Sustainable Supply Chain

TEAM 11

EXECUTIVE SUMMARY

OBJECTIVE: To provide a 5-year time-phased plan backed by data to nudge the members of NAWCI towards a carbon-neutral supply chain by considering efficiency and sustainability in all stages, hence helping India achieve its COP26 summit target.

KEY PROBLEMS	KEY SOLUTIONS	CARBON IMPACT
Packaging materials are directly sent to landfills or are incinerated without recycling or reusing, which shows lack of a circular packaging supply chain.	**CONVERTIBLE DELIVERY BAGS:** Immediate return of the external cardboard box used for only delivery and packaging in attractive, re-usable plastic bags.	**21% per delivery**
Excess travel by delivery drivers leads to higher carbon production. There is increase in idle time & more missed deliveries due to unavailability of consumers at a given slot.	**DELIVERY OPTIMIZATION:** The customer is asked for a time slot when ordering. The time is reconfirmed a day before delivery through WhatsApp notification. A pick-up-at-warehouse option is also offered. Route for all orders is optimized using an AI interface.	**20-25% decrease**
Slow Movement of goods leads to accumulation. Inability to find optimal location for storage, obsolete inventory, slotting systems optimization, etc. hampers productivity.	**AUTOMATING WAREHOUSE & INVENTORY:** A personalised, interoperable warehouse and inventory management system that considers storage capabilities, inventory levels, supplier lead times and schedules, seasonal trends, and future campaigns is deployed.	**50% decrease**

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Inefficient utilization of storage space, as pallets occupy a large volume (14.43%) in transportation trucks. Wooden Pallets are bulky, adding to transportation costs.	**SUSTAINABLE TERTIARY PACKAGING:** Re-usable slip sheets made from recycled cardboard could save 99.1% space & ~50% loading/unloading time.	**20% decrease**
Inefficient disposition of dead stocks, returns and waste generated. Average 20% deadstock in FMCG contributes to 16 million tonnes of annual carbon emissions in India.	**SYSTEMATIC WASTE MANAGEMENT:** Company sends its waste collection from returns and deadstock to the government in exchange for tradable carbon credits	**3.5 Tonnes of carbon credit/km**
There is a need to lay out guidelines for NAWCI members with added incentive to follow the provided proposals	**INITIATIVES BY NAWCI:** Initiatives like “Green Points” and “Company Green Score” will include consumers in our mission and also keep companies’ carbon emissions in check.	

CURRENT SCENARIO

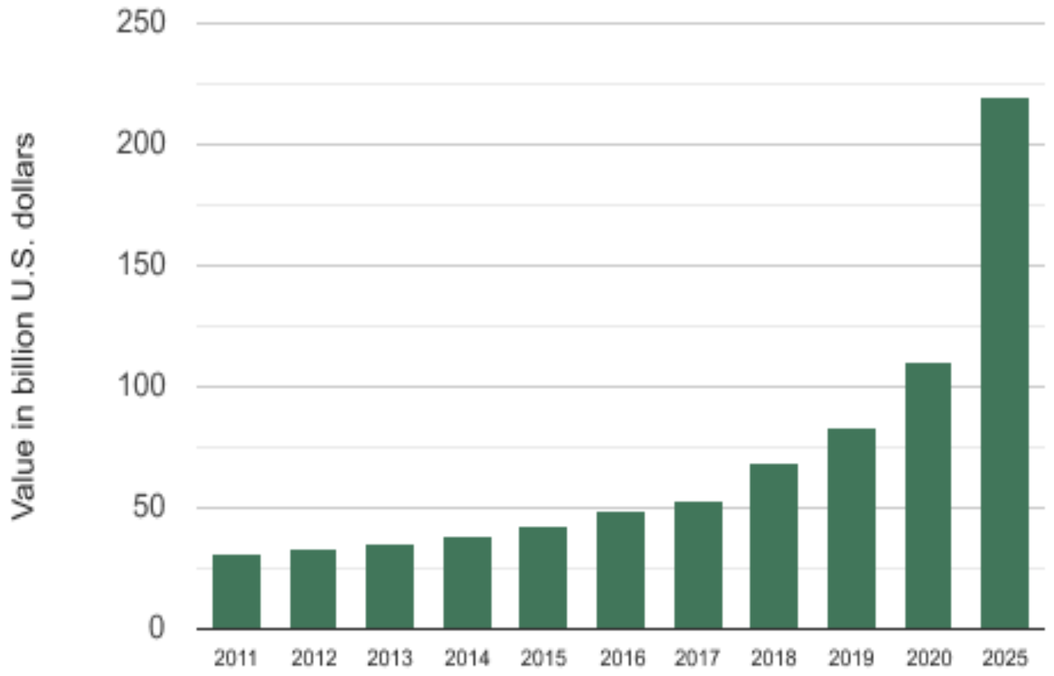
The FMCG industry is increasing with 20% CAGR with household/ personal care goods leading the way...

FMCG is **4th** largest sector

$220bn Expected Market size by 2025

50% FMCG sales are household/ Personal care goods

Year wise Indian FMCG market size



The COP26 targets: Reducing emissions, reducing carbon intensity, shifting to renewable sources...

To raise the **non-fossil fuel-based energy** capacity of the country to 500 GW by 2030

To **reduce** the total projected **carbon emission** by one billion tonnes between now and 2030

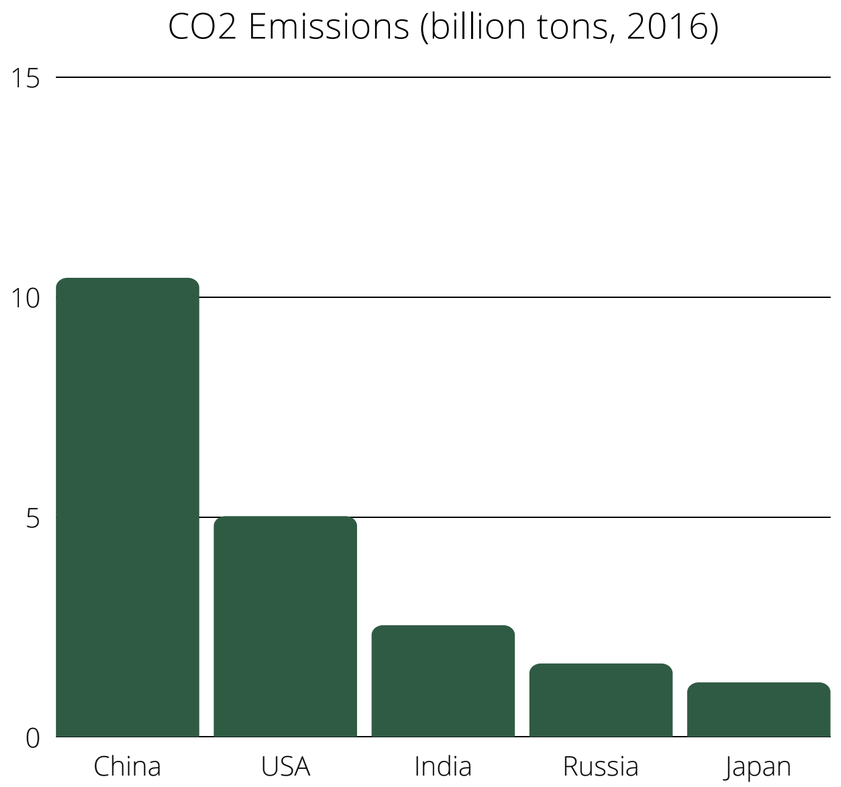
To meet 50% of the country's energy requirements using **renewable energy** sources by 2030

To reduce 45% **carbon intensity** by 2030

To become carbon neutral and achieve **net-zero emissions** by 2070

- Excess carbon emission due to inefficient loading of goods in warehouses and trucks.
- 2x more Emissions caused to a lack of proper automation in warehouses

- Emission caused due to inefficient usage of fuel and due to non-optimization of last-mile delivery.
- CO2 emission due to plastic waste in landfills lacking Circular Carbon Emission.



Current Supply chains produce GHGs through mainly fuel, cooling, lighting, plastic waste...

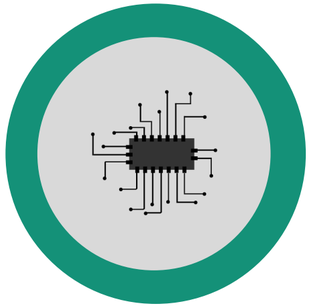
Sources of GHG:
1. Burning of fuel coal, natural gas & petroleum
2. HVAC & Lighting in the form of NOs and HFCs

75%
GHG are from supply chain

40%
Plastic waste comes from packaging

Sources of plastic waste:
1. PE, PP, HDPE, LDPE used mainly in the packaging
2. Single-use plastics used in tertiary packaging (pallets and sheet wraps)

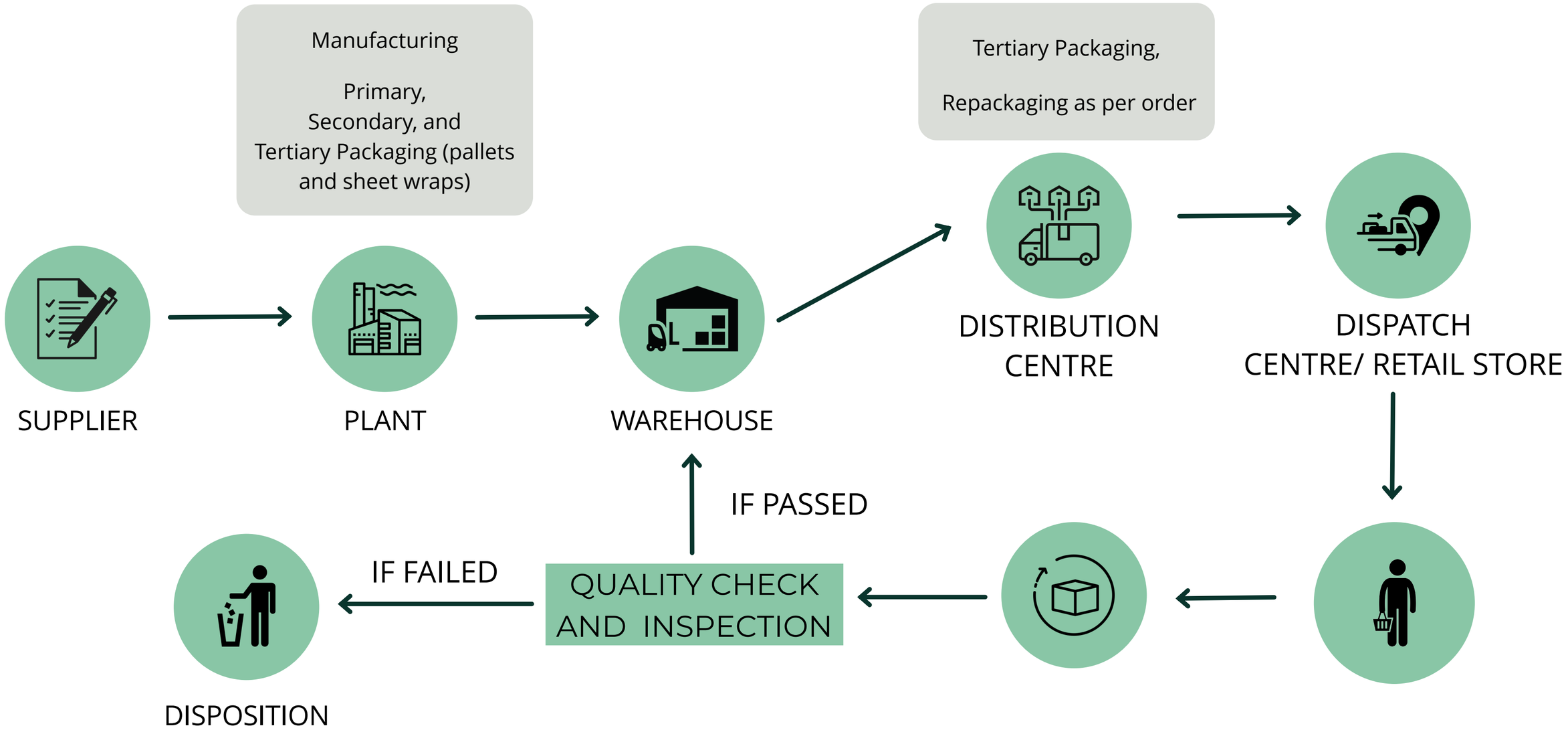
Technology plays a dual role in our tryst with carbon emissions



REDUCES
carbon emissions:
1. smart grid design,
2. low-emission infrastructure
3. Modelling climate change prediction

EMITS
carbon:
1. Cloud data storage
2. Optimization algorithms
3. Predictive technologies
4. IoT devices

How would a black-box supply chain work?



