ME545 - Project Report

Sustainable Food Packaging System in Railway Sector

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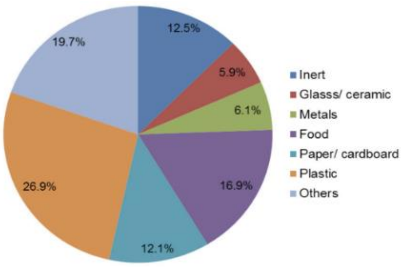
1. Introduction

1.1 The Problem Statement

Indian Railways is one of the largest transport systems in the world, carrying over 23 million passengers every day. Food catering is an important part of the passenger experience, with lakhs of meals being served on trains and at stations daily.



However, a significant environmental issue arises from the way food is currently packaged.
Most packaging materials used — like plastic trays, aluminium foils, and polystyrene cups — are **single-use, non-biodegradable**, and **difficult to manage** after consumption.

This leads to:

1. Increased plastic waste along stations, tracks, and public spaces
2. Higher greenhouse gas emissions from material production and disposal
3. Operational challenges in cleaning and waste collection
4. Negative passenger perception about Indian Railways' sustainability efforts

Although some steps have been taken (like introducing biodegradable spoons), the majority of food packaging still contributes heavily to waste problems.

As Indian Railways moves towards modernization under initiatives like the **Green Railway Vision 2030** and **Swachh Bharat Mission**, solving the packaging waste problem has become more urgent than ever.

1.2 Why Sustainable Packaging for Railways

The need for sustainable food packaging in Indian Railways is clear for several reasons:

1. Large Waste Volumes: With the number of meals served daily, even small changes in packaging can have a big environmental impact.
2. Environmental Commitment: Moving towards compostable and recyclable materials is essential to reduce pollution and carbon emissions.
3. Government Policies: New regulations like the Plastic Waste Management Rules, 2021 are pushing large public organizations to cut down on single-use plastics.
4. Changing Passenger Expectations: Surveys show that passengers are more aware of environmental issues today.

Making the shift to sustainable food packaging is not just about compliance — it is also about leading by example and improving passenger experiences.

1.3 Objectives of the Project

This project focuses on four main goals:

1. To conduct a full Life Cycle Assessment (LCA) of the current railway food packaging system, studying its environmental impacts from production to disposal.
2. To identify key challenges in the sustainability of current packaging materials and practices across their entire life cycle.
3. To design new sustainable packaging solutions that maintain functionality, are cost-effective, and significantly reduce environmental footprint.
4. To suggest policy measures that Indian Railways and IRCTC can adopt to successfully transition to eco-friendly packaging systems on a large scale.

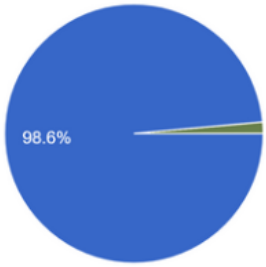
2.Current Packaging System Analysis

2.1 Survey Results and Insights

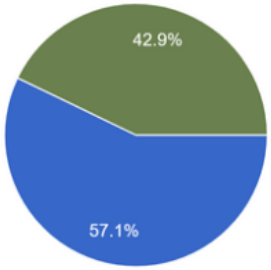
2.1.1 Introduction:

A survey was conducted among students who travel through railways to understand perceptions about food packaging sustainability, willingness to pay for eco-friendly packaging, and commonly observed packaging types.

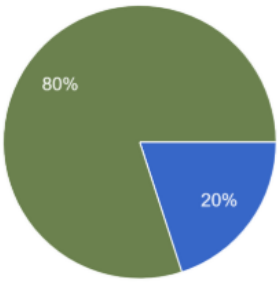
2.1.2 Survey Data Highlights:



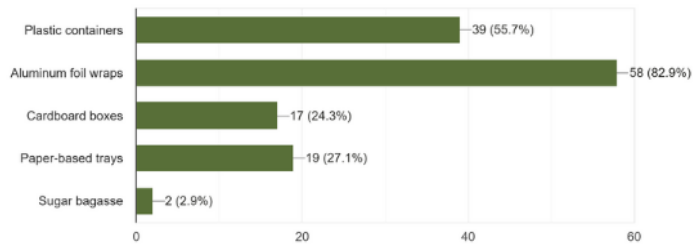
98.6% people travelled by Indian Railways



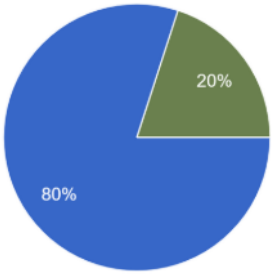
57.1% of people have food provided by the Indian Railways



80% of people agree that the packaging is not sustainable



Types of packaging of containers that people have observed being provided in trains



When asked 80% of people said yes to pay 5-10 rupees more for sustainable packing.

