TRANSFORMING WASTE INTO VALUE

Unlocking the potential of Food Waste Valorisation in India

A Scoping Paper on the Opportunity for India to create value from Waste

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FOREWORD

India wastes a colossal amount of food each year. In rural areas, the problem arises largely from post-harvest and supply chain losses caused by weak cold chains, inadequate storage, and poor handling. In urban areas, households, retail outlets, and food services generate waste through overbuying, buffet discards, and convenience-driven consumption. While preventing food waste at source and redistributing surplus to those in need remain the most effective and desirable solutions, the reality is that large quantities of food still end up in landfills, with significant portions incinerated and some composted.

Food waste valorisation offers a more promising alternative. By converting unavoidable and inedible waste into valuable resources, it goes beyond disposal to recover nutrients, energy, and materials. This not only reduces emissions and environmental burdens but also creates new opportunities for economic value and social impact, making it a vital pillar of the circular economy.

Technological innovation is central to this shift. India is already experimenting with biological, chemical, and thermal solutions—such as anaerobic digestion, pyrolysis, fermentation, and green extraction—to produce biogas, fertilisers, biofuels, nutraceuticals, and bioplastics. Emerging business models reinforce this potential: from Saving Grains' protein-rich flours and The Misfits' sustainable spreads to Wastelink's livestock feed and Dharaksha's biodegradable packaging. These ventures demonstrate how food waste can be transformed into products that are good for people, the planet, and the economy. The RUCO (Repurposed Used Cooking Oil) initiative of FSSAI is another example of how waste streams can be channelled into biodiesel, reducing both health risks and environmental impacts.

Realising this potential will require robust policy, greater investment in infrastructure, and active collaboration across government, private sector, and civil society. While schemes such as PM Kisan Sampada Yojana and GOBARdhan are important starting points, India still needs a unified national strategy and strong regulatory framework. Lessons from global leaders like South Korea and Germany highlight the value of combining regulation, innovation, research funding, and public-private partnerships. DBT-BIRAC is already fostering this space by supporting innovators through a structured pipeline of grants, incubation, and scale-up funds, enabling ideas to become commercially viable solutions.

This scoping report is intended to serve as both a knowledge resource and a roadmap. By presenting data, case studies, technologies, and policy insights, it will help policymakers, businesses, researchers, and civil society actors understand the scale of India's food waste challenge and the opportunities that lie in valorisation. Most importantly, it aims to inspire collaborative action to unlock value from waste and move India closer to a resilient and sustainable food system.

By treating food waste not as a burden but as a resource, India can turn a pressing challenge into an engine for resilience, sustainability, and inclusive growth.

Pawan Agarwal
CEO, Food Future Foundation (Co-Lead of COFTI)

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1. Introduction

Background

India is one of the largest food producers in the world, thanks to its diverse agro-climatic conditions and initiatives to achieve food self-sufficiency. India leads in producing cereals, lentils, fruits, vegetables, spices, milk, eggs, meat, and seafood. In 2020-21, agriculture contributed 19.9% to the national GDP, according to a NABCONS study commissioned by the Ministry of Food Processing Industry, Government of India.

However, this agricultural abundance is accompanied by a parallel crisis: food loss and waste (FLW). The Food and Agriculture Organization (FAO) estimates that 40% of India's food is lost or wasted, making us the second-largest food waste generator globally.

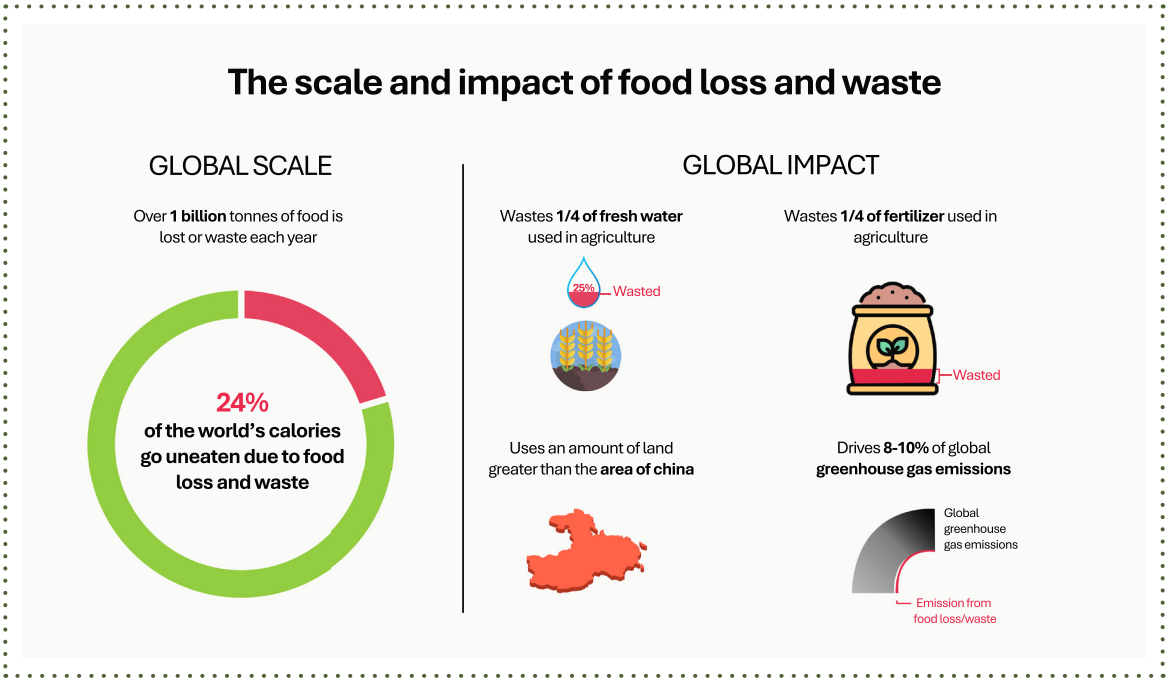
Estimates suggest India loses approximately 74 million tonnes of food annually, amounting to nearly 8% of global food waste (UNEP, 2024), valued at around ₹1.52 lakh crore (USD 177 Billion). Significant portion of food is lost before reaching consumers due to infrastructure challenges in the supply chain such as cold storages.

Additionally, food waste occurs at the household, retail, and food service levels, which include restaurants, hotels, educational institutions, and offices. According to the UN's Food Waste Index Report 2024, Indian households waste an estimated 78.2 million tonnes annually, or 55 kg per capita.

This amount of food waste, if prevented, can fulfil approximately 26.5% of the total per person annual staple food requirement in the country, that is 207.5 kg per capita per year (WRI, India).

The issue of FLW is not just an economic liability but also an ecological and social imperative for India, particularly when over 194 million Indians remain undernourished (FAO, 2022) with a ranking of 105 out of 127 countries assessed in the 2024 global hunger index.

The Impact of FLW



Source: ***World Resources Institute***

Environmental Costs

As the world's most populous country, India is the third largest emitter of greenhouse gases in the world, after China and the US. And as one of the largest global food producers, we are also the second largest emitter from agricultural land processes. These emissions can have severe environmental implications, including pushing up temperatures and contributing to climate change as well as to food insecurity.

Economic Costs

Globally, food loss and waste costs $1 trillion annually.

NABCONS also estimated that the total monetary loss was around 2.35% of the national GDP (at current prices for Q1 of 2022-23).

In India, the economic cost of post-harvest losses of 54 crops was estimated to be ₹1,527.9 billion ($18.5 billion) in 2020-21. Fruits, vegetables, and animal products accounted for nearly 60% of these losses. Wasted food also means wasted resources such as water, energy, and labour, exacerbating the financial burden.

Relevance of FLW on Sustainable Development Goals (SDGs)

By reducing food loss and valorising food waste, we advance multiple SDGs at once-supporting people, planet, and prosperity in a more integrated and sustainable way.