WAREHOUSING

After inspection, incoming goods are sorted & stored in zones, outgoing goods are picked & shipped...




Cross-Docking

Gatekeeping and Receiving

- Documentation
- Unload
- Counting
- Staged
- Quality Check 1
- Unpacked
- Labelling
- Putaway

Storage

- Reserve Area / Forward Area
  - Layout Zoning
  - Slotting
  - Active area or Shelf

Picking

- Sorting
- Search Sequence, Travel, Zone, Wave, Batch and Single Order Packaging

Shipping

- Kitting
- Packing
- Labelling
- Loading
- Quality Check 2

Lack of digitization, inefficient space utilization lead to obsolete inventory & errors, increasing cost & emissions...

20-30%

Inventory is obsolete

55%

Cost of picking process in operations

LACK OF DIGITIZATION

Documentation on paper reduces efficiency, causes errors, increases overheads

INEFFICIENT SPACE UTILIZATION

Improper product positioning & inefficient layout increases cost in picking process

LABOR INTENSIVE PROCESSES

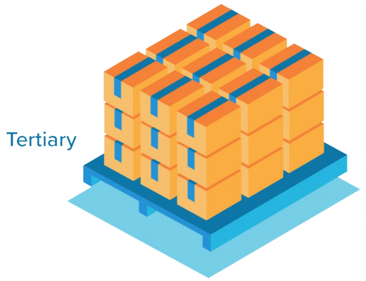
Increases manual errors, Increases returns, Slow functioning of the warehouse

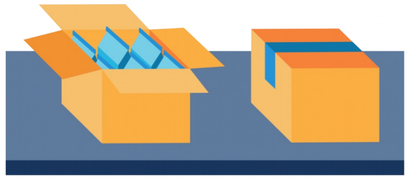
SHIPPING ERRORS

Human errors cause inefficiency & more returns, increasing C02 emission per product

PACKAGING

Goods in 3-layer packaging are placed on pallets & used packages are disposed off & not collected for recycling...





Primary → Secondary/ Tertiary → Unpack Repack as Order → Unpacking & Disposal

Single-Use Plastic

40% Plastic-Related pollution is due to the accumulation of Single-Use Plastic.

Lack of Circular Alternatives

90% Recyclable Plastic-Packaging waste is either incinerated or used for land filling.

Single-use plastics, lack of recycling, inefficient packaging designs lead to extra cost, waste and emissions...

Single Use Plastics

43%
Packaging material is SUP

50%
of plastic waste is SUP

7.1m
Tonnes of SUP reaches oceans daily

1

Extensive use of SUP

Single-use plastics account for more than 70% of the wrappers wasted and disposed, hence creating leakage into the environment.

2

Unproductive Circularity

Single-use plastics can be recycled up to five times only and from that only up to 30% carbon emissions can be saved from recycling.

3

Inefficient Packaging Design

Due to limited number of available eco-friendly options and inefficient packaging design, there is an increase in transportation costs as well as carbon footprint.

TRANSPORTATION

Forward and reverse transportation is a huge part of the supply chain costs...

Manufacturing Plant → Warehouse ⇌ Distribution Center / Fulfilment Center ⇌ Retailer / Dispatch Center ⇌ End Consumer

Unused Truck Space

33% Increase in Transportation charges due to low space utilization in vehicles

Unoptimized Routes

53% Last mile delivery costs account for 53% of overall shipping costs.

Improper routing & unavailability of customer are major “last mile” problems...

20% of COD deliveries get refused
10% of pre-paid orders get refused

Transportation charges can be higher by up to **33%** due to low space utilization.

Last Mile

- Unoptimized Routes and Missed Deliveries
- Unavailability Of Customer
- Incomplete Address Locations leading to time wastage

Long Distance

- Idle Time due to traffic and poor road conditions
- Inefficient Space Utilisation in Trucks
- Polluting Vehicles

There’s more…

Returns have increased manifold, proper processes to collect & manage returns are need of the hour...

INCREASING RETURNS

Online retail return rate 30%

The return rate increased despite demonetization, discouraging COD orders, digital initiatives. The seller bears the cost of returns, damages, inventory blocking, frauds, mal-practices etc.

LOW & UNPREDICATABLE VOLUMES

Improved monitoring of returns can reduce landfill waste up to 96%

The lack of real time data results in variety of avoidable losses by improper inventory management.
This results in a stacking effect and inaccuracies resulting in increased emissions.

VALUE DEPRECIATION

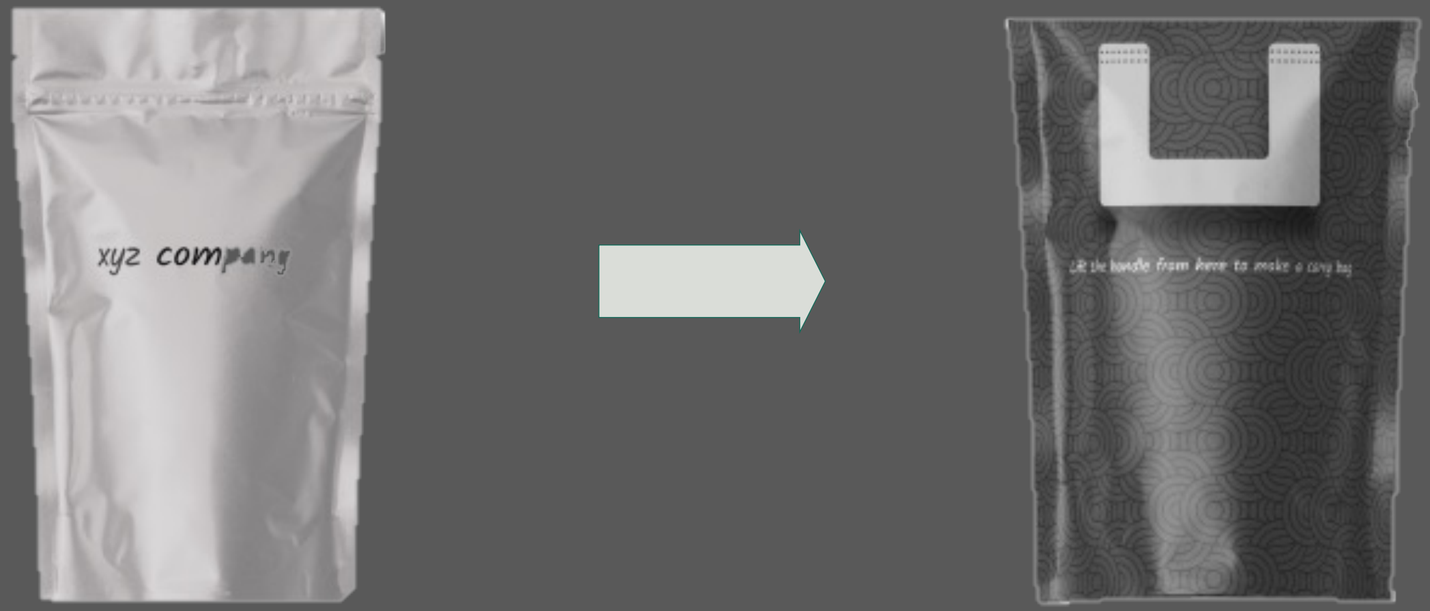
The longer an item stays out of circulation the less value it has

Shipping and handling costs lead to longer wait times which results in loss of value.
This reduces profits which could be used in green investments

LET'S TALK SOLUTIONS

1. Convertible Delivery Bag
2. Delivery Optimization
3. Sustainable tertiary packaging
4. Systematic Waste Management
5. Digitizing Warehouse & Inventory
6. Automated Guided Vehicles
7. NAWCI Initiatives

Convertible Delivery Bags



21%

Carbon emissions reduced per delivery

10-20%

Increase in cost per package

Cardboard boxes are returned to DCs while the attractive, convertible plastic bags can be used by the customer...

Packaging process

Products are placed in a plastic bag inside a compressible, recyclable cardboard box .

Circular Packaging

Cardboard boxes will return back to fulfilment centers and will be used multiple times in a cycle before being recycled

Customer Use

Plastic bags can be converted into reusable handbags by the customer by just inverting the Package

Packaging Design

Attractive design to lure customers into re-using them

Product safety

Padded layer to ensure fragile product's safety.

Customer gets green points & usable bag, company reduces overall waste and in turn carbon impact...

Ease of Integration

- Cardboard boxes are brought back to the fulfilment centre by the same trucks returning from the Dispatch centre.
- Workers need to ensure efficient unpacking of cardboard for maximum 'Reusage'. Extra effort while packing product in 2 packs

Impact on Market

- Customers get an attractive, durable & reusable bag.
- Green Points can be availed for various benefits on returning the Package.
- Extra effort and cost for separating the bag from the cardboard package and returning the cardboard.