1. 98.6% of respondents had travelled by Indian Railways.
2. 57.1% of respondents consumed food provided by Indian Railways.
3. 80% of respondents felt the current packaging was unsustainable.
4. 80% were willing to pay ₹5–10 extra for sustainable packaging.

2.1.3 Observed Packaging Types (based on survey answers):

Fig-1: Present food packaging

Passenger Attitude Analysis: The survey indicated a strong preference for eco-friendly solutions among passengers, even with minor price increases, highlighting market readiness for a sustainable transition.

2.2 Life Cycle Analysis

Life Cycle Assessment (LCA) is a systematic approach used to evaluate the environmental impacts of a product throughout its life cycle. This study aims to assess the environmental impact of two typical meal tray systems currently used in Indian Railways, identifies key impact sources.

2.2.1 Goal and scope:

To quantify multiple environmental impacts of food packaging in Indian Railways.

1. **System boundary -** Cradle-to-grave — including raw material extraction, manufacturing, packaging assembly, transport, usage, and waste management.
2. **Functional Unit -** One complete meal tray provided to a railway passenger, including all associated packaging components.

2.2.2 Life Cycle Inventory

Typical Meal Tray 1 (Aluminium-Heavy)

Component	Material	Weight (g)	Use Type
3 Foil Trays	Aluminium	15	Single use
Roti Wrap	Aluminium Foil	3	Single use
Curd Cup	Polystyrene (PS)	5	Single use
Spoon	PLA Biodegradable	4	Single use
Tray	Plastic (Reusable)	250	Reusable one

Typical Meal Tray 2 (PET-Heavy)

Component	Material	Weight (g)	Use Type
Tray	PET Plastic	30	Single use
Spoon	Biodegradable	4	Single use

Raw material Extraction

Material	Extraction Process	Environmental Impact
Aluminium	Bauxite mining, high-temperature electrolysis	High CO_2 emissions, high energy usage, deforestation
Polystyrene	Petroleum extraction and cracking	Fossil fuel depletion, air and water pollution
PET Plastic	Oil refining to produce ethylene glycol and terephthalic acid	GHG emissions, water consumption
PLA (Bioplastics)	Fermentation of corn starch or sugarcane	Lower emissions, but agricultural land use impact

Phase 2: Manufacturing and Processing

Process	Energy Requirement	Water Requirement	Emissions
Aluminium Forming	Very high	Moderate	CO_2, SO_2, NO_x
Plastic Molding	High	Low	VOCs, GHGs
PLA Spoon Molding	Moderate	Moderate	Minor GHGs

Phase 3: Transportation and Distribution

Transport Mode	Distance	Fuel	Emissions
Aluminium Forming	75-150 km	Diesel	CO_2, SO_2, NO_x

Phase 4: Usage Phase (Onboard Trains)

Aspect	Impact
Reusable Trays	Positive (lower per-use impact)
Single-Use Items	Negative (higher waste per trip)

Phase 5: End-of-Life (Waste Management)

Component	Disposal Fate	Impact
Aluminium trays, foils	Recyclable but often landfilled	Energy savings if recycled, but most not collected
PS cups	Landfill dominant, poor recyclability	Persistence over hundreds of years
PLA spoons	Compostable industrially (rarely available)	If landfilled, decomposes
Plastic Tray	If damaged, landfilled	Contributes to plastic waste burden

2.2.3 Environmental Impact Assessment of Meal tray 1

Impact Source	CO_2e (g)	Energy Consumption (MJ)	Water Usage (L)	Waste Generation (g)	Other Emissions
Aluminium packaging	225	50	10	15	CH4, NOx
PS curd cup	90	15	4	5	VOCs
PLA spoon	40	10	3	4	Biodegradable
Transport	80	8	0.5	2	NOx, SO2
Waste Handling	100	5	1	-	Methane from landfill
Total	535	88	18.5	26	CH4 (Landfills), NOx (transport), VOCs (manufacture)