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SDG 2 – Zero Hunger:

Reducing food waste helps ensure more food reaches people who need it, supporting global efforts to end hunger and improve food security.

SDG 12 – Responsible Consumption and Production:

Target 12.3 specifically aims to halve per capita global food waste and reduce food losses along production and supply chains by 2030.

SDG 13 – Climate Action:

Wasted food contributes significantly to greenhouse gas emissions. Cutting food waste reduces pressure on natural resources and lowers emissions.

SDG 6 & 15 – Clean Water and Life on Land:

Producing food that is never eaten wastes water and degrades ecosystems

Food Loss

Food loss refers to the decrease in the quantity or quality of food resulting from decisions and actions by food suppliers in the chain—excluding retailers, food service providers, and consumers. It typically occurs during production, post-harvest, storage, processing, and transportation.

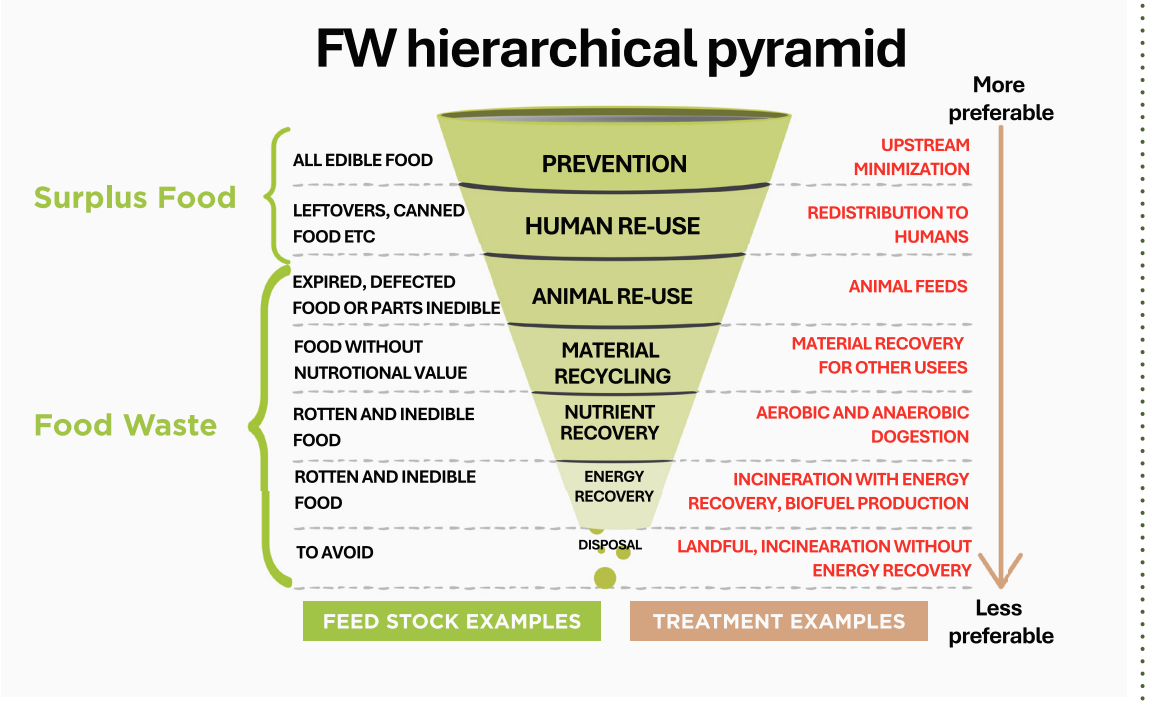
Example: Crops left unharvested or spoiled during transport due to poor infrastructure.

Food Waste

Food loss refers to the decrease in the quantity or quality of food resulting from decisions and actions by Food waste refers to the discarding or alternative (non-food) use of food that is safe and nutritious for human consumption, at the level of retailers, food service providers, and consumers. It usually happens at the end of the food supply chain.

Example: Edible food thrown away by households or restaurants due to over-purchasing or confusion over expiry dates.

A hierarchical pyramid approach highlights pathways for managing food waste. The ideal solution of course is preventing waste entirely, but other strategies, such as reusing or repurposing, offer practical ways to reduce environmental impact and foster sustainable consumption.



**SF: Surplus food*

**FW: Food waste*

Source: "A Hierarchical Pyramid for Food Waste Based on a Social Innovation Perspective (2021)

The most effective approach to addressing FLW is to Prevent, Rescue, Repurpose, Recycle

In the Indian context, the following interventions are particularly critical for reducing FLW across the food system:

- Strengthening the cold chain infrastructure post-harvest.
- Reducing time from farm to market through streamlining supply chain with efficient logistics, better market linkages, and digital traceability systems.
- On-farm training, proper handling techniques, low-cost storage methods
- Improved processing & packaging solutions.
- Education and awareness at consumer, retail and food business level.
- Re-distribution of surplus food (packaged and un-packaged).
- Policy frameworks to encourage adoption of FLW.

While reducing food waste entirely is the most efficient, cost-effective, and environmentally acceptable solution — with valorisation as a next-best option

Food Waste Valorisation

Food waste valorisation is the process of converting food waste and byproducts into valuable products, effectively turning waste into a resource. This approach aims to minimize waste disposal, reduce environmental impact, and potentially create economic value by extracting useful materials or generating energy.

Various types of food waste, such as waste from fruit, vegetables, grains, and other food production and processing, contain important bioactive compounds, such as polyphenols, dietary fiber, proteins, lipids, vitamins, organic acids, and minerals, some of which are found in greater quantities in the discarded parts than in the parts accepted by the market. These bioactive compounds offer the potential to convert food waste into value-added products, and nutritionally rich foods, bioplastics, bioenergy, biosurfactants, biofertilizers, and single cell proteins.

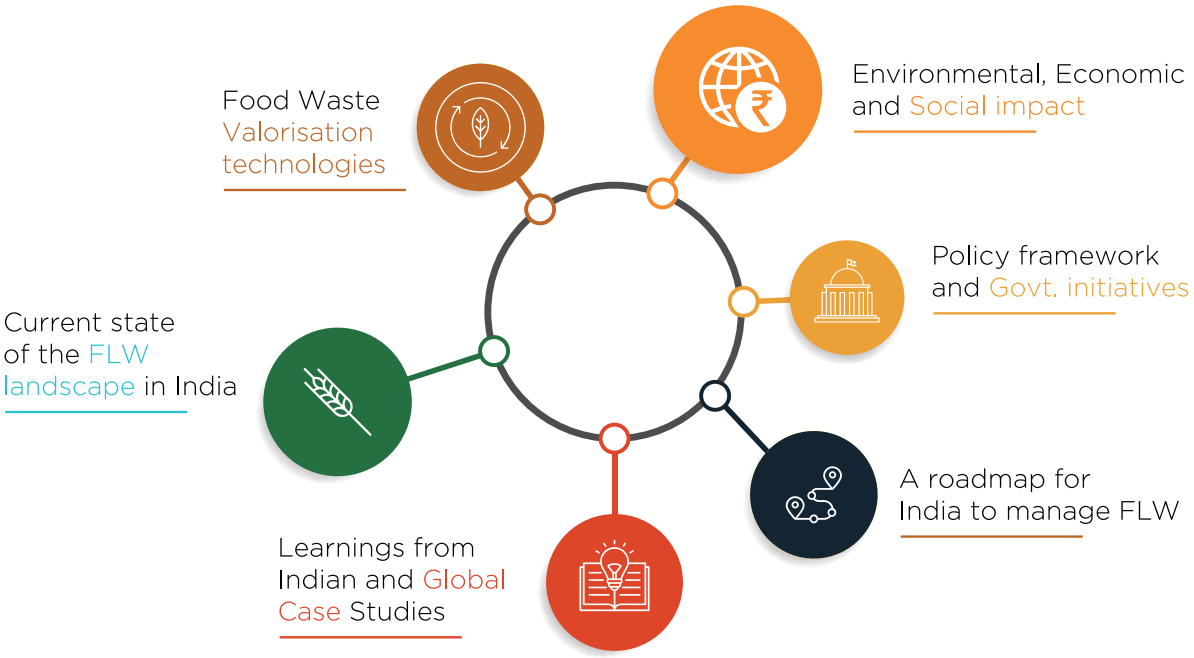
Upcycling food is also an ancient tradition based on the philosophy of using all of what you have. It's yet another way of valorising of what would otherwise be wasted food. Upcycled food is about reducing food waste, by creating high quality, nutritious food products out of the nutrients that slip through the cracks of our food system.