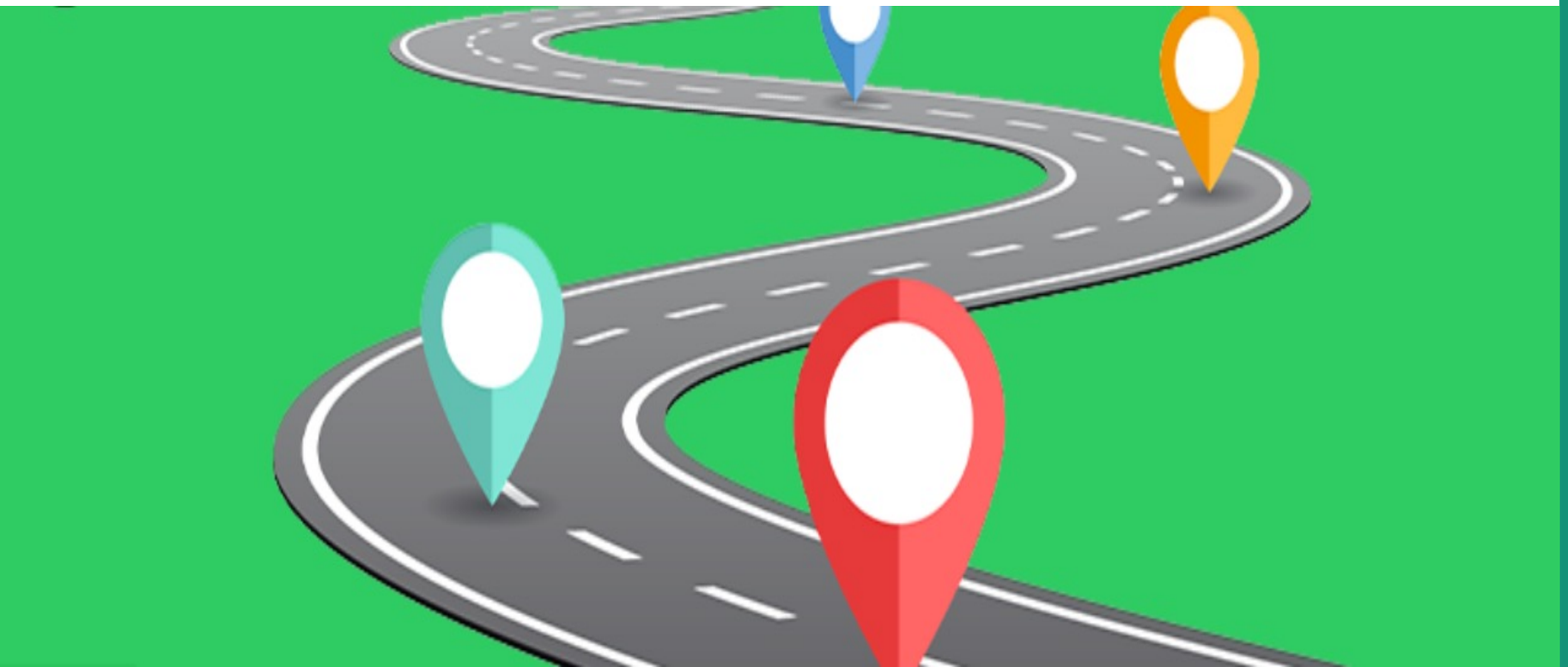
Sustainability

- With regular R&D, we can keep improving and reducing expenses to inculcate more sustainable materials.
- Companies may hesitate to spend on an extra layer of packaging.

Feasibility

- **Financial:**
  Invest in new plastic bags and Product education for customers
- **Operational:**
  Hiring and training workers to put & separate the plastic bag from the cardboard box. Delivery person has to collect the returned bags. Management of returned cardboard boxes.

Delivery Optimization



88%

Reduction in carbon emissions

8%

Freight savings

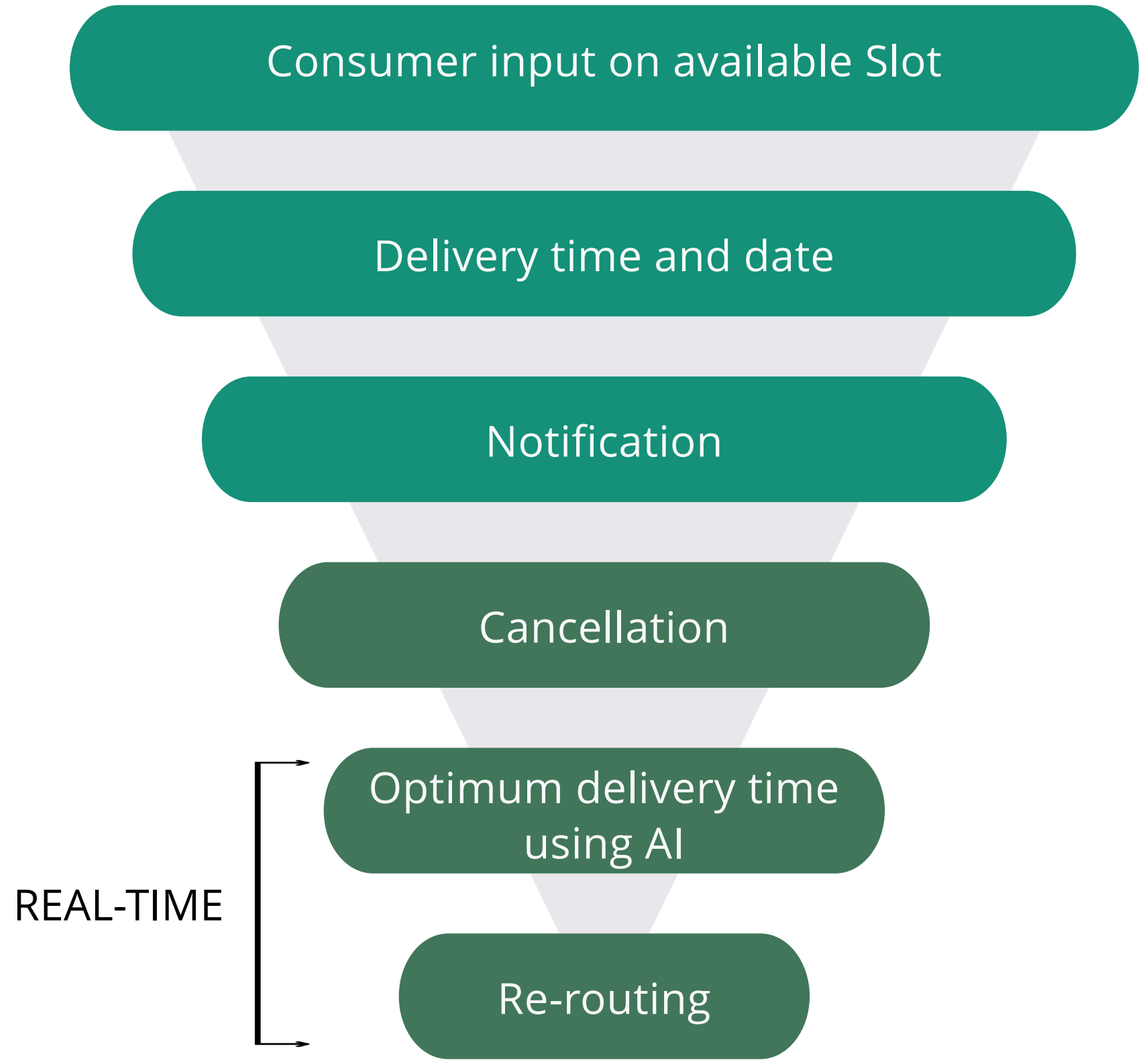
26%

Net positive profit impact

10-30%

Delivery transportation costs

Customers choose time-slot of delivery, multiply deliveries can be clubbed for green points, AI-based routing...



1. Model Overview

An AI-backed routing and scheduling software is used to allocate work to ensure accurate deliveries, reduce delivery times and save fuel.

2. Timeslot and Date of Delivery

Customers are allowed to choose a time slot of choice when informed the date of delivery. Multiple orders can be grouped into a single delivery, and receive ‘green points‘.

3. One day prior notification

Notification of the delivery one day before allowing them to change their preference or pick up at the dispatch center

4. Cancellation

After 5 Days of missed notifications, WhatsApp messages and one automated call to confirm the status one last time, the order gets automatically canceled.

5. Delivery time

The most optimum time of delivery is chosen beforehand.

6. Final Re-Routing

Customer preferences, roadblocks, traffic congestion are considered to dynamically re-route the delivery partner ensuring maximum work in minimal time.

Use historical data for efficient routing & dynamic re-routing...

MODEL TRAINING

The software uses historical data to suggest the most efficient route for delivery rather than the shortest route(saving time and fuel costs depending on slots available for the consumer, traffic, road and weather conditions).

ALLOCATION

Shipments are allocated to agents in a “logical” order to ensure maximum work in minimal time, reducing the burden on the last-mile delivery partners while ensuring accurate deliveries.

DYNAMIC RE-ROUTING

Dynamic re-rerouting notifies delivery partners in time of any upcoming congestion or no-entry windows, with an alternative route they can follow to complete the delivery.

Solution is flexible, adaptable with training, with the risk of failure due to poor internet connectivity (remote areas)...

Ease of Integration

- Driver needs to get accustomed to the new application and real-time changes in drop-off locations.

Sustainability

- Data from every travel is channeled into training the model better.
- This can be further used to increase efficiency and make better demand forecasts.

Strategic Fit

Impact on Market

- Optimized delivery ensures improved profits due to maximum deliveries per day and improved customer acceptance.

Feasibility

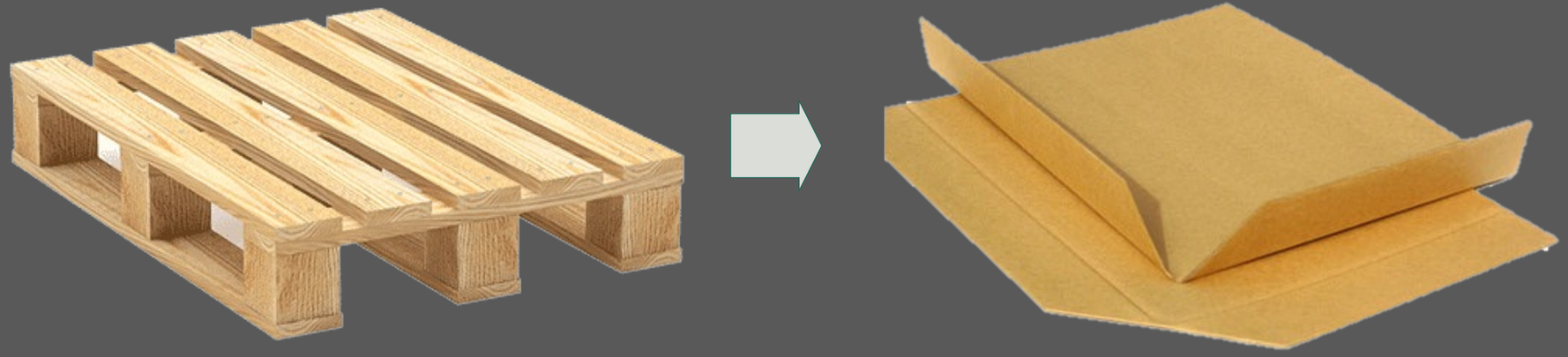
Financial:

- Company needs to spend on data storage.

Operational:

- UI and technology changes in app at both customer and driver end.
- Ability to adapt with changing consumer habits.
- Failure in case of poor connectivity.

Sustainable Tertiary Packaging



88%

Expense reduced by using slip sheets

20%

Carbon emission reduced due to fuel efficiency

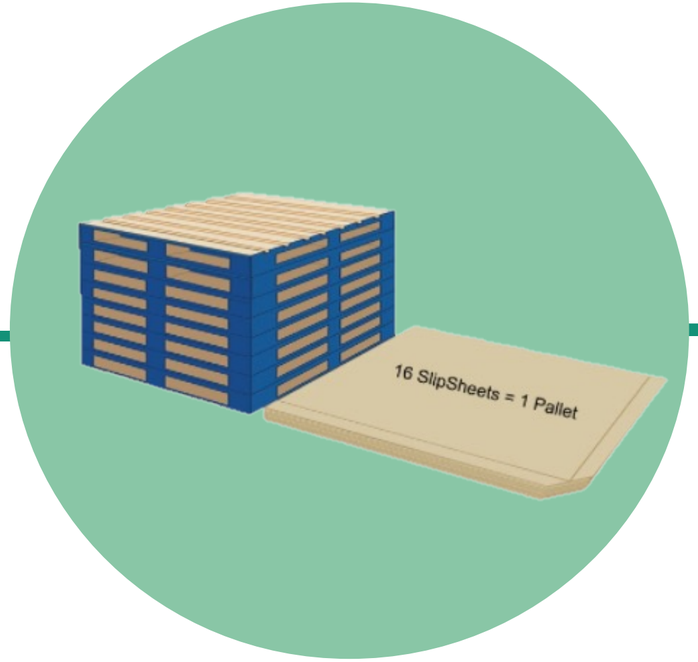
Slip sheets are 1/16th in size, save time, are safe and multi-purpose, in turn reducing cost & carbon emissions...

