writing activity on printed sheets Briefing through PowerPoint slides

Institutional Framework for Solid Waste Management in Disaster Situations in India

As explained in session 1.1, the SWM Rules 2016 are the key piece of regulation defining roles and responsibilities in solid waste management in peacetime. A summary of key stakeholders in solid waste management and their duties is given in the table below:

Table 14: Summary of Key Stakeholders in Solid Waste Management and their Duties

Stakeholders	Major duties in solid waste management	
Government bodies-Central	Ministry of Environment, Forest & Climate Change	constitute 'Central Monitoring Committee' to monitor and review every year
	Ministry of Urban Development	frame National Policy on SWM and coordinate with States/UTs, provide technical guidelines, financial support, training to local bodies, etc.
	Department of Fertilisers, Ministry of Chemicals and Fertilisers	shall assist in market development for city compost and make available to companies (3/4 bags compost: 6/7 bags Fertilizers).
	Ministry of Agriculture	make flexible Fertilizer Control Order, promote utilization of compost, testing facility for compost and issue guidelines

Stakeholders		Major duties in solid waste management
	Ministry of Power	shall fix tariff of power generation from W-T-E project and ensure distribution through companies
	Ministry of New and Renewable Energy Sources	facilitate infrastructure for waste-to-Energy plants and provide subsidy
	Central Pollution Control Board	coordinate with SPCBs/PCCs for monitoring and Annual Reports, formulation of standards, review new technologies, prepare guidelines for buffer zones restricting from residential, commercial and construction activities areas; and inter-state movement of waste
Government bodies- State	Secretary-in-charge, Urban Development departments	shall prepare State Policy/Strategy, adopt 3-Rs, coordinate for state planning, identification of common/regional landfills, notify guidelines of buffer zones.
	Secretary-in-charge of Village Panchayats or Rural Development Department	same as Secy. UD at Panchayat level
	State Pollution Control Bords (SCPBs/ PCCs)	shall monitor, issue authorization and regulate
Government bodies- District	District Magistrate or District Collector or Deputy Commissioner	shall facilitate identification of landfill site, quarterly review the performance of local bodies
Government bodies- Local Governments	local authorities and village Panchayats	shall prepare SWM plan with time line and its implementation, segregate, adopt 3-Rs, material recovery, processing/ disposal of Waste, user fee and levy spot fine.
Other Stakeholders	Waste Generators (households, event organizers, street vendors, RWAs & market associations, gated communities, hotels & restaurants, etc.)	segregate waste and store separately and hand over to Municipal workers or authorized waste pickers
	Manufacturers/ Brand owners	shall facilitate collect back wastes of their products and provide pouch for packaging sanitary wastes, etc
	Industry (cement, power plant, etc.)	shall use RDF within 100 km.
	Operator of facilities	shall follow guidelines/standards

Source: Central Pollution Control Board (2016). 'Salient Features of Solid Waste Management Rules, 2016'

The Disaster Management Act, 2005, has defined the roles and responsibilities of various departments and entities at different stages of disaster management at all levels of governance, e.g., central, state, district, and local. The National Disaster Management Plan 2019 is aligned to the Sendai Framework for DRR (2015–2030) and also provides details of the roles and responsibilities of stakeholders. NDMA has prepared 33 guidelines in various areas related to disaster management and also developed a model framework for the preparation of a district disaster management plan and a template for the same⁸².

The National Disaster Management Authority (NDMA) is responsible for the approval and facilitation of the national disaster management plan. As per the provisions of the Disaster Management Act, 2005, each state, or UT, has its own institutional framework for disaster management. The state-level State Disaster Management Authority (SDMA) and the district-level District Disaster Management Authority (DDMA) are responsible for planning and coordinating disaster management⁸³.

The central government notifies the list of nodal ministries for various disasters, which acts as a lead for disaster management efforts for that specific hazard. The National Disaster Management Plan provides a list of nodal ministries and departments for each disaster type. For earthquakes and cyclones, the Ministry of Earth Sciences; for floods, the Ministry of Jal Shakti; for droughts, the Ministry of Agriculture and Farmers Welfare; and for landslides, the Ministry of Mines are designated as the nodal ministries and departments, respectively⁸⁴.

In India, guidelines or rules specific to disaster waste are yet to be introduced. However, institutional arrangements for waste management in disaster situations have been specifically provided in some of the guidelines and plans. For example, as per the 'National Guidelines on Temporary Shelters for Disaster-Affected Families' prepared by NDMA, ensuring solid waste disposal for the affected communities is the responsibility of the state government, while constructing and managing waste disposal systems is the responsibility of District/ Block/ Local Bodies (District Administration and DDMA) and non-governmental organizations and the private sector⁸⁵.

As per the Delhi Disaster Management Plan (2016–17), 'Debris and Road Clearance' is identified as one of 12 Emergency Support Functions (ESF). For this function, the Director of Local Bodies is defined as coordinator while PWD, MCD, NDMC, Cantonment Board, DDA, MES, CPWD, traffic police, are identified as members. For equipment support, debris, and road clearance, responsibilities have been defined separately with the concerned municipal body as the primary agency for all hazards. Under the Shelter & Sanitation ESF, at relief camps and temporary shelters, the duty of managing solid waste is that of the Municipal Corporation of Delhi (MCD) and the New Delhi Municipal Council (NDMC), while the concerned responsible person is the Dy Commissioner of the district. It also mentions that the duty of segregation of

Box 14: Case Studies on Stakeholders Engaged in the Management of Disaster Waste During Past Disasters in India

After the Kerala floods of 2018, the Kerala State Cabinet delegated waste management to private firms with technology to process and recycle the waste (Devasia, 2018). The local self-government department also roped in Kudumbashree workers and Haritha Karma Sena volunteers for the collection of the waste.

After the Srinagar floods of 2014, special task groups of around 3000 officials, including officers, engineers, technicians, field staff, and temporary sanitation staff, were formed for the clearing of disaster waste. A landfill site was developed by the J&K Economic Reconstruction Agency with funding from the Asian Development Bank (ADB) (Qasba et al., 2021).

After the 2011 Sikkim earthquake, volunteer groups were formed with the help of local people to manage the disaster waste (NIDM, 2012). The NDRF forces, along with the NGOs, came forward to create an inter-agency group and funding plan for relief work along with waste management (Khanna, Verma, & Khanna, 2012).