2.2.4 Environmental Impact Assessment of Meal tray 2

Impact Source	CO_2e (g)	Energy Consumption (MJ)	Water Usage (L)	Waste Generation (g)	Other Emissions
PET Tray	225	50	10	15	NOx,SO2
Biodegradable Spoon	40	10	3	4	Biodegradable
Transport	80	8	0.5	2	NOx,SO2
Waste Handling	100	5	1	-	Methane from landfill
Total	390	53	10.5	36	CH4 (Landfills), NOx (transport), VOCs (manufacture)

2.2.5 Interpretation

Tray 1 :

The Life Cycle Assessment (LCA) of the two current Indian Railways meal trays shows that both systems have significant environmental drawbacks. **Typical Meal Tray 1**, which relies on aluminium and polystyrene components, has a very high carbon footprint (around 535g CO_2e per tray) and energy consumption, mainly due to the energy-intensive extraction and manufacturing of aluminium. Despite having a reusable plastic tray, the heavy use of single-use materials leads to substantial waste generation.

Tray 2 :

Typical Meal Tray 2, based on PET plastic trays and biodegradable spoons, shows lower emissions (around 390g CO_2e) and energy use, but results in higher plastic waste and risks of microplastic pollution due to low recycling rates. Overall, Tray 1 impacts the environment mainly through emissions and resource depletion, while Tray 2 shifts the burden toward persistent solid waste, emphasizing the urgent need for sustainable, biodegradable packaging alternatives.

3.Product Life Cycle

In developing a sustainable food packaging system for Indian Railways, it is essential to examine the entire product life cycle — from material extraction to end-of-life disposal.

Each stage presents opportunities to embed sustainability while maintaining functionality and passenger satisfaction.

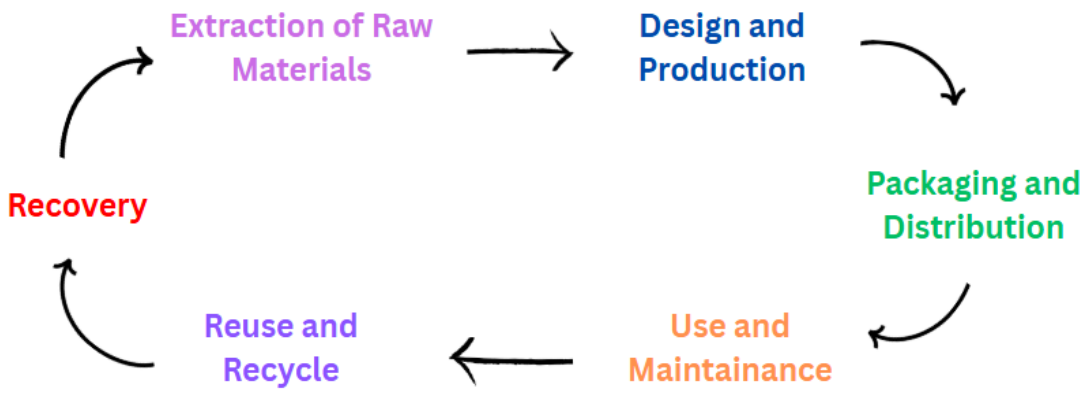


Fig-2: Product Life Cycle

3.1 Raw Material Selection and Smart Combinations

3.1.1 Sustainable Materials Considered

In order to design an effective sustainable food packaging system for Indian Railways, various eco-friendly materials were analysed based on availability, functionality, environmental impact, and cost. The following materials were shortlisted:

Material	Advantages	Disadvantages
Recycled Cardboard	- Rigid and strong - Easily available - Recyclable	- Poor water resistance - Deforms with liquids
Banana Leaves	- Natural, biodegradable - Traditional use in India - No chemical treatment needed	- Fragile - Prone to drying and tearing
Sugarcane Bagasse	- Heat and grease resistant - Compostable - Lightweight	- Brittle in very dry environments - Slightly costly
Mushroom Mycelium	- Fully home-compostable - Very low carbon footprint - Molds into custom shapes	- Fragile if not reinforced - Slow manufacturing process
Palm Leaves	- Stronger than banana leaves - Natural, biodegradable - Some natural water resistance	- Limited scalability (depends on region) - High variability (size, thickness)
PLA (Polylactic Acid)	- Made from corn starch - Compostable (industrial facilities) - Transparent (good for some food displays)	- Requires specific composting conditions - Cannot withstand very high temperatures
Paperboard with Biopolymer Coating	- Recyclable - Grease and water resistant	- Not fully home-compostable if mixed with synthetic coatings