The concept of food waste valorisation, which focuses on finding value in food waste rather than simply discarding it, has been gaining traction in recent decades, particularly with the growing concern on the environmental and economic impacts of food waste.

Scope

The objective of this report is to build awareness about the potential of converting food waste into valuable resources, outlining the benefits, technologies, and challenges associated with it. It aims to explore the role food waste valorisation can play in fostering a circular economy.

The various aspects covered in this report are:



By covering these aspects, the report aims to provide a comprehensive understanding of food waste valorisation, its potential benefits, and the challenges that need to be addressed to realize its full potential.

Ultimately, it seeks to encourage adoption of strategies, infrastructure and technologies for India to promote a more sustainable and secure food system.

Methodology and Data Sources

The methodology for information and data collection for this report involves a **mixed-methods approach,** combining quantitative and qualitative data:

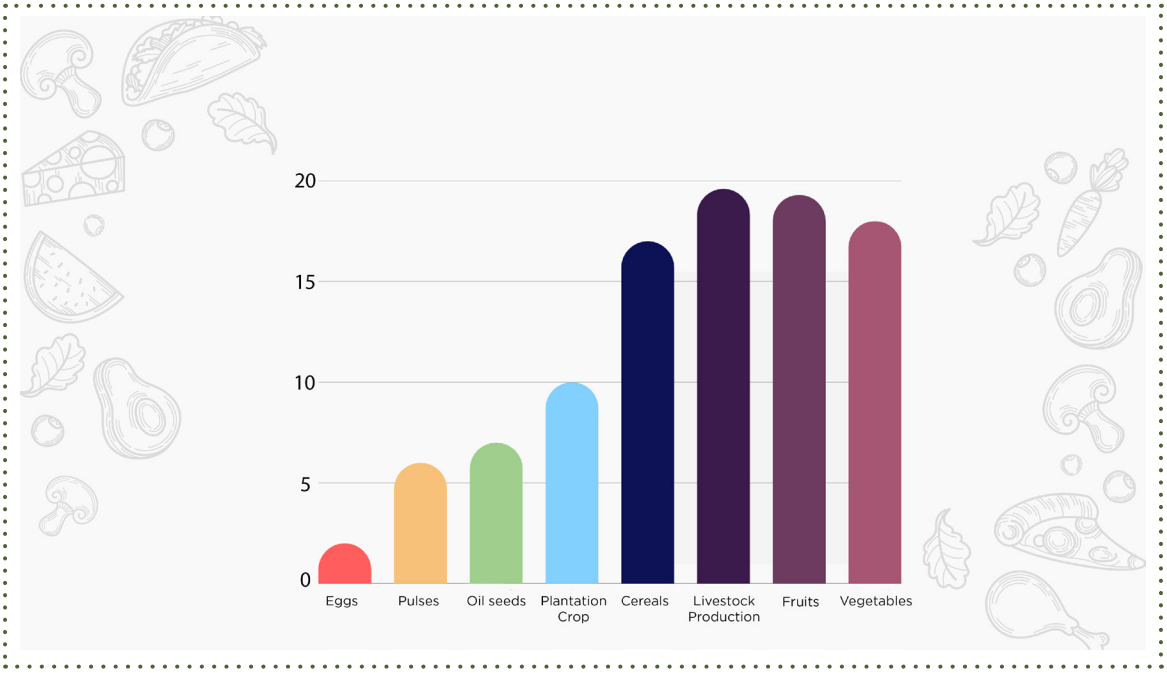
- **Secondary Data Review:** Analysis of government reports (e.g., FSSAI, MoFPI), academic studies (NABCON), industry publications, and international reports (FAO, UNEP).
- **Case Studies:** Documentation of food waste management and valorisation projects in select Indian states (e.g., Kerala, Maharashtra, Punjab) and commercially viable upcycled food startups.

2. The Food Loss & Waste Landscape in India

In India, approximately 74 million tonnes of food are wasted annually accounting for nearly 10% of the total foodgrain and horticultural output. India's annual post-harvest loss is estimated at ₹1.5 trillion (~USD 18.5 bn).

Post harvest and supply chain losses in India are substantial across all commodity groups

Losses in monetary value (%) of different commodities/crops, India, 2020-21



Food Groups	Source of wastage
Cereals	Threshing, Drying, Storage
Pulses	Drying inefficiencies, rodent damage
Fruits Vegetables	Harvesting, Transport without cold chain, market handling
Eggs	Breakage, Poor packing
Meat Fish	Inadequate icing, transport delays
Milk	Chilling gaps
Spices	Grading, packaging, transportations, storage
Plantation crops (cashew, areca nut) Shugar Cane	Drying, Storage
Oil seeds	Threshing, Winnowing, Drying, Storage

Source: "Study to determine post-harvest losses of agri produces in India (2022)," MOFPI and NABCONS

Estimated value of FLW from the above food groups amounts to approximately ₹92,651 crore (0.6% of GDP) annually (NABCONS, 2022).

According to the Food Waste Index Report 2024, Indian households alone discard an estimated 78.2 million tonnes of food annually, averaging 55 kg per person.

While the data for households is limited and fragmented, India lacks high-confidence national data for food services and retail sectors, with most available estimates based on sub-national or indirect modelling (UNEP, 2024).

This emphasizes the need to develop a standard method of defining, measuring and monitoring food waste comprehensively at the subnational and national levels. Such a standard will help provide strong evidence to guide a national strategy for food waste prevention and reduction.

(Source: World Resource Institute India, 2025)

FLW Initiatives across Urban and Rural India

Urban and rural India experience this crisis differently. While urban areas experience more waste at the consumer and retail levels, rural areas suffer from substantial post-harvest losses. Urban consumers generate large plate and packaging waste volumes owing to overbuying and convenience diets, while rural producers lose more in the fields and mandis (wholesale markets) because of bruising, spoilage, and delays in transport (UNEP, 2024).

Under the **Pradhan Mantri Kisan Sampada Yojana**, investments in integrated cold chains and packhouses curb perishability at source (MoFPI, 2024). **FSSAI's "Save Food, Share Food"** guidelines empower retailers and caterers to donate surplus safely, while the **Friends of Champions 12.3 India** network mobilises agribusinesses, governments and NGOs around measurable 50%reduction targets (FSSAI, 2024; WRI India, 2025).

Retail and foodservice waste—though largely unmeasured at scale—compound the problem through unsold perishables, buffet discards, and institutional leftovers (FAO, 2021).

The Indian Food Banking Network (IFBN) has built a federated platform that aggregates surplus edible food from manufacturers, retailers and farmers and distributes it through over 500 partner NGOs in 20 states. Since 2017, IFBN has facilitated the rescue and redistribution of more than 100 million meals, effectively diverting nutritious food from waste streams into community kitchens and shelters.

NoFoodWaste leverages an app-based, real-time matching system to connect surplus food donors—restaurants, caterers and event managers—with NGOs and relief organisations. Operating in over 25 cities, it redirects perishable inventory within minutes, preventing both edible loss and logistics bottlenecks. To date, NoFoodWaste has facilitated the recovery of over 5,000 tonnes of food .