Source: Aggarwal, G., Ratnoo, R., Bindal, M.K., Raman, D. and Kumar, S. (2023). Solid Waste Management in Post-Disaster Situations, National Institute of Disaster Management, Delhi, Page 38- 39, 44-45.

biodegradable and non-biodegradable waste is the responsibility of the camp in charge from the Revenue Department. For floods, it specifies DC (revenue), DC (MCD), and SE (DUSIB) as the concerned departments for solid waste disposal at relief camps⁸⁶. Community-based organizations, resident welfare associations, civil defense groups, media, the private sector (businesses and corporations), business associations (including chambers of commerce), educational institutions, informal waste pickers (mainly women), frontline sanitation workers, health care service providers, not-for-profit organizations, women groups, boys and girls, differently abled persons etc. are stakeholders in solid waste management in disaster situations.

Role of Other Stakeholders and Community Engagement

Considering the multi-dimensional nature of disaster waste management, various stakeholders like CBOs, NGOs, educational institutions, women groups, youth groups, self-help groups, market associations, chambers of commerce, and resident welfare associations (RWA) play an important role at different stages of disaster waste management. The nature of engagement and roles of the stakeholders vary in different stages of disaster management: mitigation, preparedness, response, and recovery. For example, in the collection and processing of disaster waste at the response and recovery stage, informal sector waste pickers and self-help groups, along with private sector recycling companies, play a crucial role. CBOs, NGOs, RWAs, youth groups, and women groups may actively contribute to the mitigation and preparedness stages by actively participating in drills and awareness-generation activities.

For poor households, the impact of disasters may cause a total loss of livelihood in addition to loss of life, injury, and other damages⁸⁷. Various activities undertaken under disaster waste management, like collection, transportation, and processing, may be potentially used to generate livelihood opportunities for communities facing livelihood losses due to disaster. Stakeholders from the private sector may financially contribute to the management of disaster waste through CSR and voluntary pooling mechanisms.

Gender Aspects in Disaster Waste Management

Since disasters impact different genders and socio-economic classes differently and have the potential to widen gender inequalities, it is crucial to address the specific needs of different genders and age groups in the planning and management of disaster waste. Engaging women-led self-help groups, women sanitation workers, and economically impacted female-headed households in the disaster waste management process can help in tackling the disproportionate impacts of disaster. Proper provision for sanitary waste management in residential areas as well as temporary relief camps in disaster situations is crucial for women and girls. Women, girls, boys, men, persons of other genders and differently abled persons should be engaged in the planning process of disaster waste management.

International Guidelines and Guiding Notes

Many international organizations have prepared guiding notes and detailed guidelines for solid waste management in disaster situations. Major guidelines include

- Disaster Waste Management Guidelines, prepared by the Government of South Australia in 2021
- Pacific island countries regional disaster waste management guideline, published by Secretariat of the Pacific Regional Environment Programme (SPREP) Apia, Samoa in 2021
- Disaster Waste Management Guidelines for Asia and the Pacific, prepared by the Ministry of Environment, Japan, in 2018
- Guidance Note on Municipal Solid Waste Management in Crisis and Post-Crisis Settings, prepared by UNDP in 2016
- Guidance Note on Debris Management, prepared by UNDP in 2015
- Flood Waste Management (FWM) Guidelines for Bangkok, prepared by the National Institute for Environmental Studies, Japan, in 2015
- A technical note on solid waste management in emergencies prepared by the WHO in 2013
- Disaster Waste Management Guidelines prepared by the Joint UNEP/OCHA Environment Unit in 2013
- ‘Planning for Natural Disaster Debris’ guidance published by the United States Environmental Protection Agency (EPA) in 2008
- Disaster waste management mechanism: a practical guide for construction and demolition wastes in Indonesia, published by United Nations Environment Programme in 2008

Below are the areas covered and highlights of the above documents.

Table 15: Areas Covered and Highlights of the International Guidelines and Guiding Notes

<p>Disaster Waste Management Guidelines, prepared by the Government of South Australia in 2021</p>	<ul style="list-style-type: none"> • General guidelines covering initial and detailed assessment, support during recovery phase, developing a Disaster Waste Management Program, oversee implementation of Program and Review outcomes • Technical guidelines for on-property waste assessments and handling collection and transport, interim storage facility, recycling and disposal options, dealing with various waste types (18 types)
<p>Pacific island countries regional disaster waste management guideline, published by Secretariat of the Pacific Regional Environment Programme (SPREP) Apia, Samoa in 2021</p>	<ul style="list-style-type: none"> • Principles and concepts of the DWM guidelines • DW prevention and mitigation, prevention and early warning • DWM response measures: response activities (rapid DWM assessment, immediate lifesaving operations, managing DW hazards), recovery of DWM operations (detailed waste assessment, collection and removal of DW, reconstruction stage etc.
<p>Disaster Waste Management Guidelines for Asia and the Pacific, prepared by the Ministry of Environment, Japan, in 2018</p>	<ul style="list-style-type: none"> • Management of risks of natural disasters and examples of natural disasters in Asia and the region • Generation amount, composition, types and materials in Asia and the Pacific, case of Fiji and Thailand • Management cycle of large-scale disasters and disaster waste, preparedness, contingency plan, and implementation plan, basic flow of disaster waste, contingency plans, after planning the contingency plan (CP) • Development of policies, guiding principles of DWM, reducing health and environmental risks, equipment and resources for 3Rs, community resilience, awareness, training, internal and external coordination, networking and information sharing

<p>Guidance Note on Municipal Solid Waste Management in Crisis and Post-Crisis Settings, prepared by UNDP in 2016</p>	<ul style="list-style-type: none"> • What constitutes municipal solid waste? • MSWM guiding principles • The planning phase: situation analysis (including needs assessment), programme strategy, identifying and mitigating risks, partnerships, monitoring and evaluation, communications strategy, resource mobilization • Project implementation: ensure community-driven and guided implementation, coordination, information management and effective communications, partnerships with the private sector, women's participation and empowerment, health and safety for workers • Key lessons learned
<p>Guidance Note on Debris Management, prepared by UNDP in 2015</p>	<ul style="list-style-type: none"> • What constitutes debris management? • The planning phase- the situation analysis (including needs assessment), programme strategy, results framework, identifying and mitigating risks, monitoring and evaluation, communications strategy, resource mobilization • Project Implementation- phases of implementing a debris management project, ensuring community-driven and guided implementation, women's participation and empowerment. environmental management, disaster risk reduction measures in debris management, health and safety for workers
<p>Flood Waste Management (FWM) Guidelines for Bangkok, prepared by the National Institute for Environmental Studies, Japan, in 2015</p>	<ul style="list-style-type: none"> • Basics of flood waste management: flood waste management in different phases, different aspects of flood waste management, composition and quantity of flood waste • Principles of flood waste management: functions, governance, technical aspects • Check list of recommended actions in each flood management phase: mitigation phase (normal time), preparedness phase (after flood warning), during flood phase (initial response), after flood phase (secondary response and recovery) • Vulnerability assessment tool for flood waste management
<p>A technical note on solid waste management in emergencies prepared by the WHO in 2013</p>	<ul style="list-style-type: none"> • Health risks related to the inadequate management of solid waste • Definitions and objectives of solid waste management • Assessment of issues and priorities, Disposal of waste caused by a disaster • Solid waste collection and transportation • Other issues like community issues, recycling and management
<p>Disaster Waste Management Guidelines prepared by the Joint UNEP/OCHA Environment Unit in 2013</p>	<ul style="list-style-type: none"> • Typical disaster waste issues and their effects • Framework for disaster waste management- Phase 1: Immediate phase, Phase 2: Medium term actions, Phase 3: Long term actions, Phase 4: Contingency planning • Suggested contents for a Disaster Waste Management Contingency Plan • Health and safety in disaster waste management • Key stakeholders, communication and coordination • Common risks by disaster waste hazard type