	(because of biopolymer) - Durable	- Slightly complex recycling if layers are bonded
Areca Palm Sheath	- Naturally waterproof - Heat-resistant - Sturdy without any chemical treatment	- Brittle over time - Seasonal availability

3.1.2 Material Combinations to Improve Performance

No single material meets all the desired properties (strength, waterproofing, compostability, affordability) on its own.

Hence, smart material combinations were developed to leverage strengths and offset

Combinations	**Why we can use this combination**
Recycled Cardboard + Biopolymer Coating (PLA or PHA)	Gives structural strength + water/grease resistance; ideal for main trays.
Banana Leaves + Palm Leaf Base	Banana gives natural eco-feel, palm leaf provides strength; perfect for rotis, sandwiches.
Bagasse Tray + PLA Inner Layer	Bagasse provides structure, PLA adds food-grade liquid/oil barrier; great for curries, rice.
Mycelium Base + Bagasse Lid	Mycelium rigid base, lightweight bagasse lid protects food; compostable and customizable.
Areca Palm + Sugarcane Bagasse	Stronger dish made with Areca + surface smoothened or heatproofed with bagasse; good for hot solid foods
Paperboard + Biopolymer	Classic lightweight solution for dry foods/snacks; recyclable if biopolymer layer is biodegradable (like PHA).

this combination strategy can be used according to the

1. Type of food served (dry, wet, hot, cold)
2. Required thermal and mechanical properties (strength, leak-proofing)

3. Ease of disposal (compostability, recyclability)
4. Passenger perception and comfort (natural, safe, aesthetic feel)

By carefully choosing and combining materials, the proposed packaging solution addresses all major concerns: durability, safety, environmental impact, and user experience.

By utilizing **locally sourced agricultural waste materials**, the dependency on long supply chains is reduced — cutting down the embedded transportation emissions and creating regional employment opportunities.

3.2 Modular Design and Customization of Packaging Templates

3.2.1 Need for Modular Design

Current railway food trays are fixed format — designed assuming all passengers will consume the same type of food (rice, roti, curd, sweet, etc.). This leads to two major issues:

1. Material Waste: Unused compartments still require packaging material.
2. Food Waste: Items not preferred by passengers (like curd, rice) are served and discarded.

To address these inefficiencies, a modular and customizable packaging system is proposed.

3.2.2 Concept of Modular Packaging

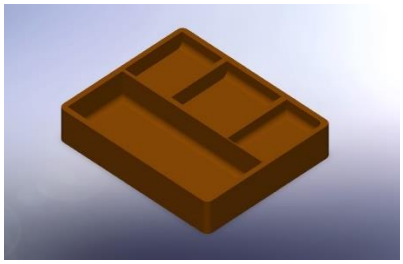


Fig-3: CAD model-1

Fig-4: CAD model-2

Fig-5: CAD model-3

The above CAD models illustrate the idea of standard templates modular packaging. This proposed design system is based on standardized templates that can be adapted dynamically to suit different food combinations preferred by passengers.

1. Adjustable compartments based on meal requirements.
2. Interchangeable inserts for different food items.
3. Standardized external dimensions for stacking, storage, and transport ease.

Example Modular Configurations

Passenger Preference	Tray Configuration
Only Roti and Curry	Roti + Sabzi compartments; No Rice, No Curd

Full Meal	Rice + Dal + Roti + Curd + Sweet
Only Rice and Dal	Rice + Dal compartments only

3.2.4 Design Details

Fig-3: Hexagonal Structure Packaging

1. Shape**:** Hexagonal or six-sided to maximize space usage and improve stability (prevents trays from sliding or tipping).
2. Material Allocation: Compartments use minimal additional material only where needed.
3. Custom Inserts: Biodegradable inserts for curd cups, sweets, or dry snacks.