Feeding India Founded by the Zomato group in 2014, Feeding India partners with hotels, caterers and retail outlets to collect edible surplus and channel it through a network of 6,000+ NGOs across 50+ cities. The initiative has rescued over 40,000 tonnes of food and delivered 40 million meals, reducing pressure on waste management systems while addressing urban hunger .

Goonj's Anna Data Goonj's Anna Data programme repurposes its established clothing-distribution network to rescue surplus staple grains from urban donors and deliver them to rural communities. In 2023 alone, Anna Data redistributed 5,000 tonnes of grains—otherwise at risk of spoilage—across remote districts, avoiding an estimated 2,500 tonnes of post-harvest loss .

Every tonne of food “lost” is also an opportunity

By integrating these redistribution channels with on-site composting, anaerobic digestion, and value-addition facilities, supported under governmental schemes, India can close the loop on edible and inedible fractions alike, transforming loss into both social impact and economic opportunity.

India’s growing valorisation ecosystem is beginning to convert food loss into tangible value across rural and urban contexts. Grassroots innovators like Saahas Zero Waste and digital platforms such as Recykal are enabling the conversion of organic discards into biogas, biofertiliser, animal feed, and industrial inputs.

In Uttar Pradesh, over ninety thousand panchayats operate compost and vermicompost units, significantly reducing dependence on synthetic fertilisers. Companies like Loopworm and ProteiNext upcycle agricultural by-products into insect protein for poultry and aquafeed, displacing resource-intensive fishmeal.

Complementing these efforts, IIT Guwahati’s rapid composting technology and mushroom cooperatives in Odisha are demonstrating how nutrient-rich waste can fuel income-generating models.

Together, these decentralised, food-focused valorisation strategies present a scalable path to mitigate post-harvest losses, support circular economic growth, and reinforce national food and nutrient security.

By embedding waste valorisation across the supply chain, India can turn loss into value and resilience.

3. Technologies for Food Waste Valorisation

The economic potential of food loss and waste byproducts is immense. From biofuels and bioplastics to animal feed and upcycled products, these innovations offer significant benefits for individuals, businesses, and the economy. There is even a lot of scope for utilising fundamental food processing technologies to extract valuable nutrients and other ingredients from food waste, providing a large opportunity for addressing the double burden India faces of over and under nutrition.

Types of Waste Valorisation Technologies

Food waste valorisation technologies encompass biological, chemical, and physical methods including anaerobic digestion, fermentation, pyrolysis, and green extraction techniques. Advanced methods like 3D printing with food waste and precision fermentation are also emerging, offering innovative ways to repurpose food waste.

Emerging streams in food waste valorisation are increasingly tapping unconventional feedstocks and streams to boost yields and broaden revenue models. Agro-industrial byproducts such as corn husks, brewers' spent grain and cassava leaves now serve as low cost substrates for microbial protein and bio-fertiliser production, delivering >45% protein conversion as demonstrated in pilot trials at the Indian Institute of Science in Bengaluru.

Oil cakes (e.g., mustard, groundnut) and rice bran are being processed via green super critical CO2 and enzyme assisted extraction to recover 7-8% antioxidant rich tocopherols and up to 18% protein isolates for nutraceutical and feed applications. Another instance is that of spent coffee grounds and bakery offcuts being reformulated into fermentation media that match conventional yields at one quarter the cost, substantially lowering OPEX for bio processors.

Such food processing residues like fruit peels, pomace, and brans are being tapped for bioactive compounds like antioxidants, enzymes, dietary fibers, and essential oils through green extraction methods. Research has shown strong potential in valorising mango and banana peels, cereal brans, and dairy whey into functional ingredients for food, pharmaceutical, and cosmetic applications.

Anaerobic digestion (AD) is one of the most practical and scalable technologies which helps convert organic waste into biogas for energy and digestate for use as fertilizer (Rai et al., 2025). A case in point is a full-scale digester in Goa, which co-treated kitchen and sewage waste and achieved methane yields of up to 71%.(Shet & Mutnuri, 2021).

WasteVentures and Hasiru Dala partner with municipalities and community groups to feed segregated wet waste into small-scale anaerobic digesters, producing biogas for local kitchens and digestate for on-site fertiliser.

Thermo-chemical methods like pyrolysis and gasification offer another route, using high heat to transform food waste into biochar, syngas, and bio-oil. With India's abundant biomass and food waste streams, these technologies could produce millions of tonnes of low-carbon fuels annually, helping reduce landfill pressure and meet clean energy targets. (Kshirsagar et al., 2021).

Cities like Bengaluru processes over 600 tonnes of organic waste daily through large-scale aerobic and vermicomposting facilities managed by the Karnataka Compost Development Corporation (KCDC) (The Hindu, 2021). These low-tech, low-cost systems are increasingly complemented by decentralised models run by NGOs and startups (Rai et al., 2025).

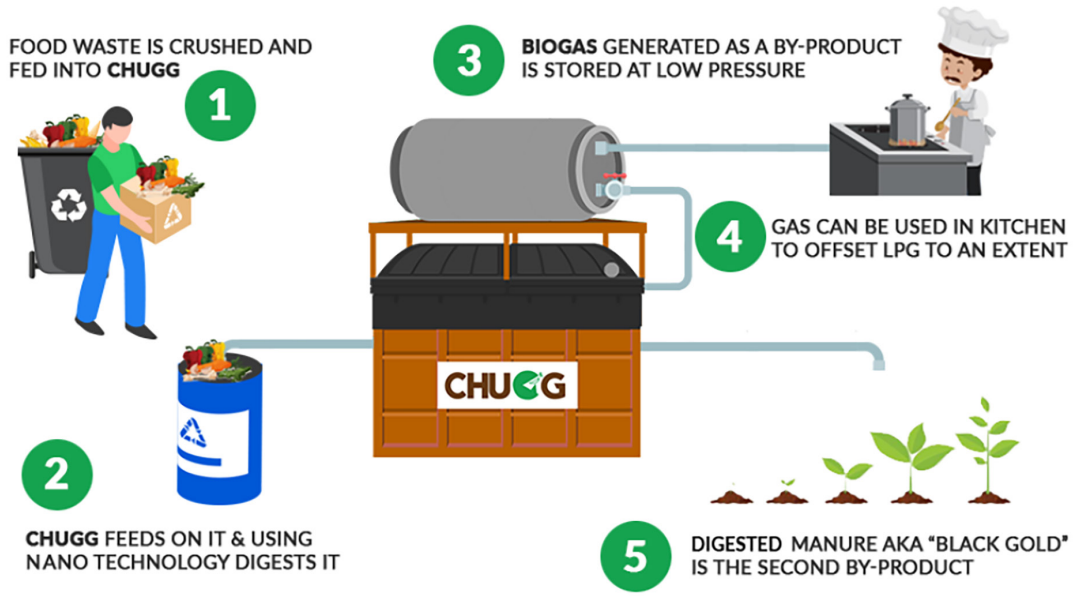
Food waste can be transformed into eco-friendly biofuels like ethanol, biodiesel, hydrogen, and methane using various processes, such as anaerobic digestion and fermentation.

Waste Valorisation Technologies Implemented in India

A. Converting Food Waste to Biofuel

Chennai-based Avris Environment Technologies has developed CHUGG, a bio-digester that converts food and garden waste into biogas and organic manure, ideal for hotels and residential complexes.

How does it work ?