<p>'Planning for Natural Disaster Debris' guidance published by the United States Environmental Protection Agency (EPA) in 2008</p>	<p>Planning process for natural disaster debris covering conducting pre-planning activities, developing a comprehensive pre-incident debris management plan, keeping the debris management plan updated, implementing the debris management plan during a natural disaster</p> <p>Lessons learned from past disasters including best management practices and case studies</p> <p>Examples of debris management plans and guidance, state plans city and county plans</p>
<p>Disaster waste management mechanism: a practical guide for construction and demolition wastes in Indonesia, published by United Nations Environment Programme in 2008</p>	<p>About DEBRI (Demonstrating ESTs for building waste reduction in Indonesia) project</p> <p>Disaster waste characteristics: types of disaster waste and its implications</p> <p>Current status in Banda Aceh, C&D waste management practice, lessons learnt in managing disaster wastes</p> <p>Technology systems for disaster waste processing</p> <p>Disaster waste planning and management components-pre-disaster assessment, post-disaster assessment, development of plan</p>

Source: Respective documents of guidelines, technical notes and guiding notes

Activity 4: Activity on Stakeholder Mapping

<p>Activity objective</p>	<p>To develop an understanding of stakeholders involved in solid waste management during different stages of disaster management</p>
<p>Time Duration</p>	<p>50 mins</p>
<p>Mode</p>	<p>Writing on the given sheet, discussions, reflections</p>
<p>Material / Venue Requirements</p>	<ol style="list-style-type: none"> 1. A-1 size printed sheets (5-6) – one for each group depending upon number of participants 2. PowerPoint slides for briefing (1- 2 slides) 3. Coloured sketch pens- 5-6 nos (set of 6 colours, one for each group) 4. Study material- pdf files of the Disaster Management Plans for respective state/ districts/ cities (optional) 5. Tables (preferably round) for writing on sheets and seating arrangement in groups
<p>Step-wise process</p>	<ol style="list-style-type: none"> 1. The facilitator gives a brief introduction of the activity at the end of the previous day and circulates study material 2. The facilitator briefs the participants about the activity and divides them into groups as per their city, each group with 4-5 members, followed by the distribution of one printed sheet to each group (5 minutes) 3. Writing on sheets in group (20 minutes) <ul style="list-style-type: none"> - Each group to discuss and write names (fills in the spaces provided) of respective stakeholder/ departments on the sheet - The facilitator goes around to facilitate writing 4. Brief presentation by each groups- 25 minutes (5 min to each group)

6. Sub-Module 3

Planning for Solid Waste Management in Disaster Situations

Sub-module objective: To equip the participants with an understanding of types of plans, elements of plans, how to prepare the key elements of the plans, and integrating disaster waste aspects into different plans.

6.1 Session 3.1 (Technical Session 7): Cycle of Disaster Waste Management and Types of Plans

Session objective: to develop an understanding of the need for planning, the cycle of disaster waste, key actions during each stage of disaster management, and the types and key elements of the plans.

Duration: 90 minutes (1.5 hours)

Topics covered, duration and method:

S. No.	Items/ topics	Duration	Method
1	<ul style="list-style-type: none"> - Need for planning and cycle of disaster waste - Conceptual frameworks and types of plans 	60 minutes	PowerPoint Presentation Video screening Reflections Special lecture
2	<ul style="list-style-type: none"> - Key elements of contingency and implementation plans 	30 minutes	PowerPoint Presentation Reflections

The Need for Planning and the Cycle of Disaster Waste

Since disasters are uncertain events and disruptive in nature, planning is crucial to efficiently respond and safely manage solid waste generation during and after disaster situations. A plan for managing solid waste generation during and after disaster situations should be aligned with the cycle of disaster waste, reflecting the major steps for disaster management. A typical disaster waste management cycle is shown below. It is important to know that the time frames of different stages vary significantly. For example, the response stage may be a few days, whereas recovery may take a few months and reconstruction may take years. Prevention and preparedness stages go on for years and are continuous in nature.

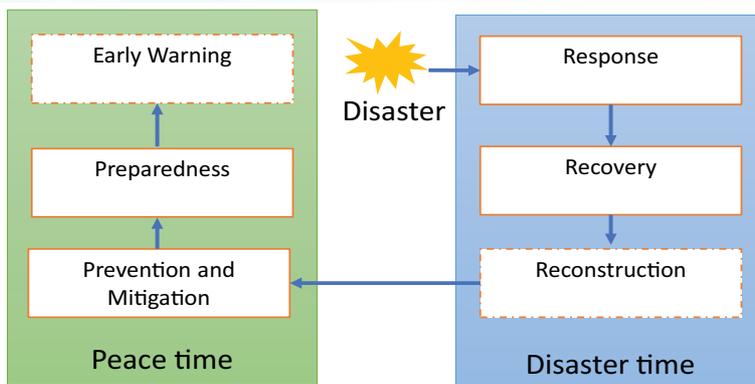


Figure 9: Cycle of Disaster Waste

Source: Figure drawn based on 1) Ministry of Environment, Japan (2018). DWM Guidelines for Asia and the Pacific. Page 5 and Pacific Regional Environment Programme (2021) Pacific Island Countries Regional Disaster Waste Management Guideline, Page 22

A description of key activities undertaken for the management of solid waste in a disaster situation are provided in Table 16.