3.2.5 Advantages of Modular Design

1. Material Savings: Only compartments required are produced.
2. Food Waste Reduction: Passengers receive only what they intend to consume.
3. Better Passenger Experience: Custom meals lead to higher satisfaction.
4. Operational Efficiency: Lighter packaging = easier handling, better stacking.
5. Environmental Impact: Reduced overall carbon footprint through optimized material use.

3.3 Production and Manufacturing

3.3.1 Importance of Sustainable Production

1. In the railway food packaging system, production processes must not only meet volume demands but also ensure minimal environmental impact.

2. Large-scale catering operations across India require packaging that can be produced efficiently, cost-effectively, and in an eco-friendly manner.

3.3.2 Manufacturing Techniques by Material Type

Material	**Manufacturing Method**	**Environmental Advantage**
Recycled Cardboard	Collection, cleaning, pulping, Molding into trays	Reduces deforestation and water usage compared to virgin pulp
Banana Leaves	Cleaning, heat-pressing, minimal processing for sterilization	Natural processing with very low energy requirement
Sugarcane Bagasse	Meals packed into modular trays at IRCTC base kitchens	Utilizes agricultural waste; avoids landfill burning

Mushroom Mycelium	Meals loaded into pantry cars or catering trolleys	No synthetic processing; fully biodegradable
Palm Leaves	Washing, drying, and light heat pressing into plates or tray components	Minimal chemical or water use

By focusing on low-energy, decentralized production, Indian Railways can align with their broader environmental and operational efficiency goals under the Green Railway Vision 2030.

3.3.3 Manufacturing of Smart Material Combinations

1. To meet the operational needs of Indian Railways, the proposed food packaging system uses **smart combinations of materials** — integrating the advantages of different sustainable resources while eliminating their individual weaknesses. Hence, the manufacturing processes must efficiently blend multiple materials into cohesive, high-performance packaging products.

Material Combination	Manufacturing Method	Environmental Impact
Recycled Cardboard + Biopolymer Coating (PLA or PHA)	-Mold recycled cardboard trays -Apply a thin layer of biopolymer coating for grease and water resistance	- Reduces need for virgin pulp - Fully recyclable or compostable depending on biopolymer
Banana Leaves + Palm Leaf Base	- Press banana leaves onto a stiff palm leaf base under moderate heat - Light bonding without synthetic adhesives	- Combines natural biodegradability with structural strength - Minimal energy use
Bagasse Tray + PLA Inner Layer	- Mold bagasse into trays using heat and pressure - Apply PLA lining for improved food-contact protection	- Fully compostable - Utilizes agricultural byproducts efficiently
Mycelium Base + Bagasse Lid	- Grow mycelium into rigid bases in shaped Molds - Attach lightweight bagasse lids for sealing and stacking	- Fully home-compostable - Ultra-low energy manufacturing (natural growth)
Areca Palm + Sugarcane Bagasse	- Shape Areca sheaths into plates - Add bagasse surface layers where heat resistance or smooth finish is needed	- Local, natural material - Avoids complex synthetic layering
Paperboard + Biopolymer Layer	- Press paperboard into tray shapes - Laminate with biodegradable coating (like PHA) to allow water/oil resistance	- Recyclable under dry conditions - Compostable under specific composting setups

Manufacturing combinations at regional facilities ensures fast production, lower carbon emissions, and compatibility with high-volume railway catering operations.

3.3.4 Setting Up Regional Production Units

To meet the needs of the vast Indian Railways network sustainably, production facilities should be strategically located:

To minimize transportation emissions and operational delays, **Regional Production Units** should be set up near:

1. Large IRCTC base kitchens (e.g., Delhi, Mumbai, Chennai, Howrah)
2. Agricultural hubs (e.g., Maharashtra, Tamil Nadu for banana leaves and bagasse)

Benefits:

1. Lower transportation carbon emissions.
2. Faster delivery of fresh packaging stock to caterers.
3. Support for local economies and farmers.

3.4 Use and Maintenance

During onboard service, packaging must ensure:

1. **Hygiene**: Single-use, tamper-evident designs protect food during transport and serving.
2. **Thermal Performance**: Ability to retain meal heat without releasing harmful chemicals (unlike conventional plastics).
3. **Structural Stability**: Modular trays resist bending or leaking during serving, even on moving trains.

