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# Case Study Project

Design Thinking & Innovation

Case Study: Ideation

**Project: Storage Unit for Post Harvest Veggies**

Section: C12, Week 12


# Design Thinking & Innovation (DT&I)

Section: C12

Week 12


# Design Thinking & Innovation (DT&I)

**Presented by:**
**Prof. Ravi Poovaiah**
IDC School of Design, IIT Bombay

# DT&I Case Study

## C12 Case Study Project:

### Storage Unit for Post Harvest Veggies

by Arunprakash Ezhilarasan
and Prof. Avinash Shende

Module C12:

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C12.1

# Storage Unit for Post-harvest Veggies

# Case Study:

## Design of **Storage Solution to Reduce Post-harvest Losses of Vegetables**

- A waste management container and cooler

by
Arunprakash Ezhilarasan and Prof. Avinash Shende

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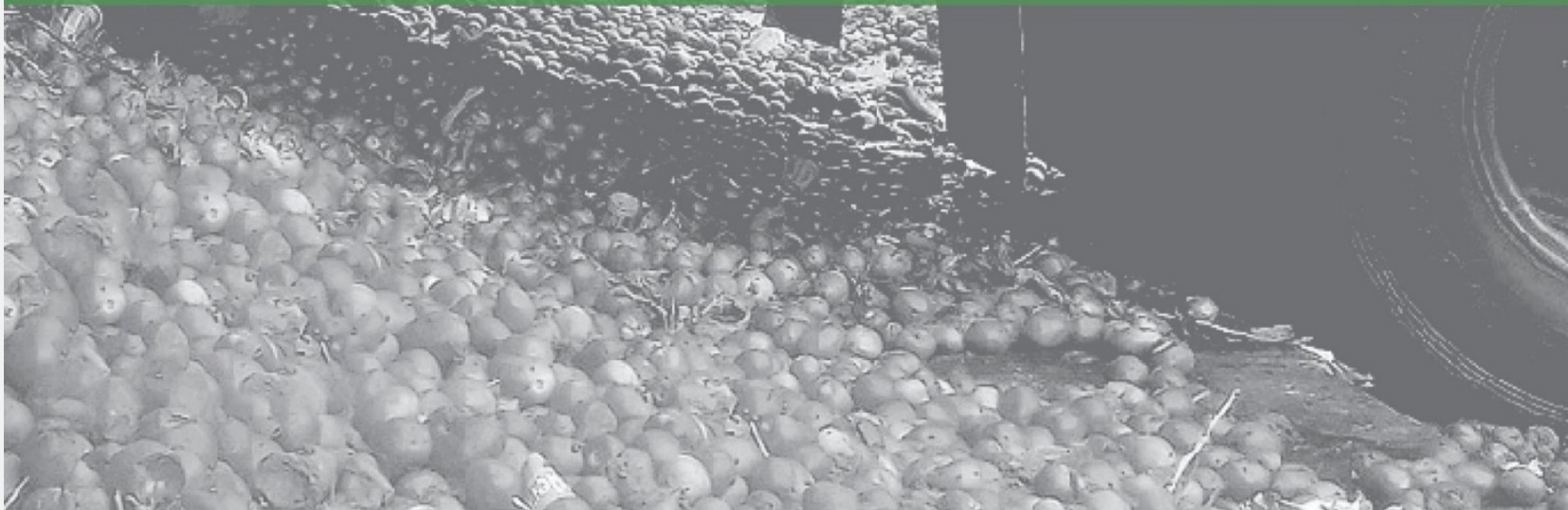
# Storage Solution to Reduce Post-harvest losses of Vegetables



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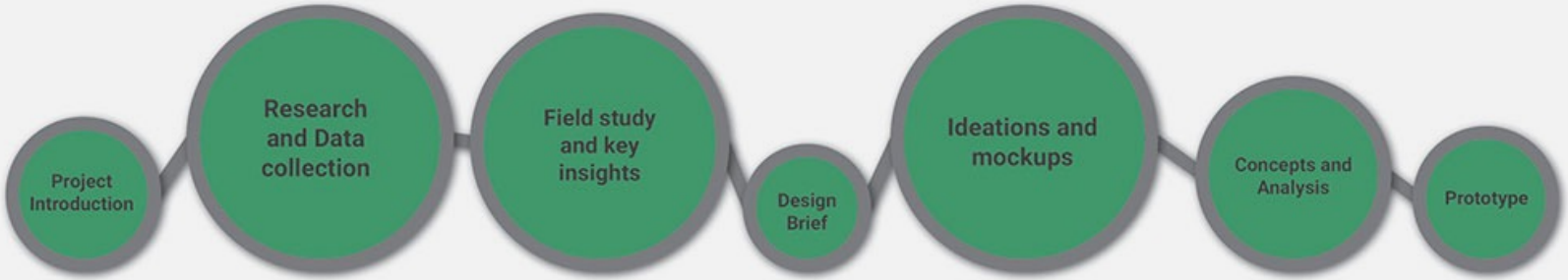
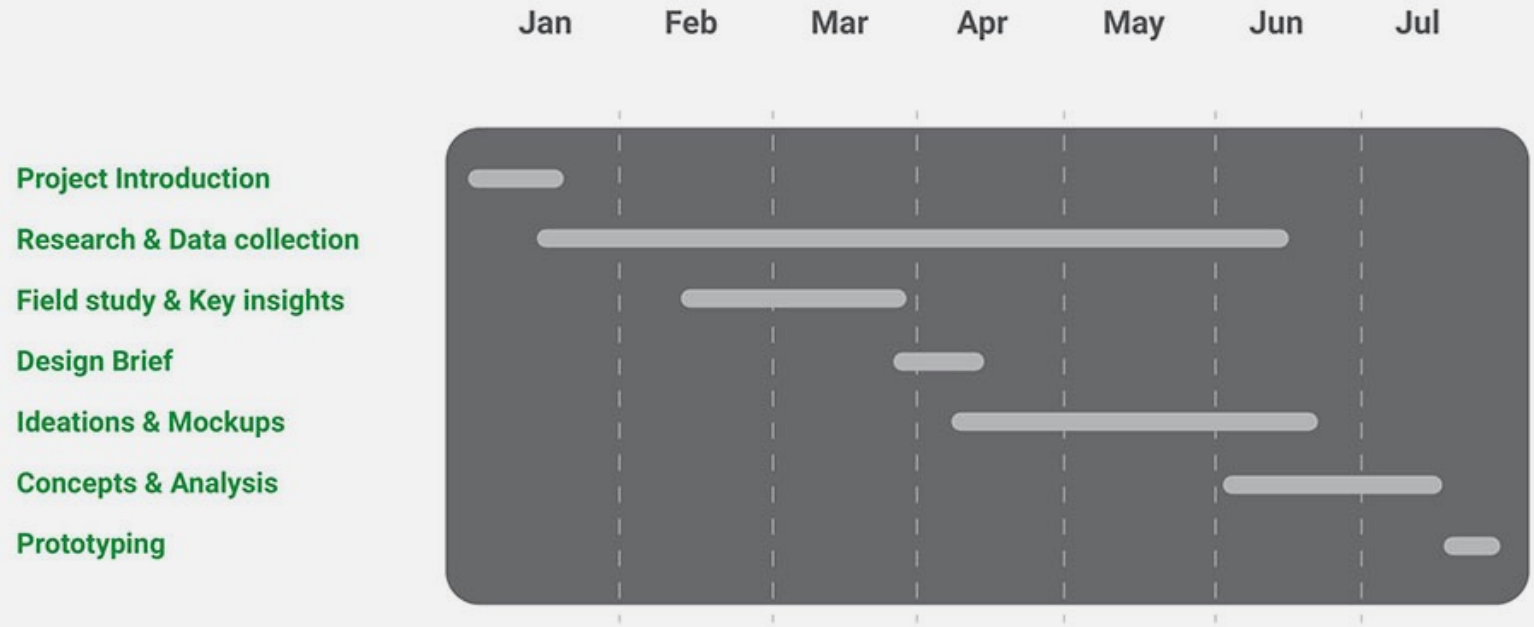
# Methodology:



# DTI Process and Timeline:



# Introduction:

Fig. 1.1 Brinjal thrown away at Koyambedu market.