Table 16: Key Activities Undertaken for the Management of Solid Waste in a Disaster Situation

Stages	Major activities undertaken
Prevention and mitigation	Undertake waste reduction activities and other preventive measures like pruning of trees, audits of vulnerable buildings, etc.
Preparedness	Periodic drills and trainings
Early warning	Arrangements for collection and storage facilities for disaster waste
Response	Removal of debris and fallen trees, identification and collection of hazardous waste, collection of waste from relief camps
Recovery	Managing food and packaging waste pertaining to relief material, Restoration of regular levels of solid waste management services, collection and disposal, and processing of waste from relief camps
Reconstruction	Managing waste generated from reconstruction and rehabilitation sites, reconstruction of solid waste collection, processing, or storage facilities

Source: Prepared based on Pacific Regional Environment Programme (2021). 'Pacific Island Countries Regional Disaster Waste Management Guideline', Page 22 and other sources

Conceptual Frameworks and Types of Plans

Planning for disaster waste management is based on fundamental principles of solid waste management like integrated waste management (including 5-R principles) and zero waste, which have been discussed in session 1.1 of sub-module 1. Some of the concepts used for disaster waste management planning include precautionary principles, clustering, participatory planning, gender equity, and building back better⁸⁸.

Box 15: Case Study on the Use of Circular Economy Principles in the Management of Disaster Waste Generated by the Great East Japan Earthquake

The Great East Japan Earthquake in 2011 led to the generation of approximately 28 million tons of disaster waste, which would have taken around 10 years for treatment. The government’s plan for the treatment of disaster waste aimed to complete the treatment in approximately three years and focused on recycling. The treatment work, undertaken in a mission mode with construction industry involvement, was extensively (around 90%) based on recycling and reuse and completed in two prefectures by the end of March 2014. The products of recycling were used for embankment, backfilling, etc. in reconstruction activities.

Source: Kazuo Ide (2016). 'Treatment of disaster waste generated by the Great East Japan Earthquake,' Federation of Construction Contractors, Japanese Geotechnical Society Special Publication

In the light of circular economy concept and Integrated Solid Waste Management (ISWM) principles, key activities and approaches for the management of disaster waste are described below.

Table 17: Key Activities and Approaches for the Management of Disaster Waste in the Light of Circular Economy Concept and ISWM Principles

At source Reduction and Reuse		<ul style="list-style-type: none"> Identify and eliminate the use of asbestos as a building material as it is hazardous Periodic pruning of trees along the roads to avoid the risk of blockage from fallen trees or branches Reducing construction waste at rehabilitation and reconstruction sites through good practices Reuse of surplus food items received as relief efforts, as animal feed Reuse the tree stems for rural houses, huts, shelter construction, fencing, or as firewood Reuse a portion of construction and demolition waste in ground filling works or landscaping
Resource Recovery	Recycling	<ul style="list-style-type: none"> Recycle a portion of construction and demolition waste to make paving blocks and other construction materials Recycle metal waste to make new metal products Recycle portions of waste like plastic and others suitable for recycling
	Composting	<ul style="list-style-type: none"> Process organic (green) waste to make compost
	Waste to Energy	<ul style="list-style-type: none"> Process organic (green) waste through biomethanation Processing of waste with high calorific value for fuel or energy generation
Landfills		<ul style="list-style-type: none"> The rejects from processing or hazardous waste can be sent to scientifically designed landfill sites

Source: Prepared based on Pacific Regional Environment Programme (2021). 'Pacific Island Countries Regional Disaster Waste Management Guideline,' Page 19 and other sources

There are three types of plans suggested in the international guidelines: contingency plans, implementation plans, and disaster waste reduction plans. A contingency plan is a plan prepared in advance for actions to be taken during and after the outbreak of a disaster. The implementation plan,

prepared after the disaster outbreak, provides the set of actions to be taken in the disaster situation using the contingency plan⁸⁹. The objective of a contingency plan is to help the authorities and other stakeholders determine the appropriate management options in advance and to avoid rushed or poor decisions at the time of a disaster outbreak⁹⁰.

Key elements of contingency and implementation plan

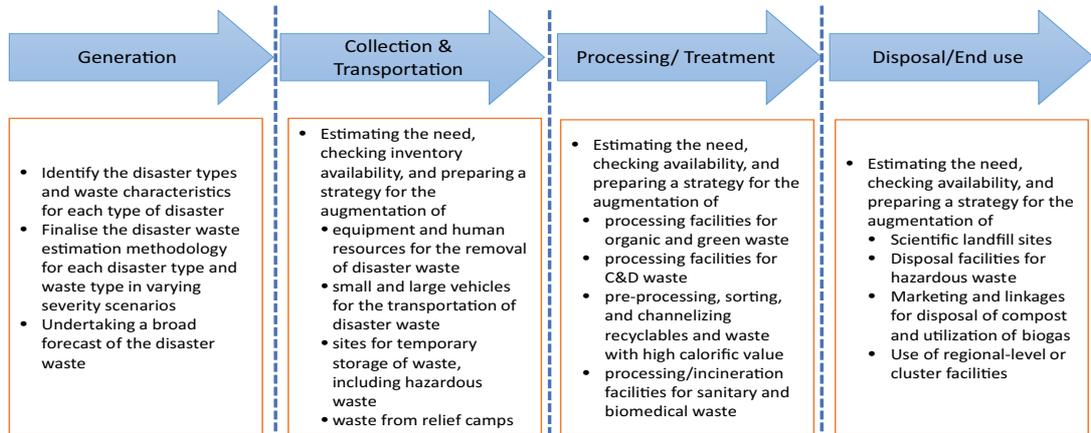


Figure 10: Key Elements of Contingency and Implementation Plan

Source: Developed with the help of – Ministry of Environment, Japan (2018). 'DWM Guidelines for Asia and the Pacific', Page 11- 12 and other sources

6.2 Session 3.2 (Technical Session 8): Planning and Action Methods and Tools for Disaster Waste Management

Session objective: to develop an understanding of basic action methods and tools like estimation, prioritization, and temporary storage site selection for the planning of disaster waste management.

Duration: 90 minutes (1.5 hours)

Topics covered, duration and method:

S. No.	Items/ topics	Duration	Method
1	<ul style="list-style-type: none"> Waste generation and need assessment Identification of urgent action points Prioritization/ hazard ranking of disaster waste Temporary disposal site location and pre- selection 	30 minutes	PowerPoint Presentation Reflections Special lectures
2	Group activity on key aspects of contingency plan for disaster waste management (two activities) (A) Initial estimates of waste volumes (B) Prioritization/ hazard ranking	60 minutes	Calculation and colouring activities Reflections Briefing

The preparation of contingency plans and implementation plans requires various analyses, assessments, and mapping activities. Some of them include damage assessment, prioritization and hazard ranking, waste handling planning, disposal site location and selection, and vulnerability

assessment.