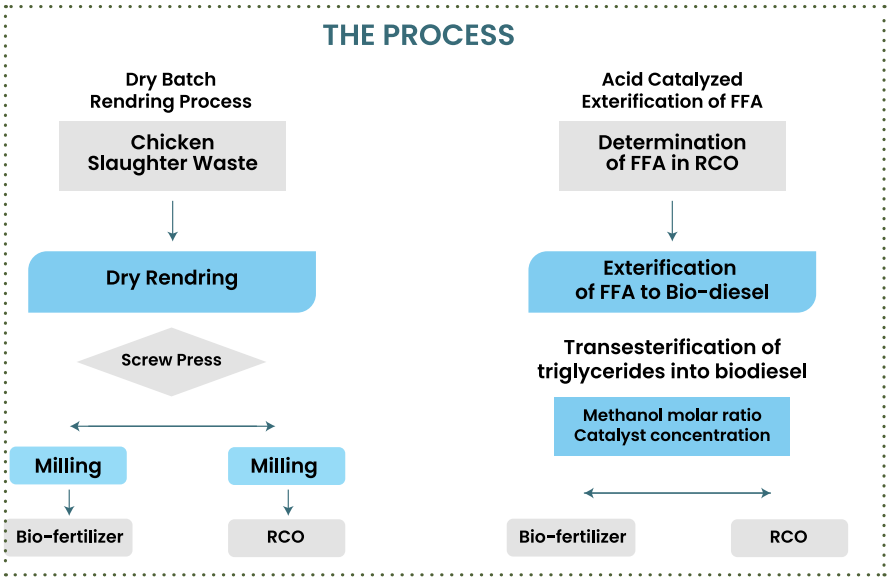
Source: "Study to determine post-harvest losses of agri produces in India (2022)," MOFPI and NABCONS

B. Producing biodiesel from chicken slaughter waste

Chicken Slaughter Waste Conversion: This patented process was created by a researcher in Kerala and it efficiently repurposes waste, creating multiple revenue streams.

Outputs of chicken waste processing, including feathers, viscera, shank, and head

- **Protein Powder:** Made from 36% of the waste, sold at ₹35 per kg
- **Biodiesel:** Chicken oil accounts for 10% of the waste, of which 87% is converted to biodiesel, produced at just ₹36 per litre
- **Glycerol:** Leftover 13% chicken oil waste is converted to crude glycerol, utilised in pharmaceuticals and baking, sold at ₹90 per kg



Source: Poultry Trends

C. From Fish Waste to Fertiliser

The Central Institute of Fisheries Technology and the **Central Marine Fisheries Research Institute** have training programmes to create value-added products from fish waste. This has encouraged individuals to create fertiliser from the byproducts of the fish processing sector. Though these are still mostly on a small scale, there is potential to scale up and even replace more harmful synthetic fertilisers.

Source: Krishi Jagran

Techno-Economic feasibility of high value nutrients from valorisation of FLW in India

An important side stream from food loss and waste are the extractable nutrients, from macro and micronutrients to enzymes and other compounds that could be used in several industries. Several academic institutions and companies around the world are already investing in researching or implementing technologies to extract nutrients from their own waste streams.

We looked at some of the major streams from top fruits, vegetables, poultry which have the highest post-harvest losses to estimate the lost socio-economic value for India in terms of nutrients. This was done by pulling together data on food loss from the **2022W NABCONS study**, evaluating relevant food processing technologies for nutrient extraction and estimating the techno-economic potential of extracting nutrients from various food sources.

For estimation purpose, it has been assumed that a maximum of 20% of the nutrient from the waste stream is extractable and clubbed that with the global prices of the nutrients.

A conservative estimation indicates that at least 69 million tonnes of valuable nutrients can be valorised from India's post-harvest losses, worth nearly ₹2.5 lakh crores (USD 291 billion)

Fruit / Item	Annual Production in weight (mt)	% Waste/ Loss	Type of Waste	Wastage (mt)	Total solids in individual stream (%)	Total solids in weight (mt)	Nutrients in waste stream	Share of total nutrients in the waste	Recoverable qty (mt)	Price of nutrient (INR/kg)	Price of valorised waste (INR in crore)
Apple	55.8	42%	Pulp, Stalk, Peel, Seeds	23.56	17%	4.07	Dietary fiber	43%	1.73	300.0	31160
Mango	25.0	25%	Peel, Pulp	6.25	15%	0.94	Dietary fiber	13%	0.19	300.0	5820
Banana	14.2	60%	Banana peel	8.52	30%	2.56	Dietary fiber	51%	1.03	270.0	7093
Cauliflower	48.2	55%	Leaves	26.51	15%	3.98	Protein	28%	1.11	1000.0	11100
Onion	31.1	37%	Outer skin	11.51	15%	1.73	Flavonoids	15%	0.26	1000.0	2600
Potato (Dietary fiber)	48.2	20%	Peel, Pulp	9.64	20%	1.93	Dietary fiber	56%	1.15	300.0	3450
Potato (Starch)	48.2	20%	Peel, Pulp	9.64	20%	1.93	Starch	14%	0.27	60.0	162
Wheat	112.0	15%	Bran, Husk	16.8	89%	14.95	Dietary fiber	42%	6.28	150.0	37675
Wheat straw	112.0	50%	Straw	56.0	85%	47.6	Neutral Detergent Fiber	25%	11.9	80.0	9520
Paddy	125.0	20%	Husk	25.0	95%	23.75	Crude fiber	25%	5.94	50.0	2970
Rice (milled)	125.0	10%	Bran	12.5	90%	11.25	Oil	22%	2.48	300.0	7440
Mango kernel	25.0	25%	Mango kernel	6.25	85%	5.31	Fat	15%	0.8	300.0	2400
Chicken (Protein)	5.0	36%	Carcass rejection	1.75	90%	1.58	Protein	36%	0.57	1000.0	5700
Chicken (Fat)	5.0	36%	Carcass rejection	1.75	90%	1.58	Fat	10%	0.16	40.0	125
Chicken (Glycerol)	5.0	36%	Carcass rejection	1.75	90%	1.58	Glycerol	1%	0.02	60.0	12
Total	nan			nan		nan			16.21	nan	252524

Source: A techno-economic feasibility assessment of the lost value of nutrients from FLW of select base food groups in India conducted by Thinking Forks Consulting Pvt Ltd.

mt = million tonnes.

4. Emerging Business Models

Food waste valorisation offers significant economic benefits by transforming by side streams of FLW into valuable products, reducing disposal costs, and creating new revenue streams. Business models for food waste valorisation include waste-to-energy, material and nutrient recovery, often utilising technologies like anaerobic digestion, composting, and extraction of valuable compounds highlighted in the previous section of the report.

Start-ups and Circular economy ventures

A. Upcycling Brewers' Spent Grain

Brewers' spent grain (BSG), a nutritious byproduct of the alcohol industry, often ends up discarded. However, companies worldwide are recognising its value and exploring ways to repurpose it into new revenue streams.

Bangalore-based Saving Grains rescues spent grain from local breweries, transforming it into high-protein, fibre-rich products like flour, crackers, granola, and laddoos.

The company's processed BSG contains 22% protein, 45% dietary fibre, and 20% carbohydrates, with products priced between ₹60 and ₹199 per pack – a significant improvement over letting this resource go to landfills.