Benefits

Slip sheets made of recycled cardboard serve as a functional substitute for pallets.

They can be reused, which increases the circularity of the product

Due to thickness as 1/16th of a pallet, they reduce loading and unloading time by 50%



Requirements

Push-Pull Forklift Attachment

Extra Safety Assurance for storage

Wider Space Aisles for movement

The pallets which have been replaced now by slip sheets can be still used for storage within the warehouse, reducing emissions in the disposal of pallets

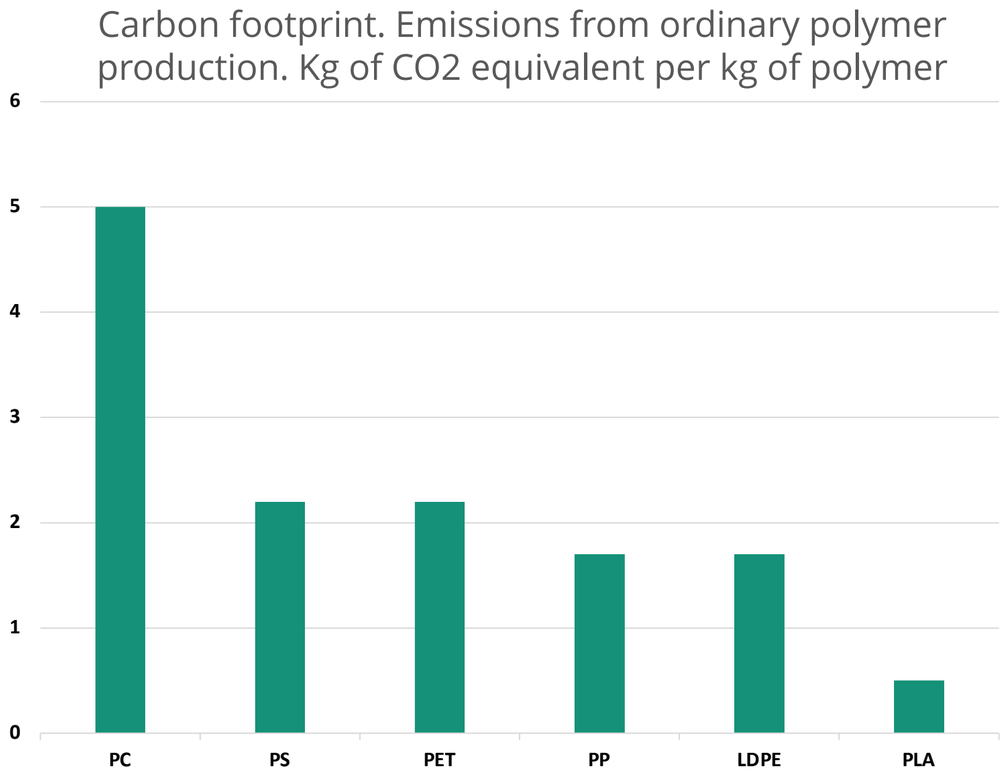
Slip sheets are biodegradable & recyclable leading to lower overall emissions...

Nonrecyclable carton stack packing can be replaced with recyclable and biodegradable PLA film. It can act as an equivalent substitute of shrink wraps.

PLA is manufactured using corn, and hence biodegradable with minimum emissions.

Decomposes into digestible polymer fragments in about 7 days at 60°C in a moist environment thus making it biodegradable while having the same properties as that of Polyethylene

There is 80% lower Carbon Emission in PLA than that of traditional plastic



More products can be transported at a time, but warehouse workers would need training to operate...

Ease Of Integration

- The stacking of similar-sized shipping cartons on slip sheets is similar to palettes.
- They need a special push pull attachment for any forklift truck and wider aisles.
- Extra safety must be ensured in pairing slip sheets with reused pallets to store goods in warehouses.

Impact on Market

- As load per trip increases and onloading and offloading time decrease, stock available for sale increases, and the number of orders completed increases.
- The transportation costs also decrease because of more orders being completed in lesser trucks involved.

Sustainability

- Palettes that were eliminated from transport usage can later be repurposed for warehouse storage.
- Workers can quickly adapt to the new forklift with a one-week training program. Warehouse Staff needs to be trained on the usage of slip sheets

Feasibility

- **Financial:**
  Purchase of attachments for converting into a push-pull forklift.
- **Operational:**
  Training workers to operate push-pull attachment.

Systemic Waste Management

Up to 3.5

Tonnes of carbon credit per tonne of plastic processed

5%

Reduction in cost of making roads

Plastics deemed non-recyclable can be repurposed into roads, fibers, etc. hereby increasing circulation time...

Repurposing HDPE and LDPE into roads

Company sends its waste collection from returns and deadstock

↓

Waste aggregator sorts then transports HDPE and LDPE

↓

Government receives and processes plastic into roads

3.5 M Carbon Credits

- Plastic roads last 3x longer than conventional roads.
- Smoother, low maintenance, and absorb sound better.
- Don't absorb water & have better flexibility and wear resistance.

Repurposing PET into fibers

PET bottles (preferred over plastic bottles) are used to make fibers

↓

Plastic is sorted according to colors. White plastic is sent for shredding

↓

Shredded plastic is cleaned and processed into fibers

- Energy efficiency in manufacturing cloth=66.66%
- Water efficiency in manufacturing cloth=90%
- Plastic waste consumption=240g is required to make a T-Shirt

Waste management requires more capital than simple disposal, but is offset by government incentives...

Adaptability

- Company needs to divert transport from landfill to government centers.
- Government needs to create space as plastic received increases.

Sustainability

- The plastics used here at the end of the recycling life.
- Hence, this becomes a sustainable alternative to incineration.

Impact on Market

- Companies receive tradable carbon credits from the government and are appreciated by consumers.

Feasibility

- **Financial:** Expenditure on transport for collection of waste.
- **Operational:** Sorting mechanism needs to be paid for. Waste collected needs to be transported to government centers.

Digitizing Inventory & Warehouse

2x

Carbon emissions less as compared to manual management

30%

Cost savings due to forecasted demand

99%

Data accuracy in picking and labelling

35%

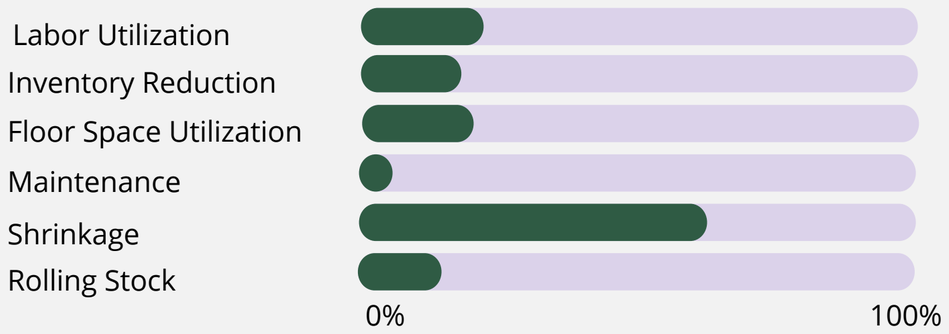
Improvement in labor utilization

A personalized, interoperable WMS with below features increases efficiency, reduces cost, wastage & emissions...

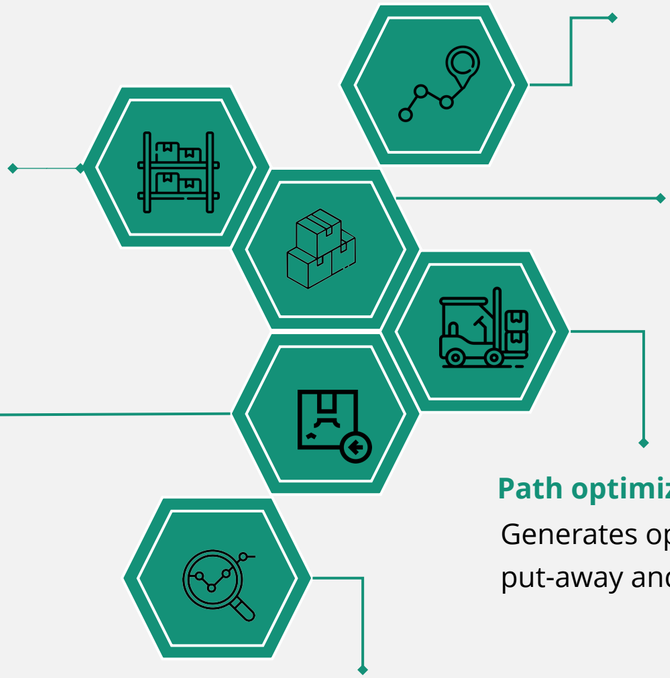
Solution

- A personalized, interoperable warehouse and inventory management system.
- It considers storage capabilities, inventory levels, supplier lead times and schedules, seasonal trends, and future campaign.
- WMS can generate algorithms and rules to perform warehouse tasks such as goods allocation, route picking lists and order division.

Potential Cost Savings



Features



Performance Tracking
Monitors product performance and creates expiry alerts.

Product positioning
Finds an optimum position in the warehouse for a specific product.

Package sizing
Suggests optimum dimensions while packing products.

Replenishment
Creates alerts for movement between reserve & forward area.

Path optimization Systems
Generates optimum paths for put-away and picking.

Demand Forecast
Predicts the future stock demand.

Capital & employee training, but using WMS one can increase efficiency and thereby customer satisfaction...

Ease Of Integration

- Integrable with supply chain processes like transportation, packaging.
- Existing machinery in the warehouse can be leveraged to improve operational efficiency.

Impact on Market

- Better customer satisfaction by reducing product mismatch & increasing product availability.
- ·Management team can integrate processes, provide the best growth strategy with real-time information about buying trends, and make recommendations for improvement.

Sustainability

- Employee reskilling for the new management system and a complete understanding of better performance rates.
- The model is sustainable and will provide better carbon savings with increasing demand.

Feasibility

- **Operational:**
  Additional research on strategic design problems, and relevant data should be incorporated into the training model to suggest the best possible results.
- **Financial:**
  Cost of IoT devices and cloud storage services, reskilling employees to facilitate easy adoption.