Waste Generation and Need Assessment

It is an important step in the planning process. The actual assessment is undertaken at different stages of disaster management, like response, recovery, and resettlement. A format for data input and waste estimation should be developed as part of the contingency plan. As per a tool developed by UNEP on waste needs assessment, a detailed assessment should be conducted for different items like relief camps (displaced persons), buildings, infrastructure, hospitals, industries, and municipal waste⁹¹. For the assessment of debris generated immediately after a disaster outbreak, a method using satellite images or damage assessment and material composition per house can be used to prepare a high-level estimate⁹². As per UNEP guidelines, 63 tonnes of debris and rubble can be generated from a modern brick house with an 86 m² floor area⁹³. An estimation of the material composition of average dwellings has been presented in guidelines for South Australia. As per these guidelines, the building structure and contents of a typical dwelling unit have approximately 165.8 and 4.3 tonnes of material, respectively⁹⁴.

Identification of Urgent Action Points

Some of the disaster waste issues require urgent action to save lives, reduce damage to health, facilitate rescue and relief, and prevent any ill impacts on the environment and economic assets. South Australian guidelines suggest a matrix to identify acute waste issues⁹⁵. The table below presents a summarized view of actions with indicative timelines.

Table 18: A Summarized View of Actions with Indicative Timelines for Management of Disaster Waste

Immediate	Debris blocking road access of search and rescue operations
	Debris disrupting critical infrastructure service restoration/operation (e.g. trees fallen on electric wires)
	Hazardous material including CCA ¹ posts/ash and creosote treated timber
	Radioactive waste
Within 1–3 days	Biomedical waste from hospitals and health care centres
	Animal carcass waste from disaster
	Spoiled perishable food
Within one week	Friable asbestos (or as early as possible)
	Municipal solid waste (if system disrupted)
	Waste from temporary relief camps

Source: Government of South Australia (2021). 'Disaster Waste Management Guidelines', page 12

1 CCA stands for Copper Chrome Arsenate, which is used for treatment of wood used in buildings and structural work to extend their life.

Prioritization/ Hazard Ranking

Disaster waste may pose various types of risks, like chemical (pesticides, dust, odors, etc.), biological (skin contact, mosquitoes, birds, etc.), physical (fire, smoke, cuts from sharp objects, etc.), and local environmental risks (contamination of soil and groundwater, wind blow, leachate, etc.). The 'source-pathway-receptor' framework is a useful tool in the prioritization of hazardous waste. Different waste types should be prioritized for handling in a disaster situation in terms of immediate, short-term, and medium-term actions. The prioritization of waste is done on the basis of its potential hazards, which are dependent on factors like its location and age (how old it is)⁹⁶. For example, the risks may be higher if waste is located near a residential area or an ecologically sensitive area. Food waste may become hazardous once it starts decomposing.

As per the UNEP's waste hazard ranking tool, infectious waste, healthcare waste, food waste, and waste with hazardous properties are ranked as high priority waste, whereas debris is ranked as low priority waste in all situations⁹⁷.

Box 16: Assessment and Key Considerations for Waste from Temporary Relief Camps or Shelters (IDP camps)

In IDP camps, solid waste generally covers food waste, packaging waste, and waste from relief supplies. The management of this waste should be integrated with the local municipal waste collection services. Information like the number of camps, their locations, and the approximate population accommodated is crucial for the planning of IDP camp waste management.

Strategies for managing the IDP waste should consider waste reduction (by minimizing packaging) for delivery of goods to camps, arranging collections for waste generated across all camps, and recycling systems as applicable.

Source: Joint UNEP/OCHA Environment Unit (2013). 'Disaster Waste Management Guidelines', Page 8, 18, 23, 24 and Government of South Australia (2021). 'Disaster Waste Management Guidelines', page 13.

Temporary Disposal Site Location and Pre-Selection

After the initial assessment post-disaster, the authority should be in a position to assess the sufficiency of existing processing and disposal facilities for newly generated disaster waste. Considering the extremely high volumes of solid waste generated in disaster situations, it is prudent to identify and pre-select the sites where solid waste can be temporarily stored, sorted, processed, or sent for processing and disposal after a disaster outbreak. UNEP guidelines suggest a 400,000 square meter land requirement for one million cubic meters of waste as a thumb rule for estimating the land area required for a temporary disposal site⁹⁸. The layout of these sites should have a provision for open space for the circulation of trucks, separate spaces for keeping segregated waste like bricks, concrete, stone, metal, wood, and green waste, and an area for fresh, unprocessed debris⁹⁹. Such interim or temporary sites should be operated taking into account workers safety, environmental aspects, traffic, and security. The below-mentioned points should be kept in mind while pre-selecting or identifying temporary disposal sites.

- Land use and proximity: Preferably, government-owned land should be selected away from residential locations and sensitive land uses. The site should be in close proximity to the disaster-affected area and connected to transport networks.
- Environmental aspects: the site should not be located in a floodplain, a suitable buffer

should be maintained from water bodies, and any adverse impacts on soil, groundwater, and air quality should be assessed and addressed.

- The land area and storage capacity should be in accordance with the estimated waste generation.
- Site layout and facility design should take into account the covered and uncovered areas, paved and unpaved areas, along with site facilities like electricity and water supply¹⁰⁰.

Use of ICT and Innovative Technologies for Planning for Management of Disaster Waste

Information and communication technologies like GIS, data analytics, and cloud computing can help enormously in the estimation of waste generated, transportation of waste, locating storage sites, etc. As a part of contingency planning, location and proximity analysis may be very helpful in identifying sites for temporary storage of disaster waste. In the aftermath of the disaster, interpretation of high-resolution satellite imagery and drone survey may be conducted to gain a more precise assessment of waste generation and locate large accumulations of disaster waste. GIS maps may be used to plan the integration of waste collection from relief camps and route the vehicles to the nearest collection or disposal centres. Using communication technologies, an innovative alert and information system in the form of web applications may be created for disseminating information on the presence of hazardous wastes, requesting and scheduling clearing activities, and sharing precautionary information on solid waste.