Over the past two decades or so, India's food system has been transitioning with a declining demand for cereals and pulses and increases in the demand for high value horticulture and livestock products with rising incomes, urbanisation, and female labour force participation.

Even in this demand led system, heavy losses occur because value chains remain poorly developed, in terms of transportation, handling methods, storage facilities. The losses are not addressed because of it occurring at small quantities compared to the huge transactions being done routinely. If it is accounted collectively the resulting loss and wastage are very huge. This is mainly because of two reasons, the perishable nature of the vegetables and the handling of the vegetables across different stages. The project focuses on addressing and giving a practical solution to reduce the losses.

# Rationale:

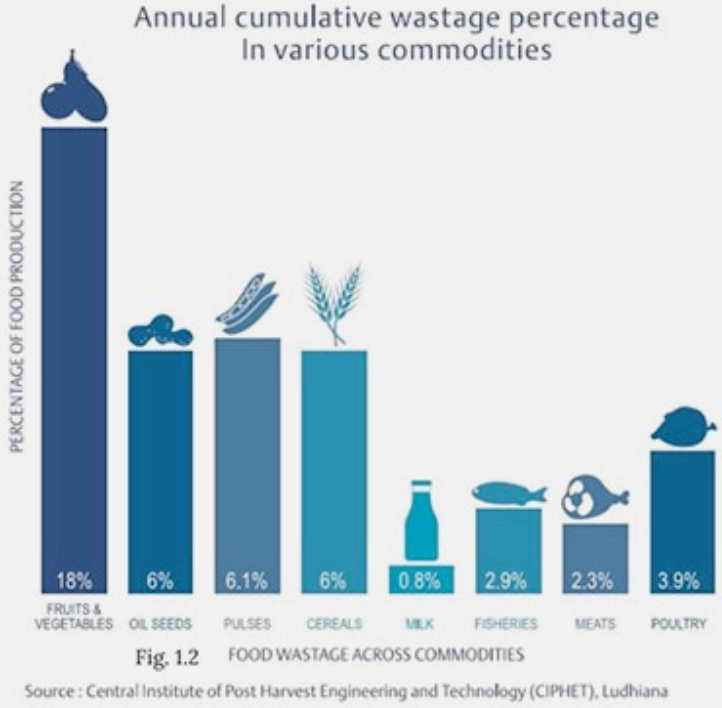



Fig. 1.2 FOOD WASTAGE ACROSS COMMODITIES

Source : Central Institute of Post Harvest Engineering and Technology (CIPHET), Ludhiana

## Need

Annually 18% of vegetables are wasted due to lack of a proper organised system and products to handle it.

If this percentage is monetised (i.e Rs. 63k crore approx.), the crisis of farmers can be readily solved

## Opportunity

Intervention in the storage solution aspect will solve most of the problems.

Till now, there are no adaptive storage containers designed for the evolved needs.

# Research: Choice of Vegetables

The number of vegetable types available in the market are very large, including the hybrid types. Each and every vegetable has different shelf life, different nature of perishing, different adaptability conditions.

Only certain vegetables are chosen for this project which are listed here. The vegetables are chosen based on the most commonly available nature and distinct characteristics of the vegetables.


Fig. 2.1 Choice of Vegetables List.

# Stakeholders

A stakeholder is a party that has an interest in a company and can either affect or be affected by the business. Every possible stakeholder has to be properly identified to address the grassroot level concerns/problems.

The stakeholders involved in this business are identified and listed based on their priority below. The Government is included because the business is mostly indirectly and sometimes directly affected by the government policies.

# User Studies

Karthik
Farmer - selling to Local Market retailers
Medium size Harvest Land

Tomatoes are not harvested at full rippen stage.

The Packaging of vegetables is based on their value.

Lady's finger - decision on maturity to weight loss has to be taken.

local markets have certain prices, special occasions have special rates, and wholesale markets have a constant rate.

Leafy veggie - no special packaging is available.

Daily usage vegetables are prone to less wastage.

Summer - vegetables have less problem in transportation

Rainy - most vegetables are prone to become waste.

Surya prakash
Farmer - directly sells in farmers market
Small size Harvest Land

Aluminium containers are mostly used to transport.

Self handling of transportation of vegetables leads to almost no loss.

No storing is needed since it is a routine business.

Limited harvest pre-planning also leads to less wastage.

Bulk purchase (catering, Functions, hotels) reduces the loss to farmers very much.

# User Studies

Venkatesan
Farmer - Exporting to Big markets.
Large size Harvest Land

Manpower to machine harvesting - cost of labour is more than cost of damaged vegetables.

Rucksacks to plastic trays - rent of trays is more since large no of trays are needed (i.e 1 - 50kgs rag = 5 trays).

Retaining the freshness and less damaging aspect of trays is overcome by manpower required in rucksacks.

Gourds are transported in corrugated boxes because of their shape.

leafy vegetables are packed such that the leaf portions are wrapped inside the wet rags and the roots are exposed to air.

Most vegetables need airflow to avoid spoilage.

6-7 rows are stacked one above for bulk transport.

Processing stage - vegetables categorised - good and bad - sold accordingly.

Manickam
Wholesaler
2nd big shop in the largest market of India

Rucksacks, plastic trays, corrugated boxes, Plastic mesh bags, plastic containers are handled.

No preserving methods are followed since mostly it is 8 hours business.

Mostly wastage is due to visual rejection of damaged goods.

Excessive goods are thrown because the supply chain is happening daily and there is very less space to handle.

10-15 people do business at peak hours.

Common cold storage is available and mostly monopolised by people who use it for cost fluctuations.

# Vegetable Study

**Shelf Life:** ~ 1 month

**Containers used:** Mesh bag, Plastic trays, simple pile up

**Reasons:** Air flow is needed to keep it dry

**Preserving method used:** Keeping it dry as much as possible.

**Reasons for wastage:** High moisture in room leads to spoilage.


Onion

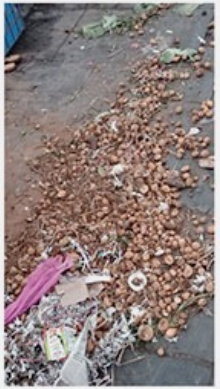

Potato

Onion bags are loaded on lorry

Onion bags are stacked outside wholesale shop

Wasted onions are thrown outside on the grounds

Wasted potato are thrown outside on the grounds




Onions in plastic mesh bags


Shopkeeper piled up onion and potato for sale


Potato bags are stacked outside wholesale shop

# Vegetable Study

**Shelf Life:** ~ 1-2 days

**Containers used:** Mesh bag, Plastic trays, Bamboo basket, simple pile up.

**Reasons:** Air flow is needed to keep it dry

**Preserving method used:** Keeping it dry and under shade as much as possible.

**Reasons for wastage:** Presence of water leads to insect infection, Transportation and handling damages, Visual Rejection.


Broad beans in aluminium container

Layer damage on tomato

Rejected tomatoes are thrown outside

Shopkeeper piled up tomato for sale

Cauliflower packed in plastic bags and stacked

Tomatoes in plastic tray are loaded on lorry.