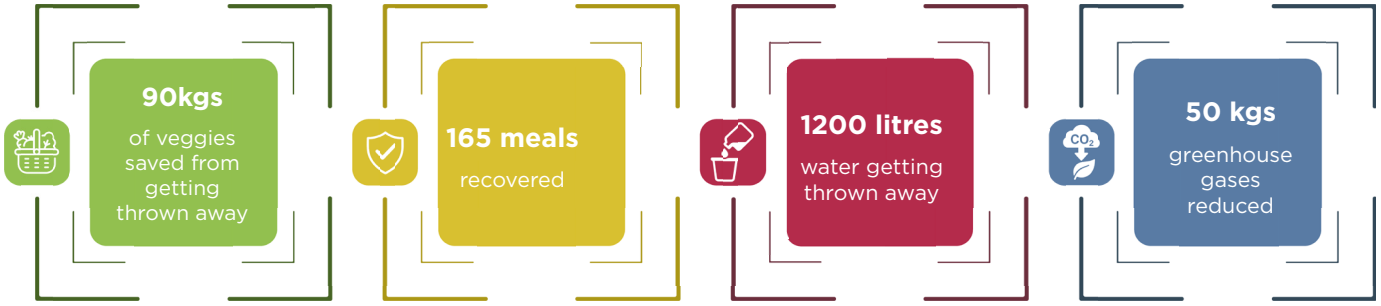
Source: Saving Grains

B. Rescuing Imperfect Produce

Repurposing imperfect produce offers a practical way to minimise waste while reintroducing high-value byproducts into production streams. Bruised or oddly shaped fruits and vegetables, peels, edible stems, and pulp can all contribute to creating sustainable, circular food systems.

Jaipur-based The Misfits specialises in transforming imperfect produce into spreads and snacks. For instance, their pesto incorporates carrot tops (40%), soft coriander leaves (13%), and nuts (26%), saving 48 grams of carrot tops per 190 grams of pesto from becoming waste. Similarly, their cocospread uses rescued pumpkin (28%), chickpea (17%), and nuts, repurposing 28 grams of pumpkin per jar.

The Misfits' products, **priced between ₹349 and ₹499**, exemplify how upcycling can combine sustainability with market appeal.



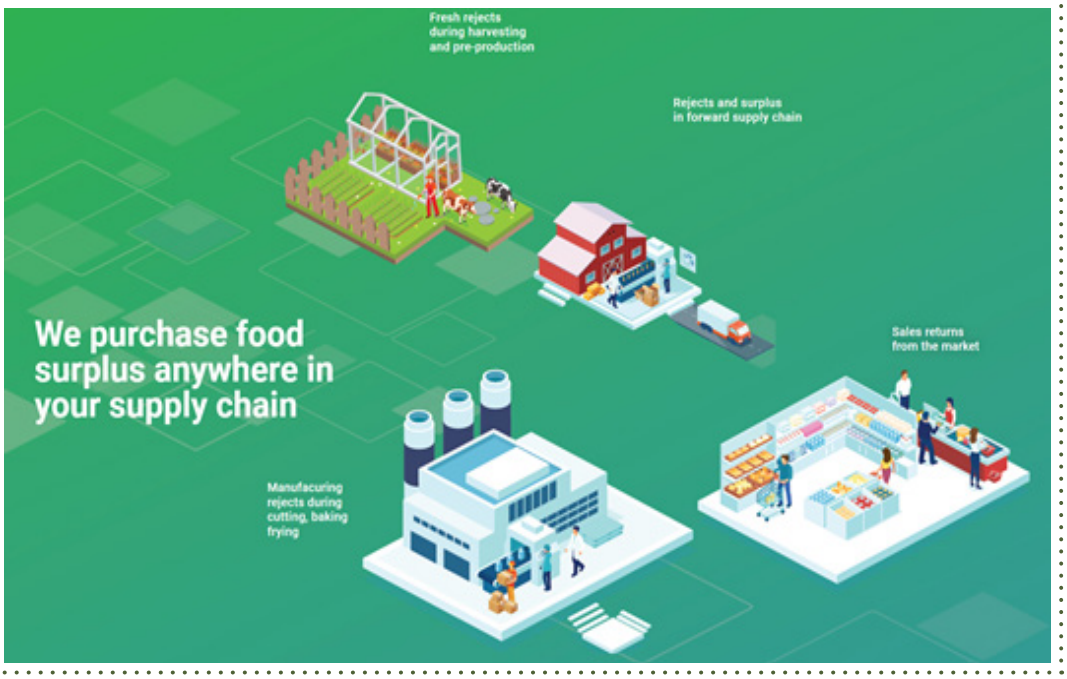
Source: The Misfits

C. Making Nutritious Animal Feed

Repurposing food waste into animal feed offers a sustainable way to manage waste while lowering the environmental footprint of conventional feed production.

New Delhi-based Wastelink transforms surplus food and byproducts into nutritionally rich livestock feed. **Their ecoFeed brand, made from bakery waste like breads and biscuits, increases feed palatability and boosts livestock yield by 15%.**

Wastelink has upcycled over 4,000 tonnes of food, handling more than 200 SKUs, while preventing 5,000 tonnes of greenhouse gas emissions and saving 15,000 litres of water. This innovative approach showcases the potential of food waste to create environmental and economic value.



Source: Wastelink

D. Creating Bio Materials

Food waste can also be transformed into eco-friendly bioplastics, biodegradable packaging, and biochemicals. Ingredients like starch from potato peels or cellulose from fruit and vegetable scraps are key raw materials for creating bioplastics used in food packaging and disposable utensils. Bio materials from food waste can reduce reliance on traditional plastics while addressing environmental challenges.

Delhi-based Dharaksha:

- Creates biodegradable packaging from paddy straw stubble, reducing air pollution caused by stubble burning.
- The material degrades within 60 days in normal soil conditions, offering a sustainable alternative to conventional packaging.

Source: Dharaksha Ecosolutions

Taruwar Agro:

- Converts banana tree waste into banana fibre for products like handicrafts, yarns, sanitary pads, and banana leather.
- Processes all parts of the banana tree, adhering to a zero-waste approach.
- India's banana industry produces 14.2 million tonnes annually, with nearly 60% of biomass left as waste, which Taruwar effectively utilises.

Source: Taruwar

Role of Public-Private partnership Model in FLW

Public-private partnerships (PPPs) could offer a promising approach to managing the Food Loss & Waste problem by combining public sector support with private sector expertise and resources to develop and implement effective solutions for reducing food waste, creating valuable resources, and promoting a circular economy.

Potential PPP business models in food waste valorization:

Anaerobic Digestion (AD) Plants:

Public entities can provide land and infrastructure for AD plants, while private companies manage the processing of food waste into biogas and digestate.

Composting Facilities:

PPPs can establish composting facilities, with public entities providing land and permitting, and private companies handling the composting process and marketing of compost.

Food Waste Recycling Centers:

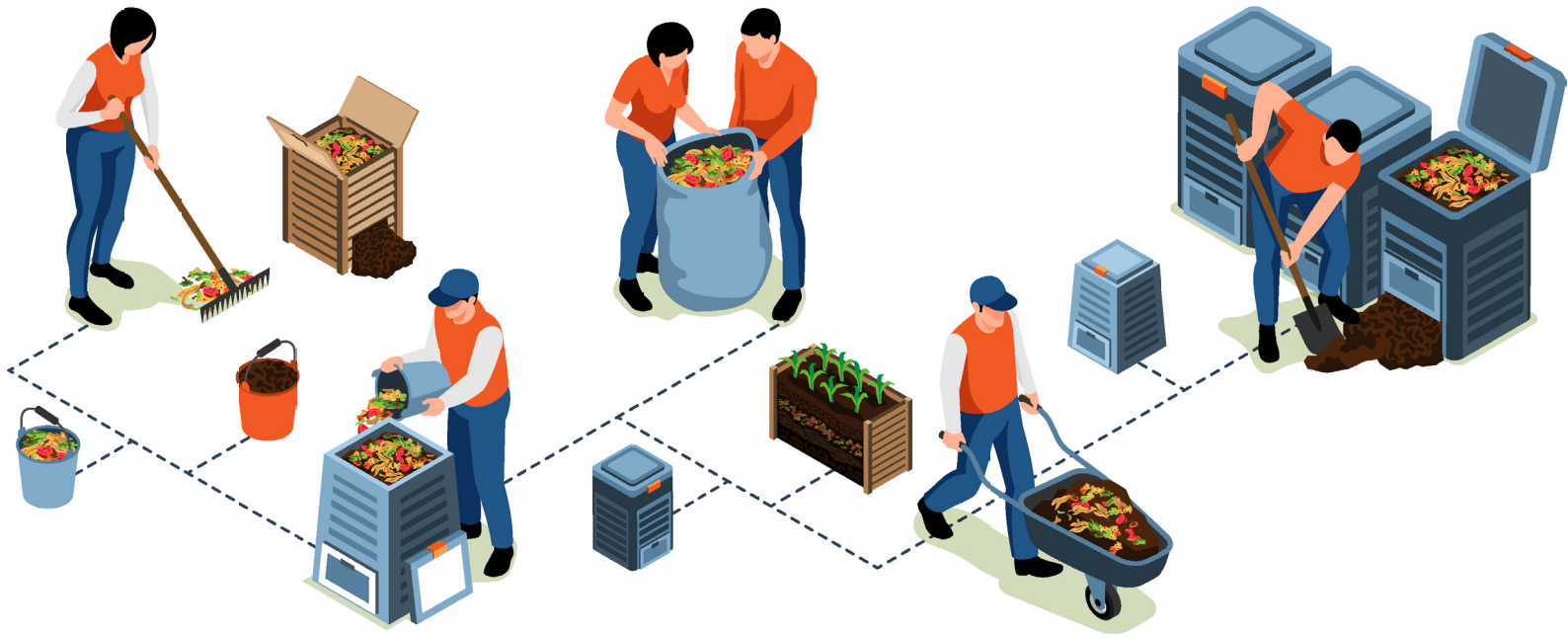
Public sector involvement can help establish collection and sorting infrastructure, while private companies focus on processing and valorizing different types of food waste.