Automated Guided Vehicles

87.5%

Reduction in annual handling expenses

75-80%

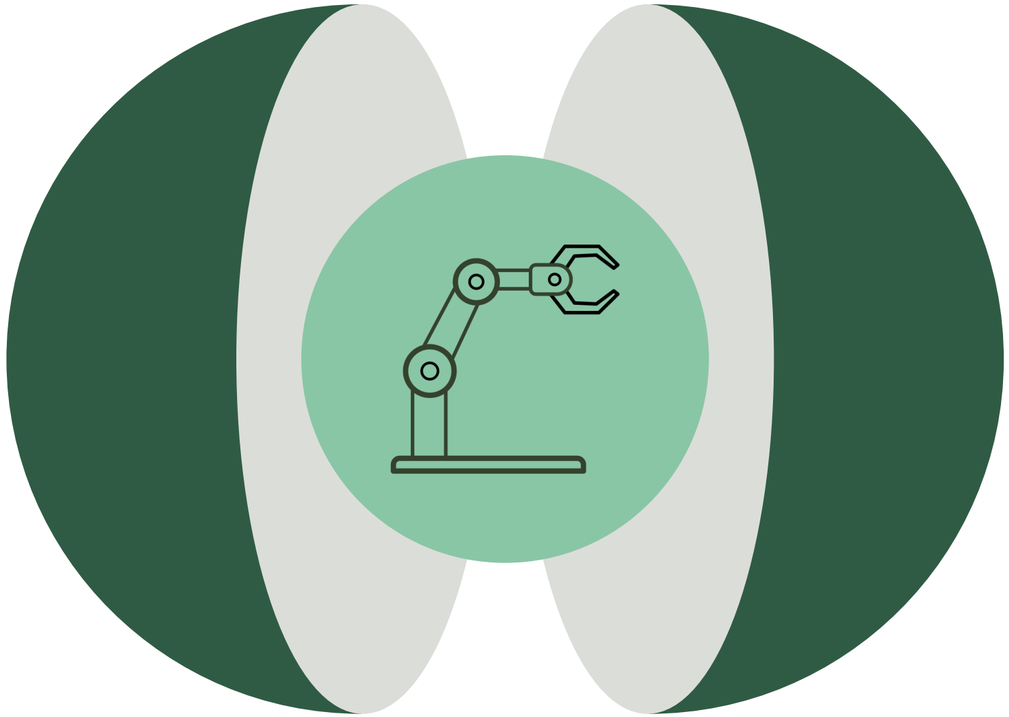
Decrease in cycle times

Automating picking and intra warehouse movement to ensure quicker and more efficient deliveries

Computer-controlled AGVs are deployed across the warehouse for

- Automated storage,
- Retrieval, and
- Auditing.

Large AGV's move bulk and palletised goods — most will act as shuttles between human pickers and packing lines.



- These systems can lift an entire shelf and move them from one place in the warehouse to another.
- They move on a predictable path with precisely controlled acceleration and deceleration, and
- They prevent collision using automatic obstacle detection bumpers, and provide safe movement of loads and high performance.

Requires a high initial investment, but reduces human errors and increases efficiency covering up on costs

Ease of integration

- Can be integrated with other warehouse processes and the WMS — and its scheduling capabilities ensure the efficiency of operations.

Sustainability

- Employees need training to adapt to the new management system, and a complete understanding is quintessential for better performance rates.
- The model can provide carbon savings in energy consumption (35%) as they can operate in a wide range of conditions.

Impact on Market

- Better handling, less frequent errors provide the best customer experience. A digital, always-on supply chain will save the company considerable expenses, which can be used for R&D.
- AGVs can also work alongside the existing workforce, minimising cycle times for processes

Feasibility

Financial:

- The company needs to analyse warehouse requirements before purchasing devices. Incorrect decisions might increase operating too.
- **Operational:**
  AGVs should be integrated with the existing systems to provide better results. AGVs are equipped with collision avoidance capabilities

NAWCI’S INITIATIVES

“**Company Green Score**” for NAWCI companies with monetary & branding incentives for abiding members…

Create a Green Score policy for NAWCI members.

Reorganize the members of NAWCI in tiers based on Green Score

Create incentives and benefits for high tier members to increase Green Initiatives

Use large number of green companies to bargain with government and get better government incentives

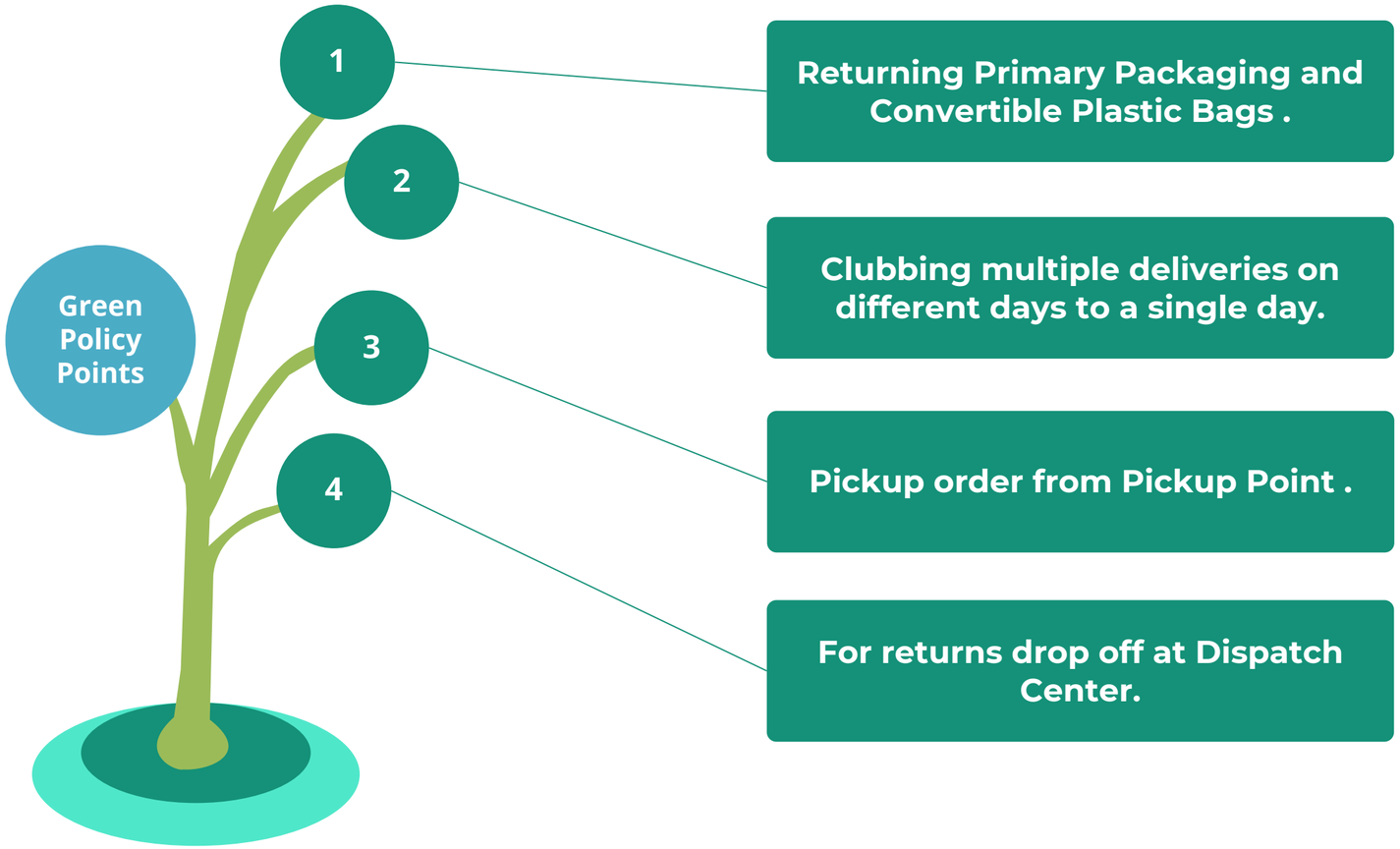
Green Score

- **Give Customers Incentives**
- **Green Internal Processes**
- **Efficient Disposal**

Incentives

- **Access to Investors**
- **NAWCI facilitated shared economy**
- **NAWCI Green Certification**

“**Green Points**” incentive to customers: Reduces transport time, cost & emissions; efficient waste collection…



What is it?

- NAWCI Members must have a green point policy for customers.
- The company rewards customers with “green points”, which can be redeemed according to company polices.
- These are awarded to incentivize customers towards greener, less convenient ideas and cause a change of habits.

Time-phased guidelines with regular checkpoints would help reduce costs & emissions and increase efficiency...

LOGISTICS

First Mile
- Analytics tools to optimize freight scheduling and routing.
- Accurate demand forecasting to avoid waiting time, additional trips, congestion at the docks.
- Incorporating exhaust heat reuse systems, continuous hull cleaning, minimum ballast navigation, and optimized sailing plans.
- Using biodegradable packaging.

Middle Mile
- Incentivising a shift to drones for transportation & inside the warehouse.
- AI based software to optimize the arrangement of products and boxes in trucks.

Last Mile
- Change in warehouse locations to function as hubs where cross-docking can occur.

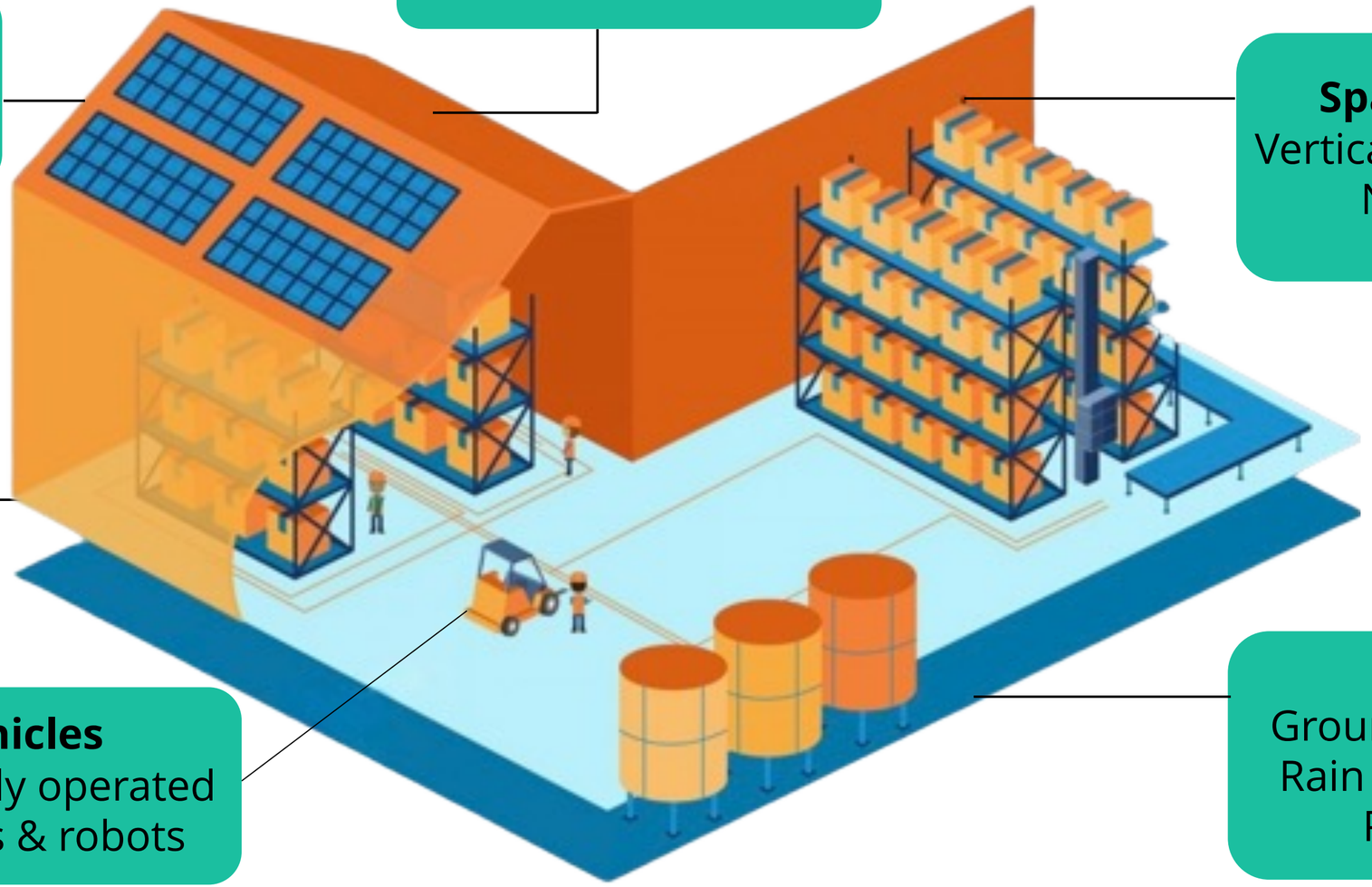
Reduce Returns
- Try on tech- 3D/AR.
- Better product descriptions => Product Videos & In-depth details of product ingredients/components.