Tomatoes in plastic tray

Okra being shipped in plastic tray

Cauliflower turning yellow and shows signs of spoiling

Cauliflower packed in plastic bags

Infected broad beans are thrown

# Vegetable Study

**Shelf Life:** ~ 5-10 days

**Containers used:** Bamboo basket, simple pile up, Mesh bag

**Reasons:** Fits more quantity.

**Preserving method used:** Keeping it under shade as much as possible.

**Reasons for wastage:** Shrinkage of skin due to loss of water content, Transportation and handling damages, Visual Rejection.


Stacked elephant yam without container

Back view showing the complete stacking

Labours piling up pumpkin in wholesale market for sale.

Damaged pumpkins are thrown outside

Cabbage are packed and stacked in plastic mesh bags

# Vegetable Study


**Shelf Life:** 1 day

**Containers used:** Plastic trays, Wet rag sacks.

**Reasons:** Cooling & Air flow to retain Freshness.

**Preserving method used:** Sprinkling water at every stage.

**Reasons for wastage:** Drying of leaves due to loss of water content, visual rejection.


Longish leafy veggis are unwrapped from gunny bags and kept outside.


Normal size leafy veggi's are kept in the plastic trays


Roots and leafs coming out through slots in plastic tray


Leafs got stuck and coming out in stacking of plastic tray

# Marketing Channels

The Vegetables after harvest pass through different channels to reach the customer. The channels are categorised based on how many stages it passes through to reach the customer.

Four channels are identified and categorised from the insights from user study and evidence from the literature survey. The channels start from farmers, then wholesalers who acquire bulk quantities for distribution. There are pre-harvest contractors in some channels and sometimes farmers directly sell by themselves through farmers markets either wholesale or retail which is shown in 2nd channel. then it passes through retail to reach the consumer.

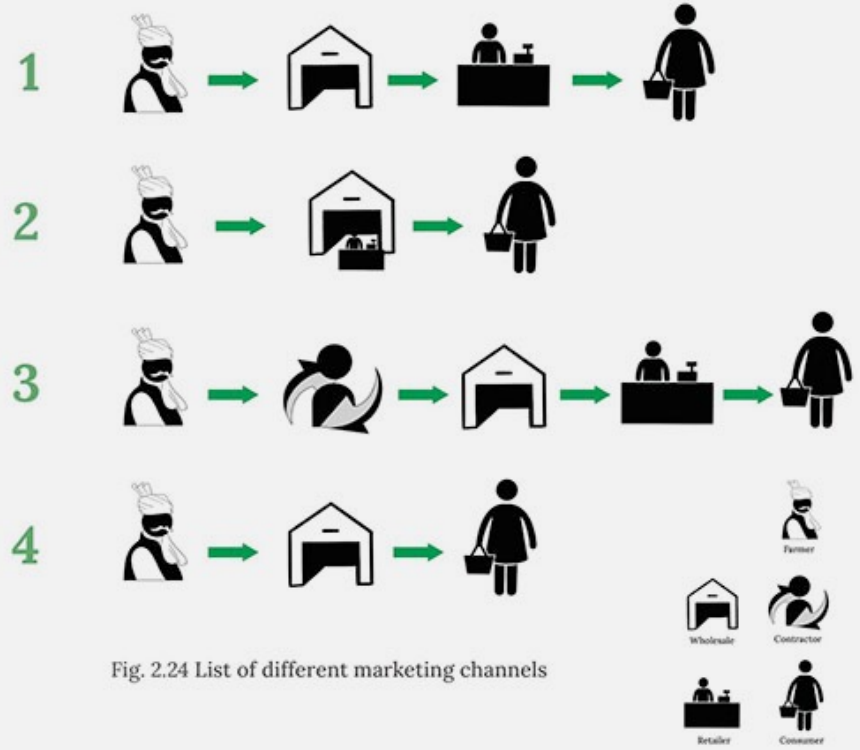



Fig. 2.24 List of different marketing channels

# Loss Identification

The data shows the minimum to maximum loss occurs at different stages of the channel of each vegetable. The physical losses (weight loss and discards) were appraised at varied stages of movement to market of the selected vegetable. Each stage of measure was where a change in custody occurred and the product entered the next step in its post-harvest journey to market.

Inclement conditions and poor handling results in loss of saleable quantity from farm to market. The losses beyond the point of wholesale or the waste in hands of the consumers were not assessed in this study.

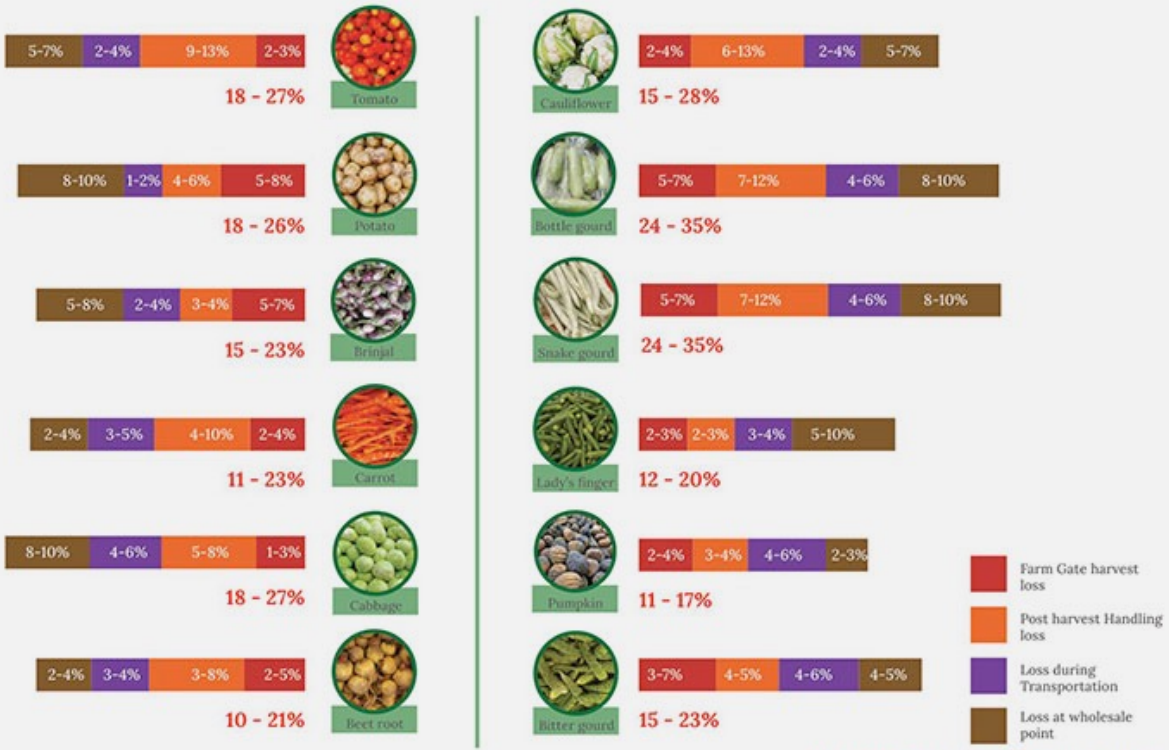
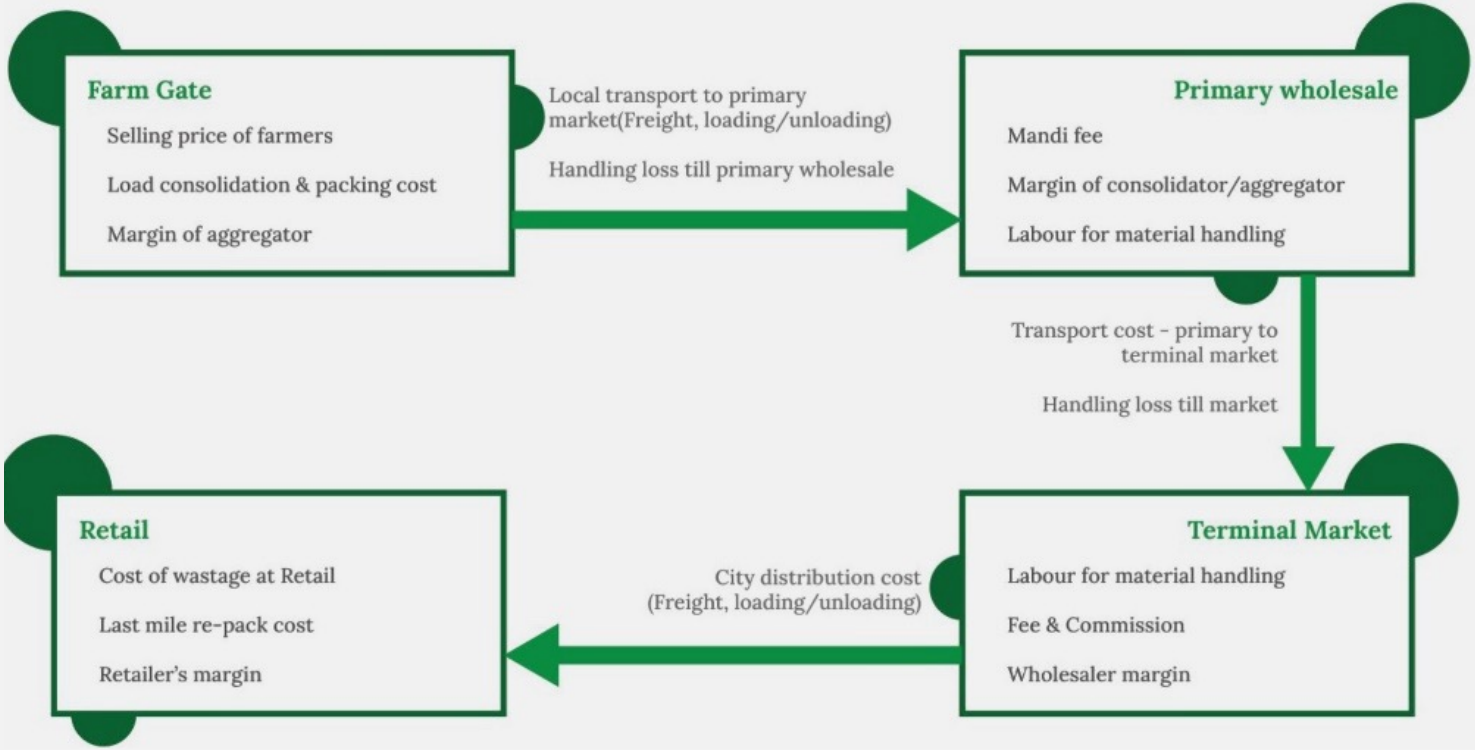