Enhancing the onboard dining experience through sustainable, high-quality packaging directly improves customer satisfaction scores — a key KPI under Indian Railways' modernization initiatives.

3.5 End-of-Life Recovery and Disposal

End-of-life management is the most critical phase where sustainability delivers maximum visible impact:

1. **Composting**: Materials like bagasse, banana leaves, and mycelium decompose within weeks under standard composting conditions.
2. **Recycling**: Cardboard components, if kept dry and clean, are easily recyclable through India's expanding dry waste recycling networks.
3. **Passenger Guidance**: Each tray can carry a **QR code** linking to simple disposal instructions — whether to compost, recycle, or return.
4. **Return and Reward Programs**: For premium reusable packaging solutions (e.g., premium mycelium boxes), return schemes can incentivize passengers (discount coupons, loyalty points).

By setting up waste segregation bins on platforms and inside trains aligned with the "Swachh Rail Swachh Bharat" mission, Indian Railways can capture maximum end-of-life value from sustainable packaging, while drastically reducing plastic litter around stations and tracks.

4. LCA for Proposed Sustainable Packaging

4.1 Introduction

To mitigate the significant environmental impacts identified in the current food packaging system of Indian Railways, a set of sustainable packaging alternatives has been proposed.

The alternatives include the use of banana leaves, sugarcane bagasse trays, mushroom mycelium trays, and recycled cardboard packaging.

4.2. Life Cycle Impact Assessment

Material	**CO_2e (g)**	**Energy Consumption (MJ)**	**Water Usage (L)**	**Waste Generation (g)**
Banana Leaf Tray	20	5	1	3
Bagasse Tray	30	8	3	5
Mushroom Mycelium Tray	25	6	2	4
Recycled Cardboard Tray	40	10	4	6

4.3 Interpretation

4.3.1 Global Warming Potential (GWP)

1. Banana leaves and mushroom mycelium offer the lowest carbon footprint, contributing almost negligible greenhouse gases when properly composted.
2. Bagasse trays, while requiring slight industrial processing, still generate less than one-sixth of the emissions from aluminium trays.
3. Recycled cardboard trays use energy in recycling plants but overall emit 80% less CO_2e than new PET trays.

4.3.2 Energy Consumption

1. Banana leaves and mushroom mycelium require minimal energy during preparation (mainly cleaning and shaping).
2. Bagasse and recycled cardboard involve some industrial energy input but remain far lower than the energy demands of mining and smelting aluminium or producing virgin plastics.

4.3.3 Water Usage

1. Banana leaves require only cleaning water.
2. Mushroom mycelium uses a little irrigation water during fungal growth, but overall water footprint is extremely low.
3. Bagasse processing involves moderate water for pulp forming, but significantly less than plastic or aluminium processing.

4.3.4 Waste Generation and End-of-Life

1. All four proposed materials are biodegradable or recyclable:
2. Banana leaves and mycelium fully compost within 30–60 days under natural conditions.
3. Bagasse is industrially compostable within 60–90 days.
4. Recycled cardboard can be recycled up to 7 times before losing fiber strength.
5. Thus, no persistent plastic waste or toxic residues are generated.

5. POLICY SUGGESTIONS

The Indian Railway Catering and Tourism Corporation (IRCTC) plays a crucial role in serving millions of passengers daily. With India's ambitious sustainability goals and global environmental trends, it is imperative that IRCTC revolutionizes its food packaging practices.

These recommendations focus on practical, impactful, and innovative solutions for sustainable food packaging, promoting circular economy principles, minimizing waste, and engaging all stakeholders.