An ideal NAWCI member Warehouse

Cooling
Heat Resistant Paint

Renewable Energy
Solar Panelled Roofs

Space Utilisation
Vertical Space Utilisation
Narrow Aisles

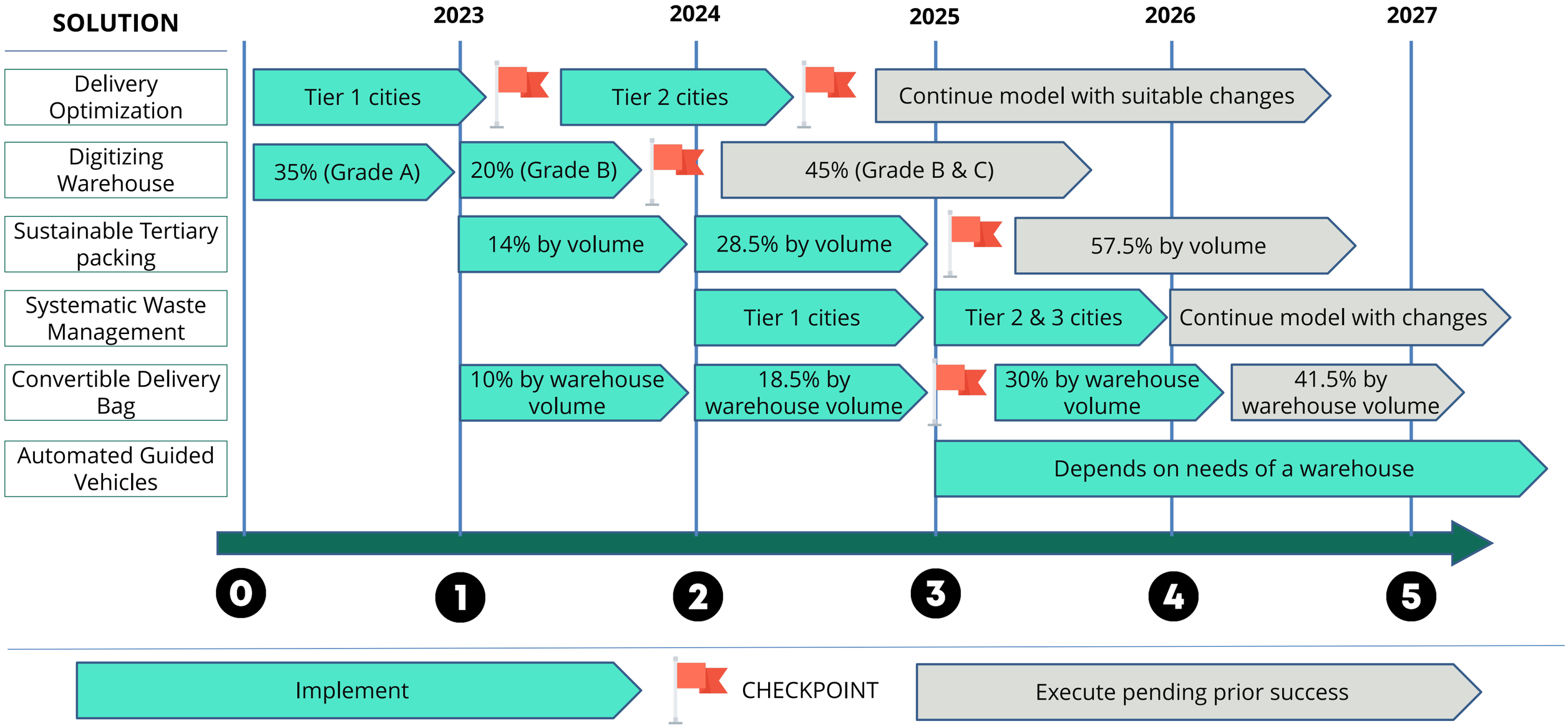


Lighting
Motion Sensor
Lighting
Adaptive Lights

Vehicles
Electrically operated
vehicles & robots

Ventilation
Ground Source Cooling
Rain Water Harvesting
Planting trees

TIMELINE

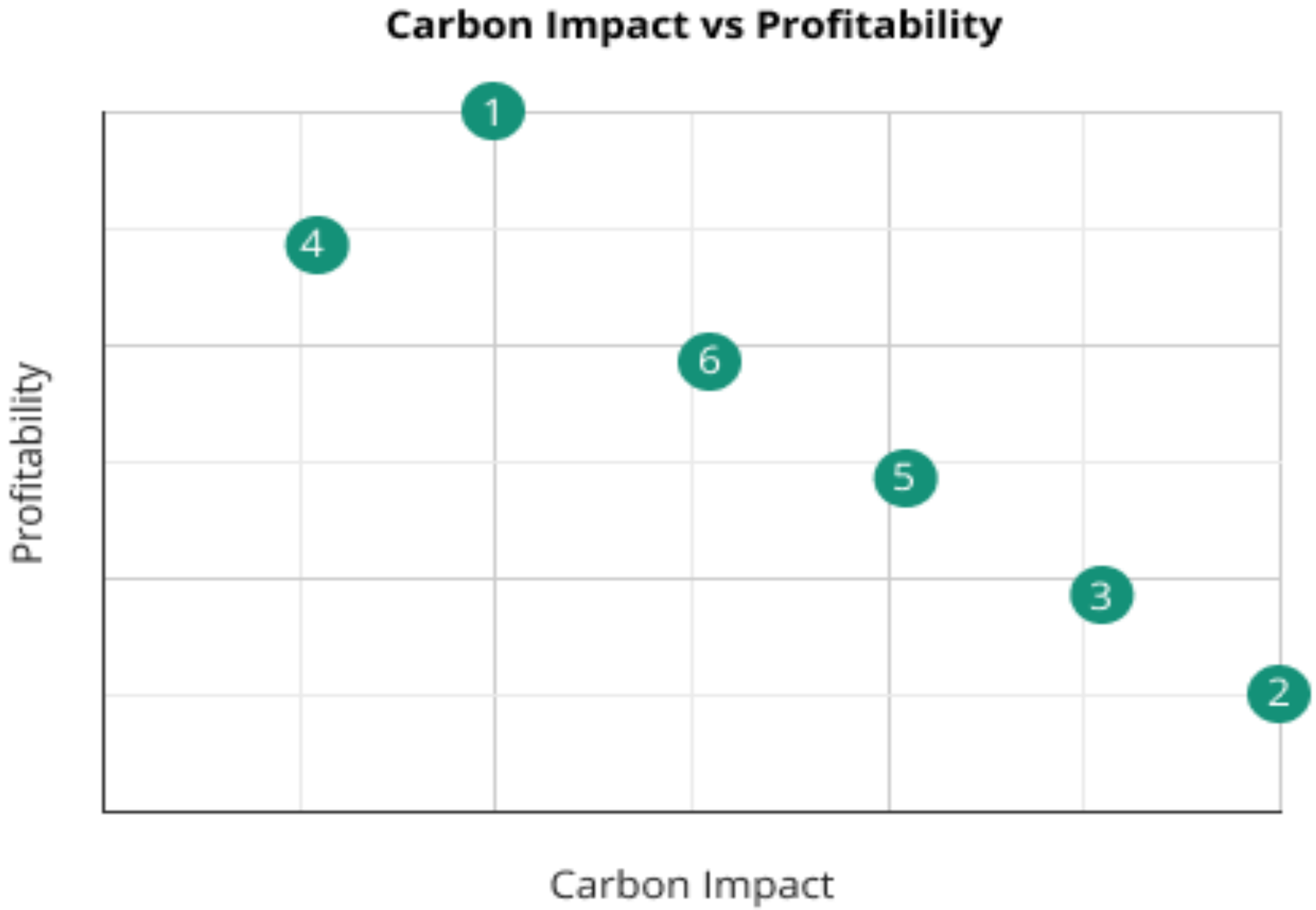

SOLUTION
2023
2024
2025
2026
2027
Delivery Optimization
Tier 1 cities
Tier 2 cities
Continue model with suitable changes
Digitizing Warehouse
35% (Grade A)
20% (Grade B)
45% (Grade B & C)
Sustainable Tertiary packing
14% by volume
28.5% by volume
57.5% by volume
Systematic Waste Management
Tier 1 cities
Tier 2 & 3 cities
Continue model with changes
Convertible Delivery Bag
10% by warehouse volume
18.5% by warehouse volume
30% by warehouse volume
41.5% by warehouse volume
Automated Guided Vehicles
Depends on needs of a warehouse
0
1
2
3
4
5
Implement
CHECKPOINT
Execute pending prior success

RISKS & MITIGATION

RANK	RISKS	MITIGATION	CONTINGENCY RESPONSE
1	Cost overruns	Ensure time appropriate checkpoints to measure success, diversify suppliers to ensure cost caps.	Contingency fund improved by bringing in more investors, Tapping into eco-conscious consumers
2	Increasing Plastic waste	NA	Integrate plastic reduction solutions, MOUs with government
3	Restrictions about recycling procedures and plastics involved	Track recycling count per product	Prioritize reusing over recycling
4	Employee satisfaction (Firing and Increased workload)	Incentives and monetary allowances	Mandatory severance pay, Phased firing
5	Moisture damaging cardboard and slip sheets	Use water repellent color coating	Replace damaged slip sheets with new ones
6	Cybersecurity issues	Regular security audits	Backup systems

RISKS & MITIGATION

RANK	RISKS
1	Cost overruns
2	Increasing Plastic waste
3	Restrictions about recycling procedures and plastics involved
4	Employee satisfaction (Firing and Increased workload)
5	Moisture damaging cardboard and slip sheets
6	Cybersecurity issues



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Guesstimates

Sustainable Tertiary Packaging
Carbon Impact

Assumptions
(i) Two layers of Pallets
(ii) Dimensions of E-Commerce Box : (9'x9'x9')
(iii) Dimension of Shipping Box : (11'x11'x11')
Wooden Pallet Cost & Dimensions: ₹ 600/piece , 7'x48'x40'
Slip sheets Cost: ₹ 70/piece, 1/16'x48'x40'
Truck Dimensions : 84"x84"x264"

#Pallets in each Truck:
264'/48' = 5 pallets in row
84'/40' = 2 pallets sidewise
Therefore, 1 Pallet stack = 5x2 Pallets = 10 Pallets
#Pallets : 2 x 10 = 20 Pallets in each Truck

Volume occupied by 20 Wooden Pallets = 20 (7'x48'x40') inch3=20*13440
Volume occupied by 20 Slip Sheets = 20 (1/16'x48'x40') inch3 =
Therefore, Volume saved =(13440-120)x20 inch3 = 266400 inch3
Slip sheets are 1/16th the size of a wooden pallet, allowing 99.85% volume saved in material.