Fig. 8.2 Loss measurement at different stages Graph.

Data source: Doubling farmer income - vol. III

# Loss Identification:






Inefficiencies in Logistics Chain

# Storage Containers:

Plastic mesh sacks

Coir rag sacks

Bamboo basket

Plastic Tray

Corrugated Box

Reinforced bamboo basket

Thin Plastic Bags

Plastic sack

# Posture Study

The study of postures while carrying a heavy load is crucial for this project. Since, heavy loads cannot be handled just like that, if it's not assessed properly accidents from small muscle sprain to bones breaking will happen.

Since ancient times users have adapted themselves to the handling posture of containers based on their comfortness. Instead of changing the product they changed their way of handling depending upon the usage. Mostly heavy loads are carried on the head, on the back or on the shoulder where the hand position is just to support and balance while the load is transferred through the body. When heavy loads are carried in front of the body like carrying a plastic tray, the entire load is held by the hands and it will easily wear out the hand muscle and it is difficult to hold such big volumes with just hands only. The best position to carry heavy loads is to rest on the back and support it with your hands.

Fig. 11.1 Different postures of carrying

# Key Inferences

Preference of rucksacks over plastic trays for handling convenience and money saving .

For most vegetables, Cold storage enabled vehicles are not needed if the travel distance is less than 300Kms or 24 hours travel (it wont get completely spoiled but perishing will happen).

There is no organised supply chain which leads to lots of inefficient losses.

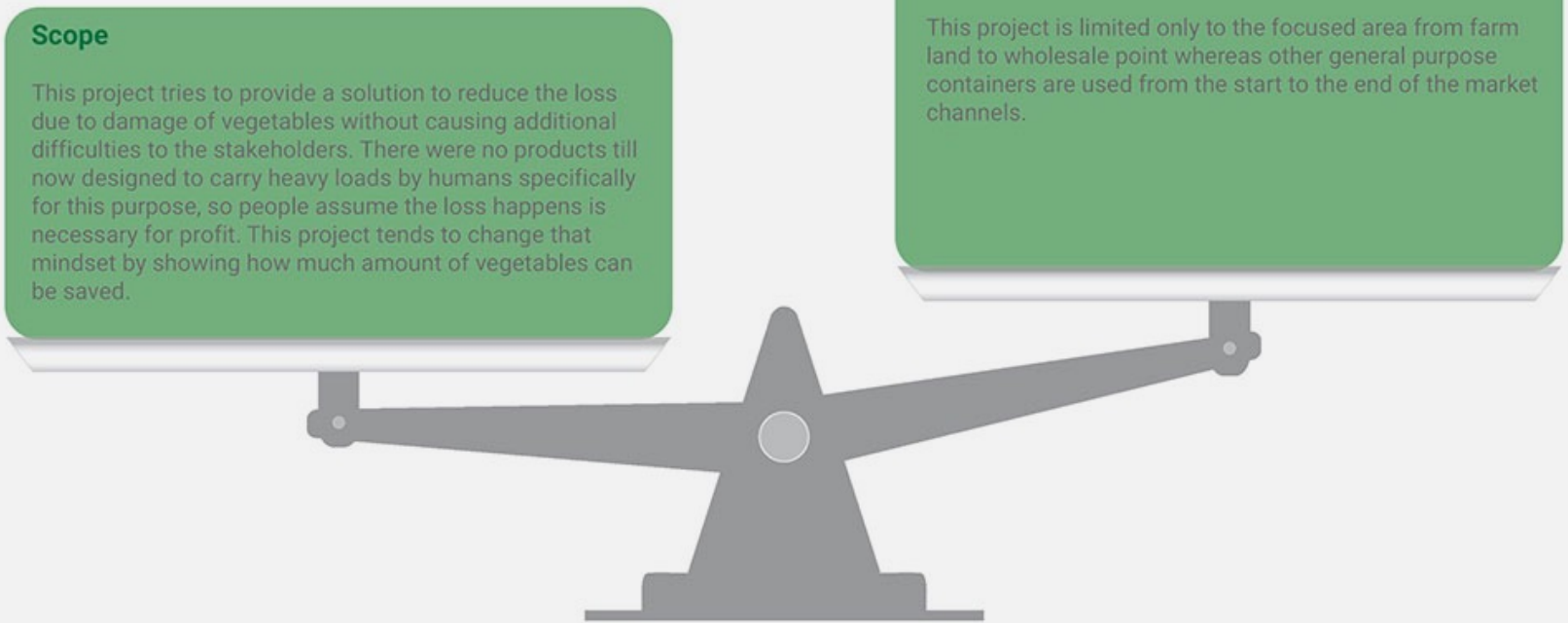
Wastage of vegetables due to Transportation & Handling is almost equal to wastage due to its perishable nature.

Wastage of vegetables almost becomes nil the more it is distributed to multiple stakeholders.