5.1 Current Policies on Sustainable Food Packaging in Railways

1. **IRCTC Sustainable Procurement Policy (2023):** Indian Railway Catering and Tourism Corporation's Policy Initiative on Food Packaging Sustainability
    a. Requires vendors to use eco-friendly materials like biodegradable, compostable, or recyclable.
    b. Promotes bagasse-based packaging, replacing conventional plastics and foils.
    c. Mandates supplier compliance with environmental norms.
    d. Emphasizes life-cycle consideration, encouraging low-energy, low-waste options.
2. **Plastic Waste Management Rules (Amended 2021):**
    a. National Policy on Single-Use Plastics in Railways
    b. Bans on single use plastic (SUPs) items like polystyrene containers, plastic cutlery, and straws.
    c. Implemented across railways at stations and trains.
    d. Regulatory by MoEFCC (Ministry of Environment, Forest and Climate Change).
    e. Prohibits 19 types of single-use plastic items.
    f. IRCTC must ensure compliance to accelerate transition to sustainable alternatives.
3. **Environment Management Policy of Indian Railways:**
    a. Sustainable Packaging in Indian Railways
    b. Promotes green practices across services.
    c. Reduces carbon emissions by minimizing plastic usage.
    d. Implements solid waste management systems.
    e. Focuses on environmental stewardship.
    f. Aligns environmental goals with procurement, operations, and vendor practices.
4. **Swachh Rail Swachh Bharat Abhiyan - Cleanliness Campaign**

a. Promotes educating passengers and vendors about waste segregation, responsible disposal and awareness about eco-friendly packaging.
b. Focuses on cleanliness and proper waste disposal at stations and trains.
c. Enforced by Indian Railways and IRCTC.
d. Promotes waste segregation, awareness campaigns, and bin installation.
e. Encourages use of biodegradable packaging for composting and large volume management.

5. **Green Railway Vision 2030**
    a. Indian Railways' Strategic Vision for Net-Zero Carbon Emissions
    b. Aims for net-zero carbon emissions by 2030.
    c. Encourages innovative sustainable packaging as part of the green railway ecosystem.
    d. Focuses on transitioning to net-zero carbon emissions.
    e. Supports sustainable food packaging as part of a green logistics strategy.
6. **Vendor Tender Conditions by IRCTC**
    a. IRCTC Catering Tender Environmental Clauses
    b. Mandatory use of eco-friendly disposables.
    c. Prohibition of non-biodegradable materials.
    d. Packaging quality and sustainability checks during inspections.
    e. Focus Area: Sets contractual obligations for catering providers.

Impact on Packaging: Adherence to eco-packaging rules, including material type approvals, hygiene standards, and proper labelling.

5.2 International Food Packaging Policies Indian Railways Could Adopt

Indian Railways has made significant progress by banning single-use plastics and promoting biodegradable alternatives, but several advanced policies from other countries could further enhance sustainability, consumer safety, and circularity in its food packaging strategy.

1. **Mandatory Environmental Labelling (Italy)**
    a. Requires clear information on material composition and end-of-life disposal.
    b. Empowers passengers to sort and dispose correctly.
    c. Improves recycling rates and reduces waste contamination.
2. **Plastic Packaging Tax (Italy, EU)**
    a. Impose taxes on single-use plastic.
    b. Exemptions for recycled and compostable materials.
    c. Financial disincentives promote sustainable packaging.
3. **Strict Extended Producer Responsibility (EPR) Schemes (Germany, France, Japan)**
    a. Manufacturers responsible for packaging lifecycle.
    b. Ensures recyclability or reuse.
    c. Implements robust collection and recycling systems.
4. **Minimum Recycled Content Mandates (EU, Japan)**
    a. Regulations mandate a specific percentage of recycled material.
    b. Encourages use of recycled plastics and papers.
    c. Promotes circular economy.
5. **Ban on Harmful Chemicals in Packaging (Denmark)**
    a. Bans PFAS use in paper and cardboard.
    b. Reduces health risks from chemical migration.
    c. Ensures safer food service.

6. **Smart Packaging and Traceability (EU, Japan)**
    a. Encourages monitoring of food safety, freshness, and traceability.
    b. Enhances food safety.
    c. Allows passenger check of origin and expiry.
    d. Supports recalls if needed.
7. **Minimalistic and Reusable Packaging Mandates (EU)**
    a. Encourages minimalistic design and reusable packaging.
    b. Reduces total packaging waste.
    c. Promotes use of returnable containers.