Food Redistribution Networks:

PPPs can facilitate the establishment of networks that connect food businesses with charities and food banks, ensuring surplus food is redistributed to those in need.

Integrated Waste Management Systems:

PPPs can develop comprehensive waste management systems that incorporate food waste collection, processing, and resource recovery, optimizing the entire waste stream.



5. Government Initiatives and Policies

Reducing food waste is central to India's commitment to the UN 2030 Agenda for Sustainable Development under SDG Target 12.3. While the country has no unified national policy or specific food waste reduction targets, several initiatives have been introduced.

India's policy push—through schemes like GOBARdhan and Pradhan Mantri Kisan Sampada Yojana is laying the groundwork, but global efforts offer valuable parallels.

Select Government initiatives to minimize Food Loss & Waste in India:

- **Pradhan Mantri Kisan Sampada Yojana (PMKSY):**

  This central sector scheme, managed by the Ministry of Food Processing Industries (MoFPI), aims to minimize post-harvest losses through infrastructure development. It provides financial aid for establishing cold chains, value-added processing, and preservation facilities.

- **Operation Greens:**

  This scheme offers financial aid for setting up food processing projects, leading to the creation of infrastructure for food processing and preservation.

- **Save Food, Share Food, Share Joy Initiative:**

  This encourages food donation and redistribution through collaborations with NGOs and aims to reduce waste and malnutrition, particularly among schoolchildren.

- **Mid-Day Meal Scheme & Poshan Abhiyan:**

  These programs utilize surplus food to reduce malnutrition, indirectly contributing to food waste reduction.

- **FSSAI Initiatives:**

  The Food Safety and Standards Authority of India (FSSAI) promotes responsible consumption through campaigns like Jaivik Bharat and provides guidelines for safe food donation, including regulations for food recovery from businesses and institutions.

- **Cold Storage Act of 1976 & AMPC Act:**

  These regulations, though not directly focused on research, indirectly support food loss and waste reduction by providing guidelines for licensing and regulating the sale of stored produce.

A. Initiatives to addressing food loss

Implemented

Integrated Cold Chain and Value Addition Infrastructure Scheme:

- Supports cold chain development to minimise post-harvest losses.
- Created 38.82 lakh metric tonnes of preservation capacity and benefited 35.53 lakh farmers as of 2024.

Mega Food Park Scheme:

- Linked agricultural production to markets via integrated parks.
- While discontinued in 2021, operational projects continue to support value addition and minimise wastage.

National Policy on Biofuels, 2018:

- Targets blending ethanol and biodiesel with petrol and diesel.
- Promotes biodiesel production from used cooking oil.

B. Initiatives to address food waste

Implemented

Solid Waste Management Rules, 2016/2024:

- Mandates waste segregation at source for large establishments.
- Introduces the "polluter pays" principle for accountability in waste management.
- Promotes resource recovery in rural areas to prevent agricultural waste burning.

Set to come into force on October 1, 2025.

FSS (Recovery and Distribution of Surplus Food) Regulations, 2019:

- Ensures safe recovery and redistribution of surplus food.
- Initiatives like 'Save Food, Share Food, Share Joy' and the Indian Food Sharing Alliance promote food donations and logistics support.

Proposed

Compulsory Food Waste Reduction Bill (2018):

- Aimed to halve food waste in India by 2025 and achieve a 50% reduction by 2030.
- Focused on reducing food waste in supermarkets and supply chains by 30% from 2016 levels.

Remains unpassed.

C. Research funding in valorising food waste

There is research on-going on food waste valorisation in institutions across the country involved in Agriculture, Food Science & Technology, with several studies in FLW receiving small levels of funding from government departments. This indicates that the government does recognise food waste as an important area of concern that needs attention and action.

A global initiative by the Food and Agriculture Organization (FAO), has also funded studies in India, particularly in Andhra Pradesh, to assess food losses in specific supply chains (rice, chickpea, milk, and mango) and identify solutions.

Select research projects on food waste valorisation in India

Project Name	Institute/ Organisation	Funding Received (in INR lakhs)	Funding Body
Development of smart foods, biocomposites, green packaging, and bioenergy from agro-residues	**NIFTEM**	**72.3**	
Development of active intelligent packaging system with antimicrobial agents for fruits & vegetables	**NIFTEM**	**53.0**	
Valorization of Food Waste for Sustainable Development	**Manav Rachna Educational Institutions**	**30.0**	**Manav Rachna Vidyanatariksha**
Pineapple fruit waste (processing by-products) characterization and its utilization in development of millet based probiotic fermented products	**NIFTEM**	**28.1**	**MoFPI**
Utilization of industrial fruit and vegetable waste streams for production of 3D printed synbiotic foods	**NIFTEM**	**26.6**	**Department of Science and Technology (DST)**
Food waste to microbial polysaccharides by fed-batch fermentation: A study on the edible and broad-spectrum biofilm retrogression properties in association with VBNC state strains	**NIFTEM**	**24.4**	
Development of micro/nano anacardic acid from cashew nut waste as an effective alternative to synthetic food preservatives	**NIFTEM**	**19.2**	
Green technologies for the extraction of bioactive ingredients from millets species and incorporate into the sustainable community food system	**NIFTEM**	**5.0**	
Bioconversion of locally produced selected waste from post-production food manufacturing units (sugar industry or any other industry) using BSFL	**NIFTEM**	**2.5**	
Production of methyl cellulose from agricultural waste	**NIFTEM**	**NA**	
Characterization and utilization of paddy straw and other agro residues for conversion into pellets for co-firing in thermal power plants (TPP)	**ICAR (CIRCOT)**	**NA**	

The lack of robust Research & Development plans and funding to support technology development and innovation to tackle Food Loss & Waste is going to be a significant bottleneck in reducing its' economic, environmental and social impact on the food system in India.

6. Learnings from Global Case Studies

A. Philippines: High value nutrient business from valorised Fruit Waste

Global fruit major Dole Sunshine Company, set up a separate B2B business unit in 2021 called Dole Specialty Ingredients (DSI). At their factory in Philippines, DSI transforms plant/fruit side streams into high-value specialty ingredients to divert feedstock left behind in the fruit industry and utilise them in making value-added ingredients such as enzymes, extracts, oils, fibres and others. These high-value natural ingredients are used by the F&B, nutraceutical, and cosmeceutical industries.