The more the routine of frequent vegetable transactions happens, cold storage is needed less.

People are used to the concept that it is necessary for some quantity of vegetables to get damaged for transportation to happen.

# Scope and Limitations



# Design Brief

## Design Brief

**To design a storage solution to reduce post harvest loss due to handling and transportation which will be used till wholesale point, with Size adaptability, Cooling enhanced and easy to handle.**

### Objectives

Space adaptable nature according to the scenarios.
Efficient air flow and cooling effect.

Reduce Mechanical loss, Physical loss and physiological losses of vegetables in every scenario.

User- centric (Stakeholders) approach.

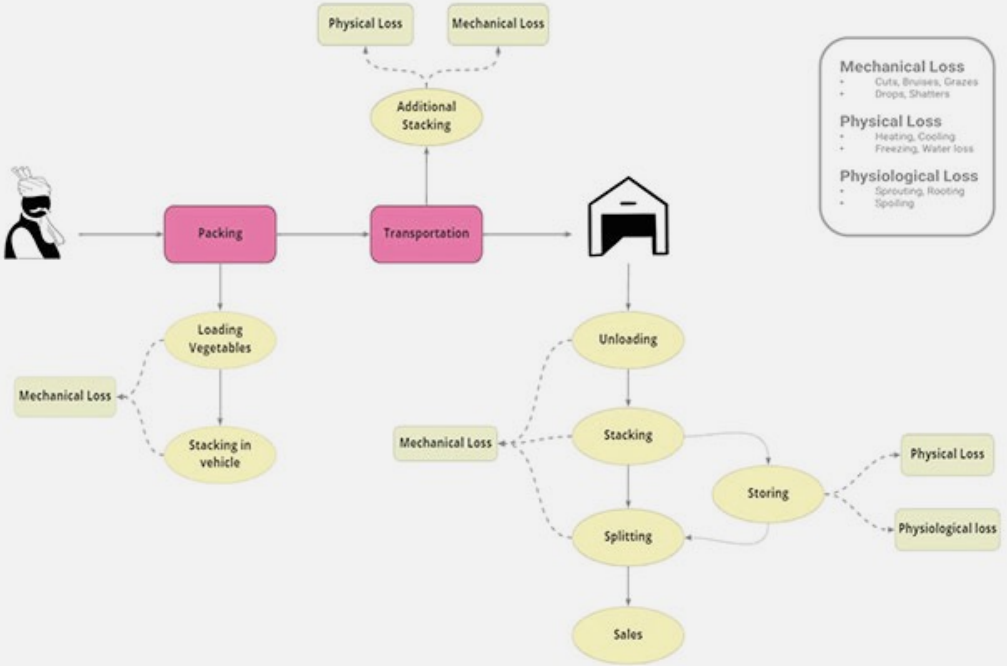
Should invoke desirability for effective reach of the product.

Should be sustainable and long-lasting.

# Design Brief

To achieve the objectives, analysing and understanding the steps and processes happening in the focus area is crucial, so that the design directions align with the design brief.

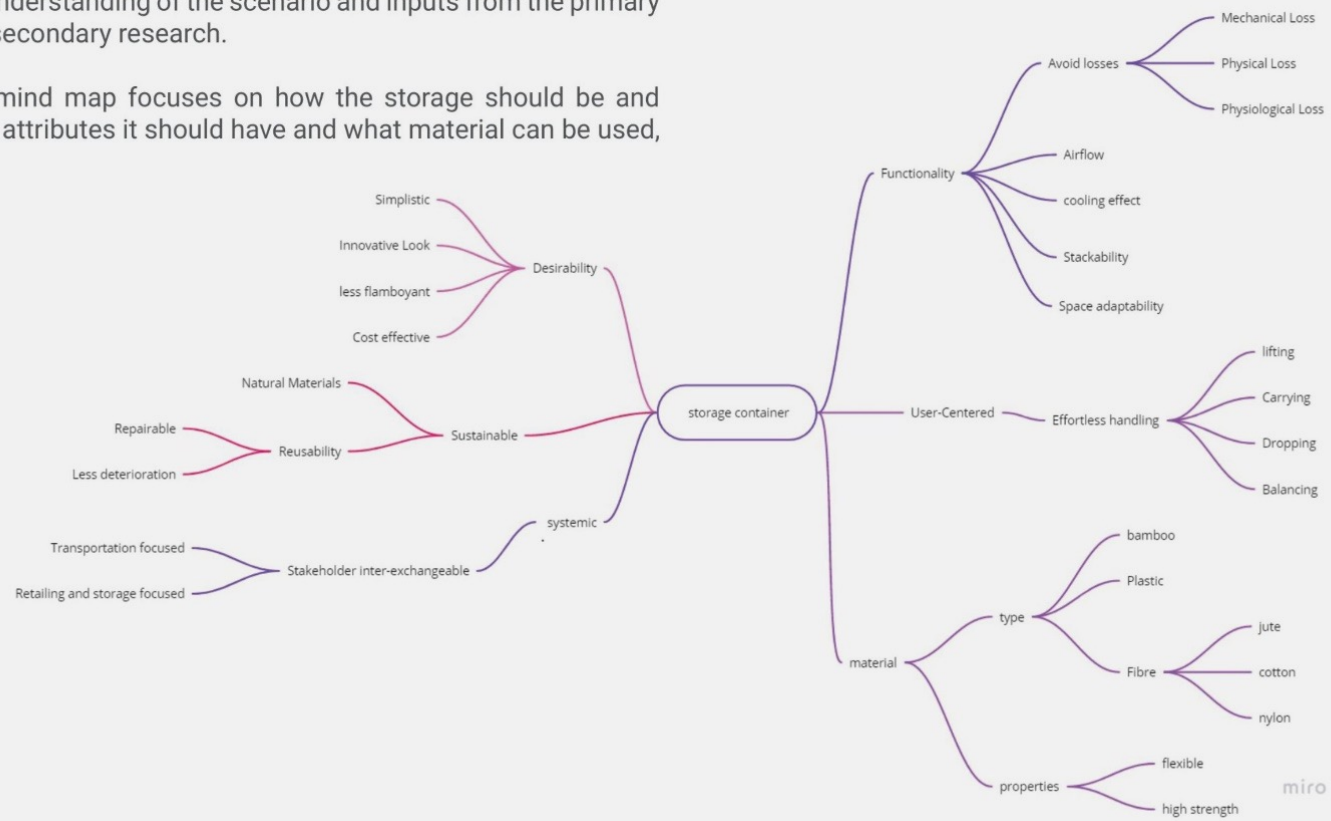
The flow chart shows the steps and processes happening between from farm land to the wholesale market. It also shows the types of losses happening at each step and each process.



# Mind Map:

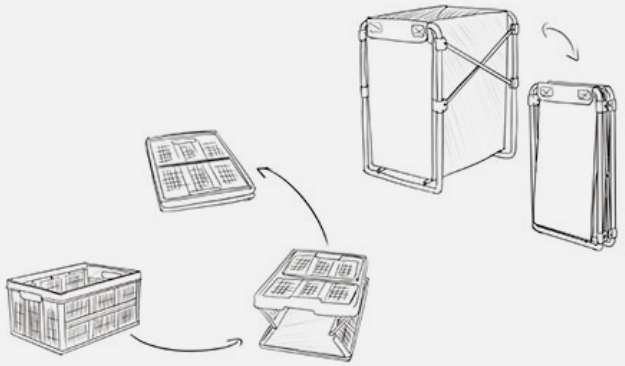
After analysing the focus area and stages where losses occur and what type losses occur, a mind map is derived based on the understanding of the scenario and inputs from the primary and secondary research.