Activity 5: Activity on Key aspects of Contingency Plan for Disaster Waste Management (two activities)

Activity Objective	To provide an orientation on key assessment and planning tools for contingency planning for disaster waste management
Time Duration	60 mins
Mode	Calculation and colouring on the given sheets, discussions, reflections
Material / Venue Requirements	<ol style="list-style-type: none"> 1. A-2 size printed sheets (5-6 of each type) – two sheets of a particular type for each of the respective group 2. PowerPoint slides for briefing (1- 2 slides for each activity) 3. Coloured sketch pens- 5-6 nos (set of 6 colours, one for each group) 4. Pencils, sharpeners and erasers: optional- 10- 12 nos (one for each group) 5. Tables (preferably round) for writing on sheets and seating arrangement in groups
Step-wise process	<ol style="list-style-type: none"> 1. The facilitator briefs the participants about the activities and divides them into groups of 4-5 participants (mixed group with participants from different cities), forming 5–6 groups. Half of the groups will participate in activity A (Initial estimates of waste volumes), while remaining in activity B (Prioritization/ hazard ranking). Two printed sheets of the respective activity will be distributed to each group; one sheet will be for reference, discussion, and rough work (10 minutes) 2. Calculation and colouring in groups (20 mins) <ul style="list-style-type: none"> - Each group, working on activity A, discusses and calculates using cell phone calculators and fills in the spaces provided. Groups, working on activity B, to color spaces provided on the sheet - The facilitator goes around to facilitate the activity. 3. Brief presentation by each groups- 30 mins (5 min to each group)

6.3 Session 3.3 (Technical Session 9): Strengthening Institutional Aspects, Awareness Generation, and Capacity Building

Session objective: to develop an understanding of institutional aspects, awareness generation, capacity building, and integration of disaster waste management in other plans.

Duration: 90 minutes (1.5 hours)

Topics covered, duration and method:

S. No.	Items/ topics	Duration	Method
1	<ul style="list-style-type: none"> - Integration in plans and preparation of guidelines and SOPs - Awareness generation and building community resilience - Capacity building 	20 minutes	PowerPoint Presentation Special lecture
2	<ul style="list-style-type: none"> - Group activity on writing points for integration of disaster waste elements into plans <ul style="list-style-type: none"> A) Integration in city sanitation action plans B) Integration in state disaster management plans 	70 minutes	Writing on sheets with help of reference material provided

Integration in Plans and Preparation of Guidelines and SOPs

For ensuring effective and sustainable management of solid waste during disaster situations, it is imperative to integrate this aspect, along with its nuances, into mainstream disaster management planning. Management of disaster waste may be integrated into national, state, and district disaster management plans, including region and city-specific disaster management plans. 'Disaster waste management' may be added as an 'Emergency Support Function' (ESF) to the disaster management plans at different levels and integrated in the Incident Response System (IRS) in the districts and states. There is a need to integrate solid waste management aspects pertaining to all stages of disaster management i.e. prevention and mitigation, preparedness, early warning, response, recovery and reconstruction in disaster management plans (Ref. Technical Session 7).

Guidelines for each type of disaster waste with step-by-step instructions for handling in different stages of disaster management—response, recovery, mitigation, and preparedness should be prepared. Such guidelines should elaborate on disaster waste assessment, prioritization of disaster waste, waste handling protocols, etc. Similarly, city specific solid waste management action plans or city sanitation plans should cover the challenges in service delivery in disaster situations.

Awareness Generation and Building Community Resilience

Awareness generation is crucial to achieving integrated waste management, effectively responding to disasters, and building community resilience. Awareness of various types of waste, hazards associated with poor management, and waste dynamics in disaster management should be generated at the community level. A multi-stakeholder approach engaging citizen groups, women, boys, and girls of schools and colleges, resident welfare associations, community-based organizations, and media is very helpful in this regard. Some of the awareness-generation topics may include source segregation and waste reduction, no waste disposal in drains and water bodies, preparedness activities covering

evacuation, aiming for a reduction in the loss of internal materials, etc. A plan for awareness generation and IEC (information, education, and communication) may be integrated into the contingency plan.

Capacity Building

The capacity building of key stakeholders in disaster waste management is necessary to equip them with the knowledge and skills to plan, manage, and execute actions in a disaster situation. Areas for capacity building may cover aspects like detailed disaster waste assessment, operating equipment, handling special and hazardous waste, preparing pre-negotiated contracts, and fund mobilization. Three key modes of training may be adopted: workshops to impart assessment methods and facility management aspects; simulation exercises to enable learning of challenges in different severity scenarios; and on-site training to enable processing, handling, and disposal of good practices¹⁰¹. Capacity building initiatives should cover stakeholders like incident response teams, volunteers, citizen groups, women groups, non-profit organizations, etc.

Activity 6: Activity on Integration of Elements of Solid Waste Management in Disaster Situations in City Sanitation Action Plans and State Disaster Management Plans (two activities)

Activity Objective	To provoke thinking and provide an orientation on key points for integration in city sanitation action plans and state disaster management plans
Time Duration	70 mins
Mode	Writing on the given sheets, referring to the provided material, discussions, and presentations
Material / Venue Requirements	<ol style="list-style-type: none"> 1. A-1 size printed sheets (5-6 of each type) – two sheets of a particular type for each of the respective group 2. PowerPoint slides for briefing (1- 2 slides for each activity) 3. Coloured sketch pens- 5-6 nos (set of 6 colours, one for each group) 4. Pencils, sharpeners and erasers: optional- 10- 12 nos (one for each group) 5. Tables (preferably round) for writing on sheets and seating arrangement in groups
Step-wise process	<ol style="list-style-type: none"> 1. The facilitator briefs the participants about the activities and divides them into groups of 4-5 participants, forming 5–6 groups. The first set of groups (2 or 3 groups) will be formed with participants from SWM service delivery backgrounds, while the second set will be from disaster management backgrounds. First set of groups will participate in activity A (integration in city sanitation action plans) while second set, in activity B (integration in state disaster management plans). Two printed sheets of the respective activity will be distributed to each group; one sheet will be for writing points, while another will be for rough work (10 minutes) 2. The facilitator distributes the reading and reference material to the respective groups (alternatively, it can be distributed at the end of the previous day). Each group, working on activities A and B, reads the reference material, discusses and writes in the spaces provided. The facilitator goes around to facilitate the activity (30 minutes). 3. Brief presentation by each group: 30 minutes (5 minutes for each group)

7. Field Visit

Duration: 180 minutes (3 hours)

Topics covered, duration and method:

S. No.	Items/ topics	Duration	Method
1	Transporting the participants from the training venue to the site	30 minutes	-
2	- Briefing by the plant operator or manager - A guided tour of the different parts of the plant - Noting down observations by the participants	90 minutes	Observation Site reconnaissance Writing
3	Transporting the participants from the site to the training venue	30 minutes	-
4	Activity on writing the observations from the field visit	30 minutes	

A visit to the waste processing facility is expected to induce knowledge of various aspects related to waste processing, covering inputs, throughputs, and outputs of the plant. Input aspects may cover quantity processed, capacity and capacity utilization of the plant, machines, land, and human resource requirements. Throughput may cover processes involved and maintenance requirements, while outputs may cover the type and quantity of recycled products, the value and marketability of the products, etc.