Pineapple Fiber Powder

DESCRIPTION

DSI's 100% Natural Pineapple Fiber Powder is produced by minimal processing of Pineapple Pomace (pressed pulp). It is a free-flowing powder with a neutral taste, rich in Dietary Fiber and minerals such as Potassium and Magnesium.

Green Banana Powder

DESCRIPTION

DSI's 100% Natural Green Banana Powder is produced by minimal processing of freshly harvested green bananas from sustainably managed Dole's Banana plantations. Green banana is naturally rich in Resistant Starch which aids in better Gut Health and improved maintenance of the Digestive System. Green Banana Powder is also rich in minerals such as Potassium and Magnesium.

Source: Dharaksha Ecosolutions

B. South Korea: A Model Food Waste Recycling Programme – Govt. Initiative

South Korea's food waste recycling programme is among the most effective globally, combining innovative policies, advanced technologies, and strong public engagement. It prioritises waste reduction at the source and maximises resource recovery, aligning with the country's sustainability goals.

Core Features

- Mandatory Waste Separation: Since 2013, households and businesses have been required to segregate food waste from general trash, enabling efficient recycling.
- Pay-As-You-Throw Model: Residents pay based on the weight of food waste produced, often measured using smart bins with RFID technology, incentivising waste reduction.
- Resource Transformation: Collected waste is processed into compost, animal feed, and biogas, minimising environmental impact and ensuring sustainable reuse.
- Public Engagement: Education campaigns foster participation and shared responsibility for environmental protection.

Impact

- South Korea now recycles over 95% of its food waste, a leap from less than 5% in the 1990s. This achievement has reduced landfill use, lowered greenhouse gas emissions, and supported the production of renewable energy and high-quality compost. However, the system's high costs and maintaining output quality remain challenges.
- South Korea's approach demonstrates how policy innovation and public participation can drive transformative progress, setting a global benchmark for sustainable waste management.

C. Germany: Tafel Deutschland's Volunteer-Powered Food Rescue Network

Tafel Deutschland orchestrates a network of over 975 non-profit food banks nationwide, rescuing surplus edible food that would otherwise go to waste and distributing it—free or for a nominal fee—to 1.6–2 million people in need each year, nearly one-third of whom are children and youth. Operated almost entirely by a force of 60,000 volunteers and financed through private donations (no public funding), each local Tafel collects from retailers, manufacturers and farms, then redistributes 100 % donated food via weekly food parcels, social grocery stores and community meals. This volunteer-driven, large-scale model not only bridges excess and scarcity but also prevents millions of tonnes of perfectly good food from entering landfill.

D. United Kingdom: Bio-bean's Coffee-to-Fuel Biorefinery

Founded in 2013, Bio-bean operates the world's first commercial plant converting spent coffee grounds into advanced biofuels and biochemicals. Each year, the Cambridgeshire facility in the UK, now run by Envar Composting Ltd, processes roughly 50,000 tonnes of coffee waste sourced from major chains like Costa and Pret into 12,000 tonnes of Coffee Logs (sustainable biomass pellets) and 2,500 tonnes of Coffee Oil, a drop-in biofuel feedstock. The process yields 95% waste diversion from landfill and offsets over 20,000 tonnes CO2e annually by replacing fossil wood pellets and diesel. Bio-bean's model demonstrates how a single high-volume by-product stream can underpin a profitable circular enterprise, turning an urban waste challenge into scalable renewable energy and chemical outputs.

> Large-scale food waste valorisation is gaining momentum globally through industrial anaerobic digestion infrastructure.

In the UK, companies like ReFood operate multiple commercial-scale AD plants that convert surplus food including packaged retail waste into biomethane for the national grid and nutrient-rich biofertilizer.

Similarly, Dark Green is developing six urban food-to-energy plants across cities like Nottingham and Birmingham, each processing up to 60,000 tonnes of food waste annually and generating 7 MW of renewable energy, backed by long-term green gas support schemes.

E. United States: Artificial Intelligence Institute for Next Generation Food Systems (AIFS)

The AIFS, led by University of California Davis and including University of California Berkeley, the University of Illinois Urbana-Champaign, Cornell University and the University of California's Division of Agriculture and Natural Resources, was established in 2020 with a grant from the U.S. Department of Agriculture's National Institute of Food and Agriculture.

In its first three years, the institute has funded research projects on AI technology across the food system, from cheaper sensors for agricultural production to digital simulators to manage indoor farming and technology to predict the nutritional content of food.

Researchers from UC Davis and other institutions are using AI to reduce loss of tomatoes grown in California as they are trucked from field to cannery.

Pacific Coast Producers Cannery in Woodland, California, uses data every step of the way including sorting the fruit. Precision agriculture technology developed in Professor Earles' lab at UC Davis is being commercialized by Scout, a startup company based in Napa County and Davis. Instead of a farmer walking through their vineyard and inspecting vines in person, Scout's technology uses AI to analyze thousands of images of grapevines collected at ground level and provides insights.

F. United States: Upcycled Food Certification

The mission of the Upcycled Food Association is to champion upcycling as one of the most critical solutions to mitigate the climate crisis and advocate for the best interests of the upcycled food industry.

Upcycled Food Association is leveraging market forces to prevent food waste by coordinating hundreds of companies around the world and empowering millions of consumers to prevent climate change with the products they buy.

The Upcycled Certified program is designed to reduce food waste by promoting the upcycling food economy. Upcycled products use ingredients that have full nutritional value and are safe, but for various reasons, would have gone to waste.

7. Roadmap Ahead

India's food waste challenge presents both a critical concern and a significant opportunity. With 40% of food production lost or wasted, the country faces substantial economic losses of post-harvest waste alone. This wastage is particularly concerning given India's position as one of the world's largest food producers and yet more than 194 million Indians being undernourished and its significant contribution to global greenhouse gas emissions.

A comprehensive roadmap for addressing food loss and waste in India should focus on strengthening infrastructure, improving supply chain management, promoting sustainable consumption patterns, and fostering a supportive policy environment. This includes investing in cold storage, enhancing processing capabilities, raising consumer awareness, and implementing regulations that encourage food recovery and donation.

While existing initiatives, rather than laws, focus primarily on post-harvest losses, food waste at retail, food service, and consumer levels remains largely unaddressed. Strong legislative frameworks, mandatory policies, and public engagement is bound to have a transformative impact on waste management in India.

It is important to foster sustainable consumption patterns at home, retail and food service level through public awareness campaigns to educate consumers about the environmental, economic, and social impacts of food waste. Encourage restaurants and catering services to offer smaller portion sizes and promote mindful eating habits.

Moreover, while food loss data is regularly collected, as seen through the NABCONS and ICAR studies, data on food waste from other sources is scarce, creating gaps in targeted policy-making.

Within this challenge of Food Loss & Waste, lies a remarkable opportunity for economic growth through food waste valorisation

Startups in the country are already demonstrating successful models of waste valorisation, creating valuable products which are good for people and the planet, ranging from nutrient-rich foods and animal feed to biofuels and biodegradable packaging.

The path forward for India to address Food Loss & Waste requires a multi-faceted approach:

- Implementing waste management laws and a regulatory framework.
- Credible data generation on food waste at retail, food service, consumer home.
- Increase grants to fund research & development and accelerate technology for valorising food waste.
- Promote the startup ecosystem to bring to market innovative Food & Beverage products from valorised food waste streams that are good for people and the planet.
- Certification of products made from utilisation of food loss & waste.
- Fostering of public-private partnerships.

By taking decisive action now, India can transform its food loss & waste challenge into a driver of sustainable economic growth while significantly reducing its environmental footprint and providing greater access to nutritious food.

The time has come to view food waste not as a burden, but as a valuable resource waiting to be unlocked

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