The mind map focuses on how the storage should be and what attributes it should have and what material can be used, etc



# Design Directions:

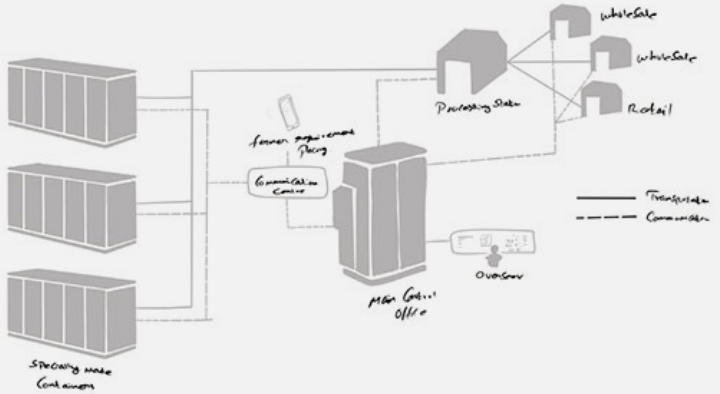
## Design Direction 1



A Range of containers as a product to replace the existing containers which should be desirable and affordable by the stakeholders who have minimum purchase capacity.

# Design Directions:

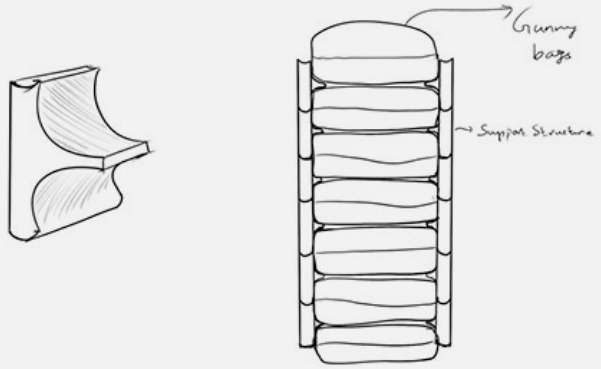
## Design Direction 2



System level Organised solution which involves Govt intervention or private organisation for the Orderly distribution and maintenance of storage containers.

# Design Directions:

## Design Direction 3



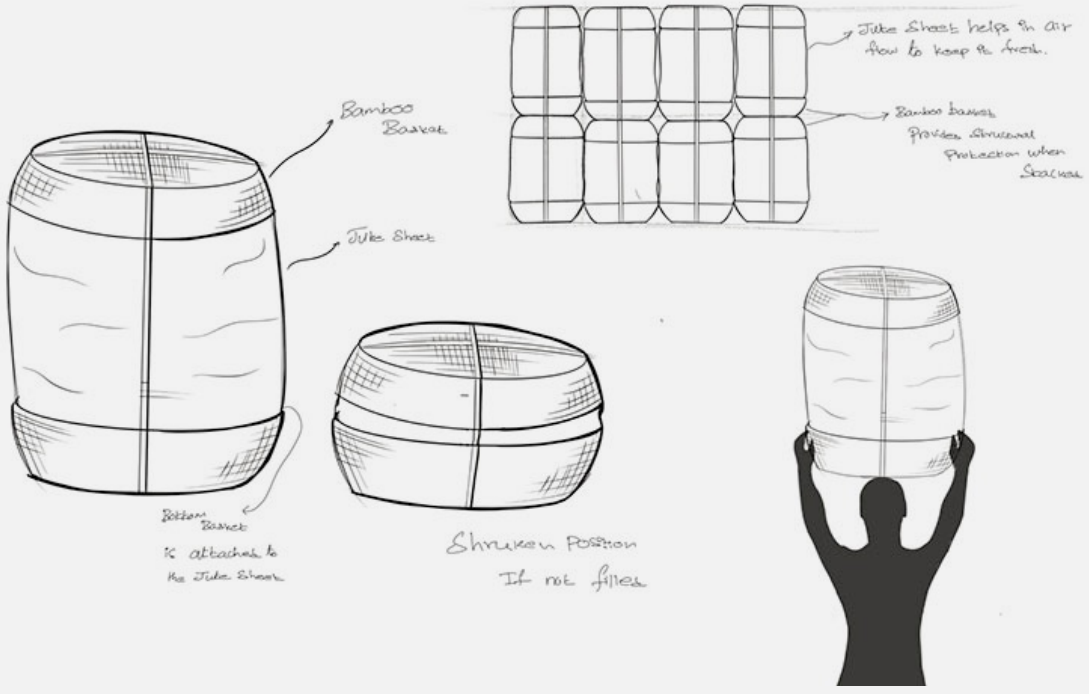

An additional attachment-like product for the most used existing storage containers.

# Ideations 1:

The design direction 1 is chosen for further ideations , the 2nd direction involves collection of more inputs which is not possible in this covid period and the 3rd direction involves usage of a lot of products to achieve the purpose which leads to various handling and storing problems.

This idea is an improved version of the reinforced bamboo basket. The bamboo baskets serve as the structural support and the jute sheet creates the volume to store.

## Idea 1




### Pros

- Light weight
- Complete customization
- Repairable

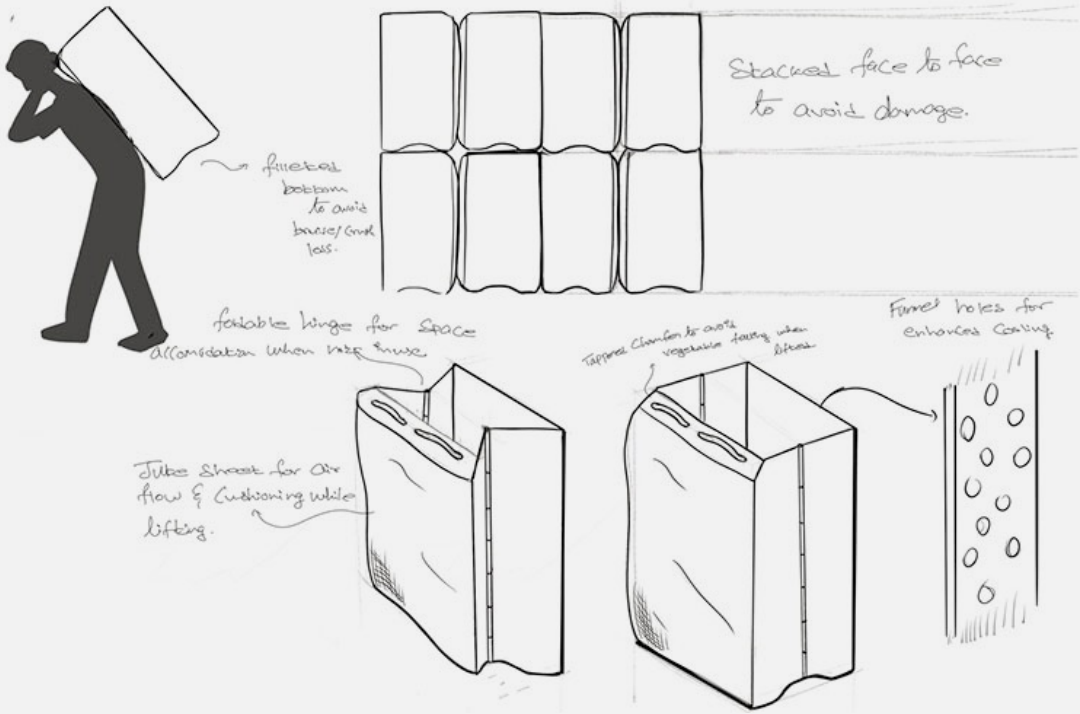
### Cons

- Load is directed on the vegetable
- balance while handling

# Ideations 2:

This idea is a combination of a gunny bag and plastic tray, it gives the comfortness of a gunny bag and structural support of plastic trays. This idea uses the gunny bag carrying posture which is the most suited for heavy load carrying purposes. The slots will give an ample cooling effect.