5.3 Policy Recommendations for Sustainable Food Packaging in Indian Railways

1.Incentives and Economic Tools

Catering Contractors and Suppliers' Responsibility

a. Extended Producer Responsibility (EPR)

1. Require contractors and suppliers to collect and recycle packaging waste.
2. Tying contract renewals to waste reduction metrics.
3. Shifts responsibility from Indian Railways to a shared responsibility model.
4. Tie performance bonuses to measurable waste reduction and recycling rates.

b. Tax Rebates and Vendor Incentives

1. Financial incentives for vendors exceeding sustainability benchmarks.
2. Introduce rewards for vendors exceeding basic sustainability norms.
3. Allowing passenger-owned containers for snacks and beverages.
4. Encourages voluntary compliance, innovation, and customer participation in green practices.

c. Reuse and Refill Systems

1. Introduce returnable steel or fiber containers for frequent travelers.
2. Allow passengers to bring their own containers for snacks and beverages.
3. Reduce single-use waste and engage passengers in circular practices.
4. Launch reuse programs with steel or fiber containers.
5. Encourage voluntary compliance, innovation, and customer participation in green practices.
6. Introduce tax rebates, bonus contracts, or recognition for vendors exceeding sustainability requirements.
7. Deploy reusable food containers for passengers to return in exchange for reward points or small discounts.

2. Infrastructure and Waste Management

a. Onboard Composting and Segregation

1. Install Modular Composting Units for biodegradable waste processing (e.g., food scraps, bagasse) importantly on Long-Distance Trains
2. Mandate color-coded bins (**green for compostable, white for recyclable, black for landfill)** on all trains and platforms for easy waste segregation.

3. Train staff and passengers on proper disposal practices.
4. Limited to pilot programs and some stations.
5. Improves waste volume reduction and disposal hub efficiency.

b. Local Sourcing and Circular Economy Partnerships

1. Prioritize locally produced packaging to reduce transport emissions.
2. Partner with regional composting/recycling facilities to reduce waste.
3. Support rural economies and reduce carbon footprint.
4. Promote local economy and environmental sustainability.
5. Encourage partnerships with local recycling/composting facilities for end-of-life processing.

3. Design and Innovation

a. Standardized, Minimalist Packaging-Design Guidelines for Packaging

1. Minimize material use and empty spaces.
2. Promote modular/stackable formats.
3. Impacts - Lower material costs and optimize storage/transport, Reduce material consumption, carbon footprint, and logistics complexity.

b. Smart Packaging and Traceability -QR Codes on Food Packaging

1. Display material type, disposal instructions, and sourcing details.
2. Enhance transparency and educate passengers on proper disposal.
3. Launch awareness campaigns about segregation and green packaging benefits.
4. Boost transparency, facilitate compliance tracking, and build responsible passenger culture.
5. Not yet implemented in any country.
6. Increases transparency and allows IRCTC to monitor vendor compliance.

4. Passenger and Staff Engagement

a. Awareness Campaigns and Training - Railway Sustainability Initiatives

1. Conduct bi-annual training for catering staff on sustainable materials, segregation, and passenger communication.
2. Launch passenger campaigns promoting correct disposal practices.
3. Build a sustainability culture across the railway ecosystem.
4. Formalize annual or bi-annual training modules.
5. Promote eco-friendly practices to improve system credibility and execution.

b. Green Train Certification - "Green Train" Rating System

1. Evaluates packaging sustainability, waste management, and carbon emissions.
2. Fosters competition for eco-performance improvement.
3. Previously focused on energy efficiency.
4. Suggested policy includes food packaging standards, carbon emissions, and waste management.
5. Encourages competition and improvement, similar to energy star ratings.

6 Conclusion

Indian Railways, serving millions of passengers daily, faces significant environmental challenges due to the large-scale use of non-biodegradable food packaging materials.
Our Life Cycle Assessment (LCA) of the existing system highlighted high carbon emissions, plastic waste generation, and operational inefficiencies.

Survey insights showed that 80% of passengers believe the current packaging is unsustainable and are willing to pay extra for eco-friendly alternatives.
This strong public support reinforced the need for a shift toward sustainable practices.

In response, the project proposed a **modular food packaging system** made from **smart combinations of sustainable materials** like recycled cardboard, bagasse, banana leaves, palm leaves, and mycelium.
These combinations address both functional needs and environmental concerns.

Additionally, the project outlined strategies for **sustainable production**, **efficient distribution**, **improved passenger experience**, and **eco-friendly disposal**.
Policy recommendations such as **QR-code-based disposal guidance**, **mandatory biodegradable materials**, and **return incentives** were developed to support implementation.

Overall, this project presents a practical, scalable, and sustainable pathway for Indian Railways to modernize its food packaging system, reduce environmental impact, and enhance passenger satisfaction.

7 References

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