Slip Sheets also reduce the number of transport trucks or containers by 17%.
For the same volume of load :-
10 Trucks are required with Wooden Pallets
8 Trucks are required with Slip Sheets
Average fuel consumption from Truck = 0.3 liters /km
CO_2 emission from 1 liter of Diesel oil = 2.68 kg/ liter CO_2

Therefore, reduction in Carbon emission = (10-8)x 0.3 x 2.68= 1.608 kg/km CO_2
Net carbon emission reduced = (1.608/8.04) =
20 % Curb on Carbon emission

Systematic Waste Management
Impact Metrics

3.1 *Annual Energy Consumption*
T-Shirts manufactured from PET plastic (Annually) = x T-Shirts
Energy consumed for manufacturing 'x' T-Shirts from virgin PET = y
Energy consumed for manufacturing 'x' T-Shirts from Recycled PET= ⅓ y
Net annual Energy Saved =⅔ y
Energy efficiency(Annual) = 66.66 %

3.2 *Annual water resource (Fashion Industry) consumption*
Water consumed for manufacturing 'x' T-Shirts from virgin PET = y
Water consumed for manufacturing 'x' T-Shirts from Recycled PET= 0.1 y
Net water annually Saved = 0.9 y
Water efficiency (Annual) =90%

3.3 *Plastic waste Consumption*
#PET Bottles required for one T-Shirt = **12 bottles** make one T-shirt.
Weight of a 500 mL (Standard) PET bottle = **20g**
240 g of PET is required to make **one T-Shirt**
Polyester (Annual) manufactured in India= **10 million tonnes** of polyester (2020)
Assumptions
Fabric of 160-190 grams for making one T-shirt = **175 g** of Polyester
#T-Shirts manufactured in India (Annual) = 10 million tonnes/175 g = $10^{10}/0.175$ = $6x10^{10}$ T-Shirts
#PET required = 240 x $6x10^{10}$ = **1.44×10^7 tonnes** of PET

Guesstimates

Systematic Waste Management
Carbon Impact

Construction cost of conventional roads = Rs. 1,49,000/km (Single lane Road)

Plastic reduces the cost to around Rs 1,42,000/km (Single lane road)

Net Cost saved = ₹7000/km (Single lane Road)

Cost saved on constructing 13,298km of Highways = (7000/149000)x100= 4.697% expenses saved

Source: https://ijcrt.org/papers/IJCRT2107194.pdf

Guesstimates

Route optimization
Carbon Impact

Cash on delivery Case:
Assuming **60%** of the total deliveries are Cash on Delivery
Assuming **20%** of the actual cash on deliveries does not get delivered.

Prepaid Order Case:
Assuming **40%** of the total deliveries are Pre-Paid orders.
Taking **10%** of the Total Prepaid orders do not get delivered.
Net Total :
20% of 60 + 10% of 40
20% of 60 = 12
10% of 40 = 4
Therefore Total deliveries that did not get delivered = 16% of the Total Deliveries
Assuming 4% of the deliveries that were not delivered were Fraudulent Orders.
So, In actuality, **12%** of the Net Deliveries were not delivered.

Actual Process without the Fraudulent Orders:
We have **84%** of orders which were delivered in One Trip **(Delivery Center to Delivery Point to Delivery Center)**
Thus, Net One Trip Distance = 2 x (Delivery Center to Delivery Point) Km.

We have **16%** orders which were delivered in 2 Trips.
2 Trips = 4 x (Delivery Center to Delivery Point) Km
Therefore net = One Trip Orders x One Trip Distance + Two Trip Orders x Two Trip Distance.
= 84% x 2 + 16% x 4

The process with Fraudulent Orders:
We Assumed that **4%** of the orders were Fraudulent. Thus **96%** of the charges were supposed to be delivered in one trip.
Thus Total = 96% x 2
And 4% was never meant to be Delivered.
Thus Net Difference Between the 2 Cases.
84% x 2 + 16% x 4 - 96% x 2
84% x 2 + 16% x 4 = 232
96% x 2 = 192

Net Difference = 232 - 192 = 40
Now Calculating Percentage Relative to the Initial Data
= (40/232) x 100
= 17.24%

Guesstimates

Automating Inventory and Warehouse Carbon Impact

Median Warehouse Size: 50,000 sq. ft.

1.1 Warehouse Emissions

Emissions are divided as follows:

Lighting: 40%
HVAC: 25%
Fuel & Equipment: 25%
Other (Water and Supplies): 10%

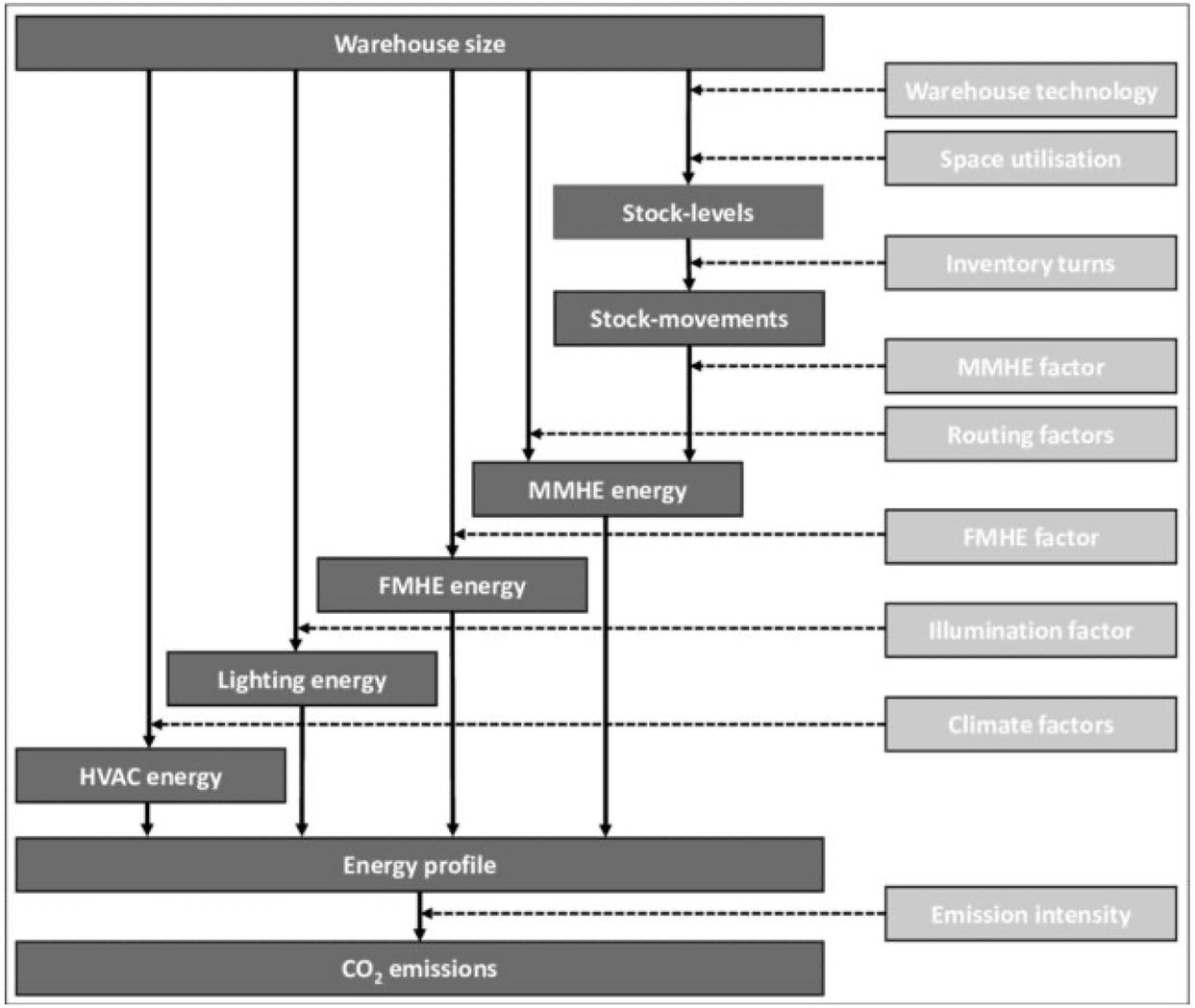
1.2 Planting Trees

Unused plot space at the median warehouse location: 30%
Out of these, let's consider 20% as the area for planting trees.
300 trees can be planted per acre considering each tree takes 150 sq ft.
This means we can plant 70 trees in the unused area.
5% reduction in carbon emissions annually.

1.3 Rainwater Harvesting + Ground Source Cooling

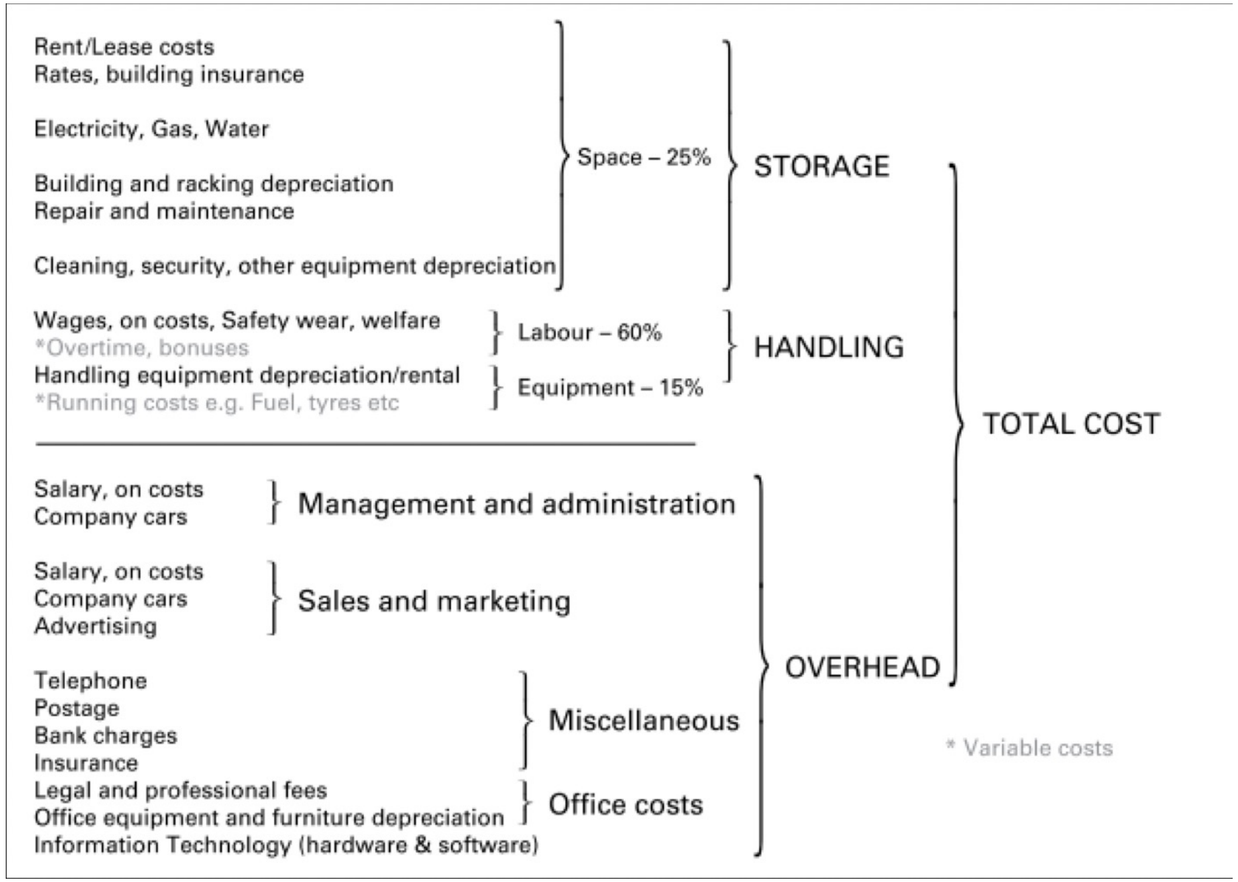
Rainwater Harvesting reduces water intensity by 50%.
Reliability varies between 50-80%.
Break-even in 5 to 7.5 years.
https://iopscience.iop.org/article/10.1088/1755-1315/248/1/012005/pdf