**Idea 2**




**Pros**

- Light weight
- Repairable
- space saving

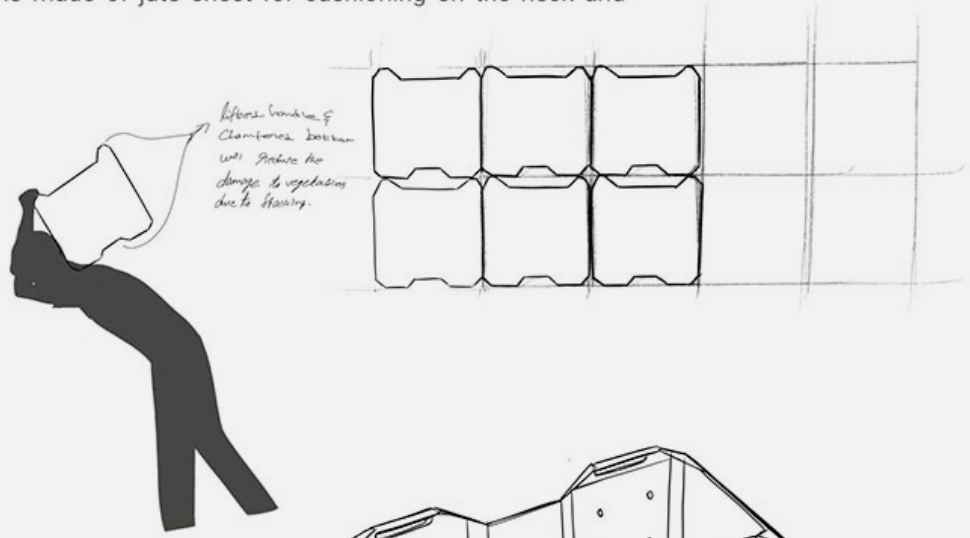
**Cons**

- Imbalance while stacking
- hinge becomes weak

# Ideations 3:

This idea is inspired from the 90's trend where people carry audio speakers on their shoulder, and this is also one of the preferred positions of carrying a gunny bag. The bottom of the middle portion is made of jute sheet for cushioning on the neck and shoulder parts.

**Idea 3**




**Pros**

- Stylish
- ease of handling

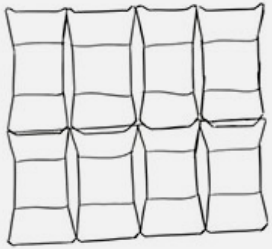
**Cons**

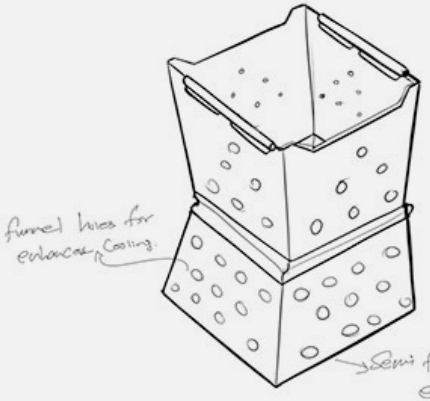
- Space occupying when not in use
- weak middle part

# Ideations 4:

This idea is the evolved version of the gunny bag. It is handled just like a gunny bag because of the flexible middle part and it also has the structural strength of the plastic trays. When not in use it can be compressed and stored.

**Idea 4**






**Pros**

- Adjustable storage volume
- space saving
- ease of handling

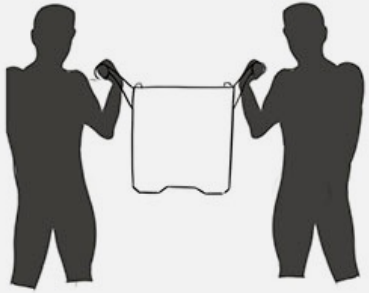
**Cons**

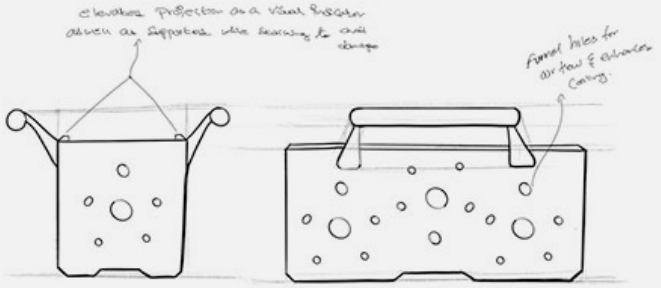
- heavy

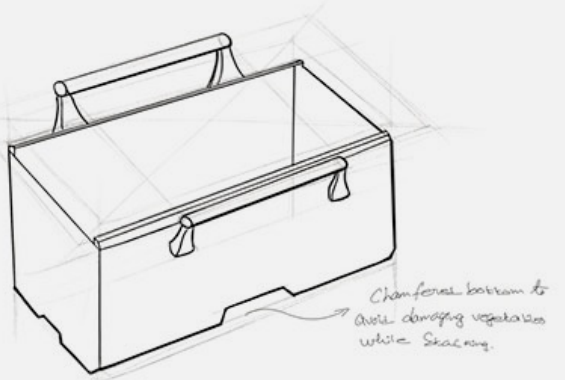
# Ideations 5:

Idea 5

This idea is designed by making the plastic tray bigger in size and letting 2 people carry it. This solves the renting large number of small tray problems. This sturdy structure reduces all the losses caused due to physical and mechanical aspects for vegetables.







**Pros**

- Big storage volume
- sturdy

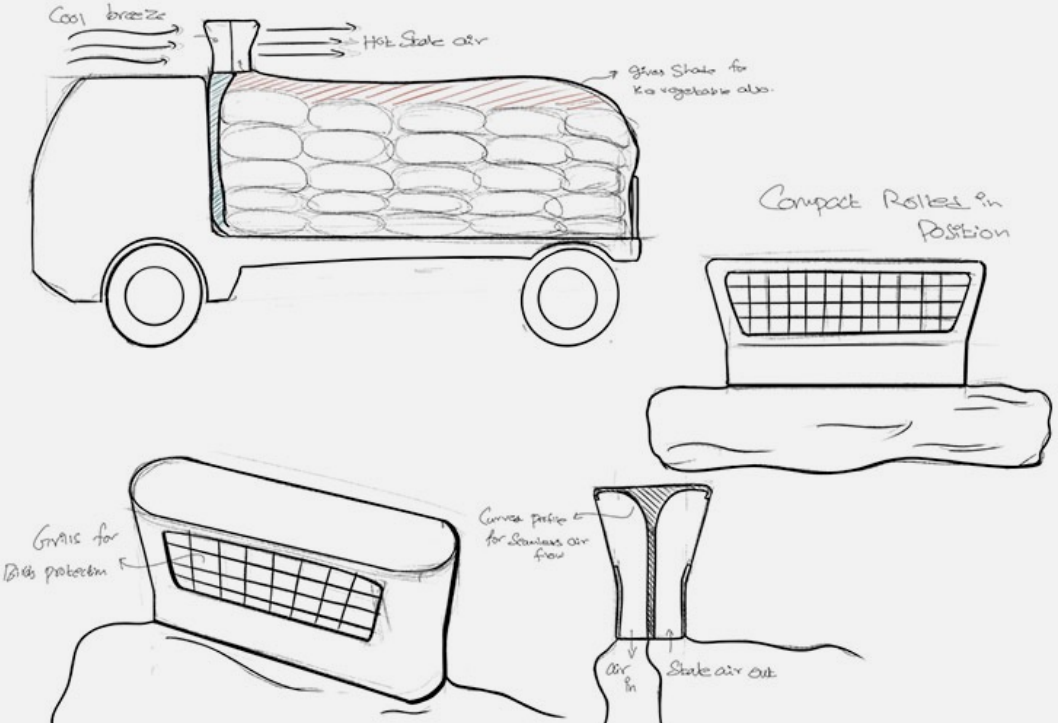
**Cons**

- heavy
- occupies large space when not in use.