The options to improve management of the facility will cover workflow, equipment, health and safety, maintenance, efficiency of the plant, behavior of workers, quality of segregated products, and evaluation and monitoring¹⁰².

Activity 7: Activity on Observations During the Field Visit

Activity Objective	To develop an understanding of the functioning of a solid waste processing plant and its associated strengths and challenges through visualizing a real-life example
Time Duration	30 mins
Mode	Writing on the given sheets, discussions, and presentations
Material / Venue Requirements	<ol style="list-style-type: none"> 1. A-3 size printed sheets: 5-8 nos., 1 for each of the respective groups 2. Colored sketch pens or gel pens: 8-10 of each red and green color (one set of two for each group) 3. Tables (preferably round) for writing on sheets and seating arrangements in groups
Step-wise process	<ol style="list-style-type: none"> 1. The facilitator briefs the participants about the activity before departing for the site visit and divides them into groups of 4-5 participants, forming 5-6 groups. One printed sheet will be distributed to each group (5 minutes). 2. Each group discusses and works on the activity. The facilitator goes around to facilitate the activity (15 minutes). 3. A brief presentation by two selected groups: 10 minutes (5 minutes for each group)

8. Valedictory Session

Duration: 90 minutes (1 hour 30 minutes)

Topics covered, duration and method:

S. No.	Items/ topics	Duration	Method
1	Feedback from participants - each participant to reflect on learnings and experience gained from the training - filling feedback forms Assessments - each participant to answer the objective type questions	50 minutes	Reflections Writing on post-it (optional) Google Forms
2	- Address by the ED - Address by the HOD - Vote of thanks by facilitators	40 minutes	Speech Reflections

Feedback from the participants is an important element of the training program. In the valedictory session, each participant will be required to reflect on the learnings and experiences received from the training. The feedback will be noted by the facilitators and organizing team. Similarly, the suggestions for improvement shall be noted down, discussed internally, and used to improve future training programs. The program will come to a close with an address by the dignitaries as per the protocol and a formal vote of thanks.

9. Session Plans for Training Program

9.1 Session Plan: Option 1 (Training Program Duration- 3 days)

Session Plan Summary:

Total number of days- 3

Total technical sessions- 9 along with inaugural and valedictory session

Assessment: at end of training program

Feedback capturing: at end of training program

Indicative Session Plan:

Program	Timings
Day 1	
Registration	9.00 AM – 11.00 AM
Inaugural Session	
- About the training program and welcome address	
- Key note address	
- Vote of thanks	
- Meet and greet	
- Pre-training assessment	
- Summarization by the facilitator	
Tea break -----	11.00 AM – 11.20 AM
- Technical session 1. Basics of solid waste management	11.20 AM – 12.50 PM
Lunch break -----	12.50 PM – 1.40 PM
- Technical session 2. Solid waste management concepts and challenges in the existing SWM system	1.40 PM – 3.10 PM
Tea break -----	3.10 PM – 3.30 PM
- Technical session 3. Dealing with the specific waste types (C&D waste, plastic waste, biomedical waste, hazardous waste and sanitary waste)	3.30 PM – 5.00 PM
Day 2	
- Recap of Day 1 proceedings: reflection from the participants	10.00 AM – 10.10 AM
- Technical session 4. Disaster Management and Disaster Risk Resilience	10.10 AM – 11.40 AM
Tea break -----	11.40 AM – 12.00 PM
- Technical session 5. Post disaster waste situation: Hazard- wise waste characteristics and quantities	12.00 PM – 1.50 PM
Lunch break -----	1.50 PM – 2.40 PM

Program	Timings
- Technical session 6. Institutional and governance frameworks	2.40 PM – 4.30 PM
Tea break -----	4.30 PM – 5.00 PM
Day 3	
- Recap of Day 2 proceedings: reflection from the participants	9.30 AM – 9.40 AM
- Technical session 7. Cycle of disaster waste management and types for plans	9.40 AM – 11.10 AM
Tea break -----	11.10 AM – 11.30 AM
- Technical session 8. Planning and action methods and tools for disaster waste management	11.30 AM – 12.50 PM
Lunch break -----	12.50 PM – 1.40 PM
- Technical session 9. Strengthening intuitional aspects, awareness generation, and capacity building	1.40 PM – 3.10 PM
Tea break -----	3.10 PM – 3.30 PM
Valedictory Session - Feedback from the participants - Assessment - Address by the ED - Address by the HOD - Vote of thanks	3.30 PM – 5.00 PM

9.2 Session Plan: Option 2 (Training Program Duration- 5 Days)

Session Plan Summary:

Total number of days- 5

Total technical sessions- 9 (divided across 14 sessions) along with inaugural and valedictory sessions and a site visit

Assessments- three, one at end of each of the three sub-modules

Feedback capturing- thrice, at end of each of the three sub-modules

Indicative Session Plan:

Program	Timings
Day 1	
Registration Inaugural Session - About the training program and welcome address - Key note address - Vote of thanks	9.30 AM – 11.30 AM