1.4 Picking Process
https://faculty.chicagobooth.edu/donald.eisenstein/research/DiscreteOrdPickingFinal.pdf



References

Warehouse
Cost Analysis

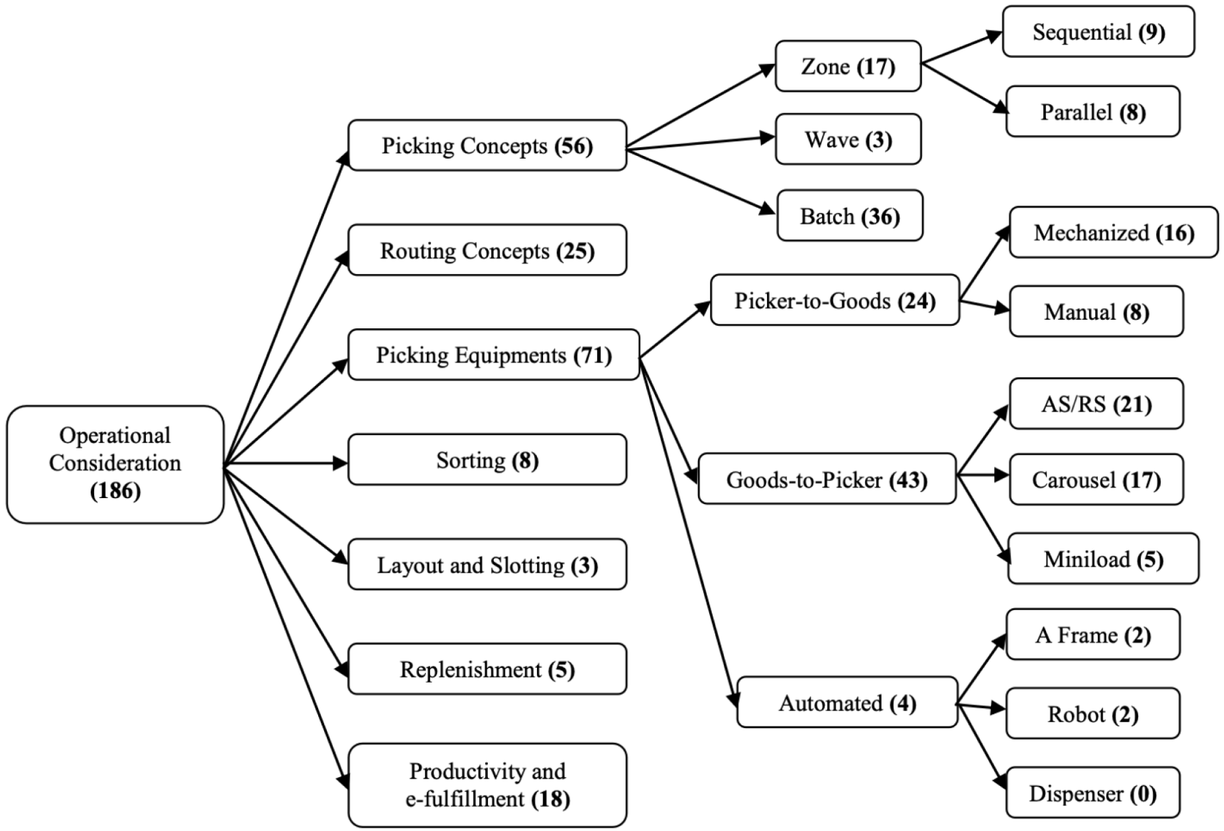


Warehouse
Layout Analysis

Storage system	Block place	Wide aisle	Narrow aisle	AS/RS
Storage density [Pal./m²]	1	2	4	10
Storage utilization [%]	70%	95%	95%	95%
Non-storage overhead [%]	15%	30%	50%	70%
Space utilization [%]	60%	67%	48%	29%
Building height [m]	8	10	15	25
Required illumination [lx]	200	300	300	100
Air changes [units/hour]	0.6	0.4	0.3	0.2
FMHE utilisation [%]	0%	5%	5%	10%

References

Warehouse
Terminology



Warehouse Management System
Cost Savings

Potential Cost Savings	
Labor Utilization	10-35%
Inventory Reduction	5-30%
Floor Space Utilization	10-30%
Maintenance	0-10%
Shrinkage	50-75%
Rolling Stock	10-20%
Increase Shipping Accuracy to	99% +
Increase Data Entry Accuracy to	99% +

https://bridgesgi.com/wp-content/uploads/2014/11/Bridge-Solutions-JDA_Cost_Justification_WMS_WP_0613.pdf

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Warehouse Automation Impact / Concerns

Domestic Demand	Low Floorspace: -20%	Medium (Stable at 2012 Level)	High Floorspace: +20%
Inventory Turns	Inventory Turns 9.38 → 10.57	Inventory Turns 9.38 → 10.57	Inventory Turns 9.38 → 10.57
Operating Technology	Low Degree of Automation | High Degree of Automation	Low Degree of Automation | High Degree of Automation	Low Degree of Automation | High Degree of Automation
Equipment	Low | High | Low | High	Low | High | Low | High	Low | High | Low | High
Emission intensity	Low | High | Low | High | Low | High | Low | High	Low | High | Low | High | Low | High | Low | High	Low | High | Low | High | Low | High | Low | High
Scenario	S1 | S2 | S3 | S4 | S5 | S6 | S7 | S8	S9 | S10 | S11 | S12 | S13 | S14 | S15 | S16	S17 | S18 | S19 | S20 | S21 | S22 | S23 | S24
CO_2 2025 (% change)	-36 | -20 | -45 | -32 | -15 | +7 | -26 | -8	-20 | +0 | -32 | -15 | +7 | +33 | -8 | +15	-4 | +21 | -18 | +3 | +28 | +60 | +11 | +38

Reusable Packaging

Carbon Emission from Cardboard Box

Cardboard box with measurements

Length = 9 inch = 25 cm

Breadth = 4 inch = 10 cm

Width = 4 inch = 10 cm

Basic industry thickness = 2.5 mm = .25cm

Net Weight of the Box = (250.cm.Cube + 50.cm.cube)xdensity

Industry density of cardboard box = .04g/cm.cube

Weight = 12.25gram per Box (Approximately)

Carbon Emission of cardboard box creation = .54 kg per kg

= (.54 x .0125)kg carbon emission per box.

= .01134 kg carbon emission per box

= 6.62 gm Carbon emission per box (For Creating a virgin cardboard box)

Assuming 50 boxes per bike ride.

= (6.62 x 50) = Carbon emission for 50 boxes

Assuming 50% Retention Rate =(x 50) x 50%

= 165.5 gm of carbon emission

Reusable Packaging

Carbon Emission from Reusable Plastic bag

Assuming bag of the weight = 1g

Carbon emission for a plastic bag = 1.6 kg per kg

Carbon emission per bag = 1.6 gm carbon emission per plastic bag (For creating a virgin plastic bag)

(Source: https://www.ted.com/podcasts/ted-climate-what-happens-to-the-plastic-you-throw-away-transcript)

Assuming 50 Plastic Bags per bike ride

= (1.6 x 50) = carbon emission of 50 plastic bags

Assuming 80% Retention Rate, Thus the left 20% are the ones producing emmisions.

= (1.6 x 50) x 20%

= 16 gm of Carbon emission

Net Difference Carbon emission per bike ride = Carbon Emission of Cardboards - Carbon Emission of Plastic Bags

= (165.5 - 16) gm of Carbon emission per bike ride

= 149.5 gm of Carbon emission per bike ride.

Impact: Carbon Emission:

We will measure the cost difference between the initial process and the process we propose to calculate the cost impact.

The initial process used only cardboard boxes.

One cardboard Box = 6.62 gm of carbon emission.

It has a 50% chance to get Recycled.

Therefore 6.62 x 50%

= 3.31 gm of Carbon Emission.

Reusable Packaging

Cost of Reusable Plastic Bag

New Process uses Reusable Cardboard Boxes with Plastic Packets.

Assuming one cardboard box can be Reused five times and that a Plastic Packet has a probability of 80% to be reused in the Supply chain.

Therefore, (6.62/5) + 1.6 x 80% = Net Carbon Emission in the new Process.

2.60gm of Carbon Emission.

(Reference : Guesstimate from Carbon Emission from Reusable Plastic Bags)

Net Difference Percentage = ((3.31 - 2.60)/ 3.31) x 100

= 21% Carbon Emission Decreased.

Initially, we only used Cardboard boxes.

Assuming one cardboard to cost 0.5 Rupees.

Now in the New Process, we use Cardboard Boxes and Plastic Packets.

Cardboard Boxes are used five times.

Assuming Plastic Packets also to cost 0.5 Rupees only.

0.5/5 + 0.5 = 0.6

Thus Net Cost for the production of One package is Increased by a margin of 0.1 Rupees per product

Timeline Implementation Plan

Sustainable Tertiary Packaging

Year	Grade A 35%	Grade B 50%	Grade C 35%	Total
1	40%	-	-	14%
2	60%	7.5%	-	24.75%
3	-	92.5%	100%	61.25%

Automating Warehouse and Inventory

Year	Grade A 35%	Grade B 50%	Grade C 15%	Total
1	100%	-	-	35%
2	-	100%	100%	65%

Convertible Delivery Bag

Volume Basis/ Year	Type 1 50%	Type 2 35%	Type 3 15%	Total
1	Research And Development			
2	20%	-	-	10%
3	30%	10%	-	18.5%
4	40%	20%	20%	30%
5	10%	70%	80%	41.5%