Program	Timings
<i>Tea break</i> -----	11.30 AM – 12.00 PM
<ul style="list-style-type: none"> - Meet and greet - Expectation setting - Pre-training assessment - Summarization by the facilitator 	12.00 PM – 1.00 PM
<i>Lunch break</i> -----	1 PM – 2.00 PM
<ul style="list-style-type: none"> - Technical session 1. Basics of solid waste management 	2 PM – 3.30 PM
<i>Tea break</i> -----	3.30 PM – 4.00 PM
<ul style="list-style-type: none"> - Technical session 2 a. Solid waste management concepts and challenges in the existing SWM system- I 	4.00 PM – 5.00 PM
Day 2	
<ul style="list-style-type: none"> - Recap of Day 1 proceedings: reflection from the participants 	10.00 AM – 10.20 AM
<ul style="list-style-type: none"> - Technical session 2 b. Solid waste management concepts and challenges in the existing SWM system: II 	10.20 AM – 11.00 AM
<i>Tea break</i> -----	11.00 AM – 11.20 AM
<ul style="list-style-type: none"> - Technical session 3. Dealing with the specific waste types (C&D waste, plastic waste, biomedical waste, hazardous waste and sanitary waste) 	11.20 AM- 1.00 PM
Assessment and feedback on sub-module I	1.00 PM- 1.30 PM
<i>Lunch break</i> -----	1.30 PM – 2.30 PM
<ul style="list-style-type: none"> - Technical session 4 a. Disaster Management and Disaster Risk Resilience- I 	2.30 PM – 3.30 PM
<i>Tea break</i> -----	3.30 PM – 4.00 PM
<ul style="list-style-type: none"> - Technical session 4 b. Disaster Management and Disaster Risk Resilience- II 	4.00 PM – 5.00 PM
Day 3	
<ul style="list-style-type: none"> - Recap of Day 2 proceedings: reflection from the participants 	10.00 AM – 10.20 AM
<ul style="list-style-type: none"> - Technical session 5 a. Post disaster waste situation: Hazard- wise waste characteristics and quantities- I 	10.20 AM – 11.30 AM
<i>Tea break</i> -----	11.30 AM – 12.00 PM
<ul style="list-style-type: none"> - Technical session 5 b. Post disaster waste situation: Hazard- wise waste characteristics and quantities- II 	12.00 PM – 1.00 PM
<i>Lunch break</i> -----	1.00 PM – 2.00 PM
<ul style="list-style-type: none"> - Technical session 6 a. Institutional and governance frameworks- I 	2.00 PM – 3.00 PM
<i>Tea break</i> -----	3.00 PM – 3.30 PM
<ul style="list-style-type: none"> - Technical session 6 b. Institutional and governance frameworks- II 	3.30 PM – 5.00 PM
Assessment and feedback on sub-module II	5.00 PM – 5.30 PM

Program	Timings
Day 4	
- Recap of Day 3 proceedings: reflection from the participants	10.00 AM – 10.30 AM
- Technical session 7. Cycle of disaster waste management and types for plans	10.30 AM – 12.00 PM
Tea break -----	12.00 PM – 12.30 PM
- Technical session 8 a. Planning and action methods and tools for disaster waste management- I	12.30 PM – 1.30 PM
Lunch break -----	1.30 PM – 2.30 PM
- Technical session 8 b. Planning and action methods and tools for disaster waste management- II	2.30 PM – 3.30 PM
Tea break -----	3.30 PM – 4.00 PM
- Technical session 9 a. Strengthening intuitional aspects, awareness generation, and capacity building -I	4.00 PM – 5.00 PM
Day 5	
- Recap of Day 4 proceedings: reflection from the participants	9.30 AM – 9.50 AM
- Technical session 9 b. Strengthening intuitional aspects, awareness generation, and capacity building -II	9.50 AM – 10.40 AM
Assessment and feedback on sub-module III	10.40 AM – 11.10 AM
Tea break -----	11.10 AM – 11.30 AM
Field visit to a solid waste processing plant and activity on observations	11.30 AM – 2.30 PM
Lunch break -----	2.30 PM – 3.30 PM
Valedictory Session - Reflections from the participants - Address by the ED - Address by other dignitaries - Vote of thanks	3.30 PM – 4.30 PM
Tea and dispersal	4.30 PM

10. Annexure

10.1 Pre-Training Assessment Form

Self-assessment form to be created in Google-forms or on another suitable platform

1. Email id.
2. Name
3. Type of organization or institution
 - a. Central Government department
 - b. State Govt department
 - c. District Administration
 - d. Urban Local Body
 - e. State Disaster Management Authority
 - f. District Disaster Management Authority
 - g. Other Govt department or PSU
 - h. Educational Institution
 - i. NGO or CBO
 - j. Private Sector
4. Name of the organization or institution.
5. Designation.
6. Have you attended any training programs on disaster management or solid waste management in the past?
 - a. Yes, training on disaster management
 - b. Yes, training on solid waste management
 - c. Not attended any such program
7. Have you worked on any of these in the past?
 - a. Disaster management activities
 - b. Solid waste management activities
 - c. Management of disaster waste
 - d. I have not worked in these areas
8. Please express your understanding of the following as high, medium, and low

a. Hazards, Vulnerability, Risk and Exposure	Low	Medium	High
b. Disaster management and Disaster resilience	Low	Medium	High
c. Solid waste management steps	Low	Medium	High
d. Concepts of circularity, 3-R and zero waste	Low	Medium	High

e.	Processing and disposal of different waste types	Low	Medium	High
f.	Management of disaster waste	Low	Medium	High
g.	Solid waste management in disasters	Low	Medium	High

10.2 Feedback Form

Form to be created in Google-forms or on another suitable platform

1. Did you find this training program/ session useful in doing your work better?
 - a. Extremely useful
 - b. Reasonably useful
 - c. Somewhat useful
 - d. Not useful
2. What did you like the most about this training program/ session?
 - a. Skills of the facilitators/ resource person
 - b. Learning methods used
 - c. learning material provided
 4. Ambiance and venue
3. How did you find the learning methods used in this training program/ session?
 - a. Very good
 - b. Good
 - c. OK
 - d. Needs improvement
4. How will you use the learning and knowledge you received from this program/ session in your work?

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5. Please give your suggestions to improve this training program/ session

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About the Institute

The National Institute of Disaster Management (NIDM) was constituted under an Act of Parliament with a vision to play the role of a premier institute for capacity development in India and the region. The efforts in this direction that began with the formation of the National Centre for Disaster Management (NCDM) in 1995 gained impetus with its redesignation as the National Institute of Disaster Management (NIDM) for training and capacity development. Under the Disaster Management Act 2005, NIDM has been assigned nodal responsibilities for human resource development, capacity building, training, research, documentation and policy advocacy in the field of disaster management.

NIDM is proud to have a multi-disciplinary core team of professionals working in various aspects of disaster management. In its endeavour to facilitate training and capacity development, the Institute has state-of-the-art facilities like class rooms, seminar hall and video-conferencing facilities etc. The Institute has a well-stocked library exclusively on the theme of disaster management and mitigation. The Institute provides training in face-to-face, on-line and self-learning mode as well as satellite based training. In-house and off-campus face-to-face training to the officials of the state governments is provided free of charge including modest boarding and lodging facilities.

NIDM provides Capacity Building support to various National and State level agencies in the field of Disaster Management & Disaster Risk Reduction. The Institute's vision is to create a Disaster Resilient India by building the capacity at all levels for disaster prevention and preparedness.



Resilient India - Disaster Free India

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