# Ideations 6:

This idea is for providing a cold storage kind of experience without using electric power, just by redirecting the air which passes over the vehicle and letting it pass to the bottom of the payload area and pushing the hot air inside upwards and then outwards.

**Idea 6**




**Pros**

- single part
- easy to mount

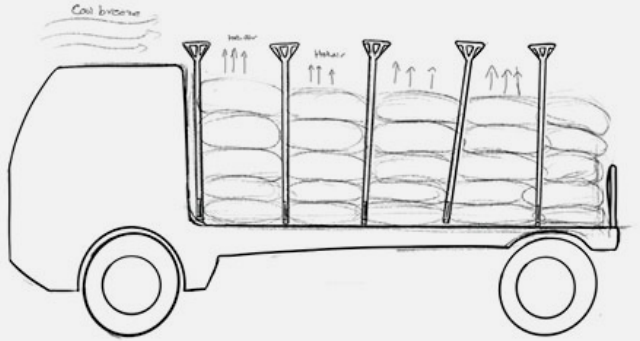
**Cons**

- Space occupying when not in use
- air doesnt reach till the end of payload area

# Ideations 7:

This idea is a stick-like version of the wind catcher. it can be inserted in between the gaps of the containers. it pushes the air downwards uniformly in all parts of the payload area.

Idea 7

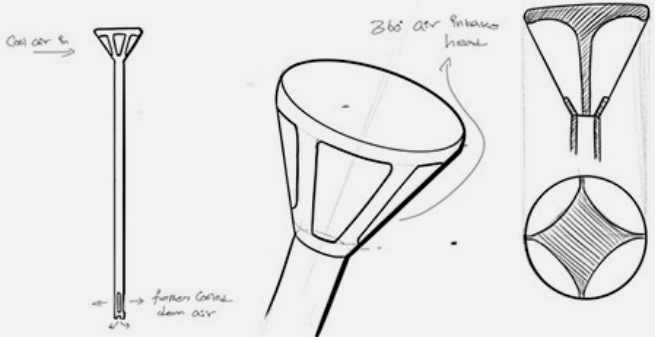



**Pros**

- easy to handle
- no complicated mechanisms to mount

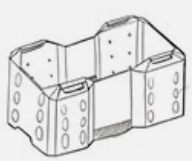
**Cons**

- too many products to achieve the purpose.
- prone to get damaged.



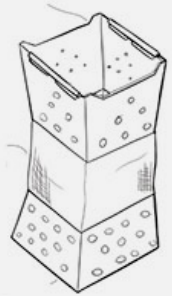

# Evaluation:




| | | | | | |
|---|---|---|---|---|---|
| Stackability | 8 | 8 | 9 | 10 | 10 |
| Posture | 8 | 10 | 9 | 7 | 8 |
| Balancing | 6 | 9 | 9 | 7 | 8 |
| Space saving | 10 | 10 | 9 | 5 | 5 |
| Adjustability | 10 | 9 | 9 | 0 | 0 |
| Handling | 7 | 9 | 9 | 7 | 8 |
| Desirability | 7 | 9 | 9 | 9 | 5 |
| Strength | 7 | 7 | 9 | 10 | 9 |

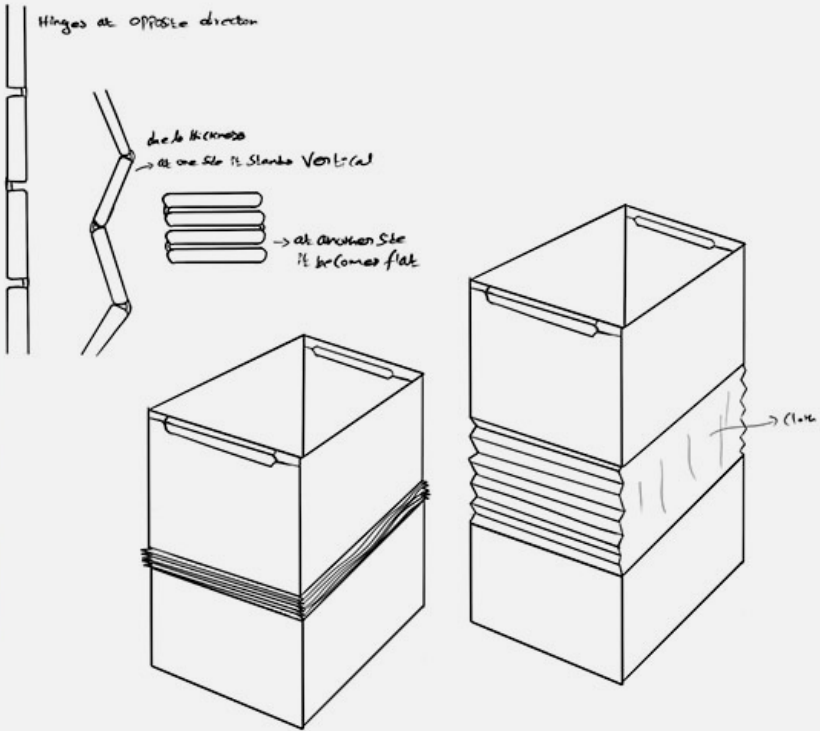
The ideation in the middle scores highest among the others and it scores balanced highest in all the parameters. So, that is selected and taken further for concepts development.

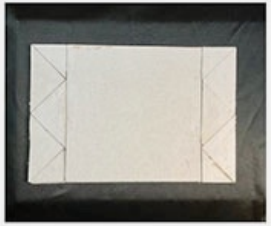


# Concept 1:

This concept is based on a wave pattern formed through origami. Folding paper resembles the hinge. with 2 thick sheets, if it is connected to one surface, it will act as a hinge in one direction and the motion will be constrained in the other direction. So implementing this concept in the wave pattern forms the mechanism for our idea. The disadvantage is, it is easily triggerable and collapses which was found in doing a quick mockup with box board and scotch tape.

Concept 1



# Concept 2:

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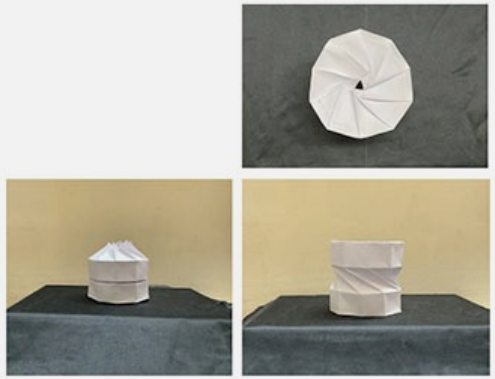
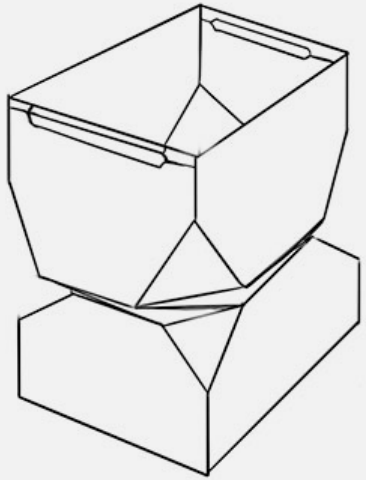
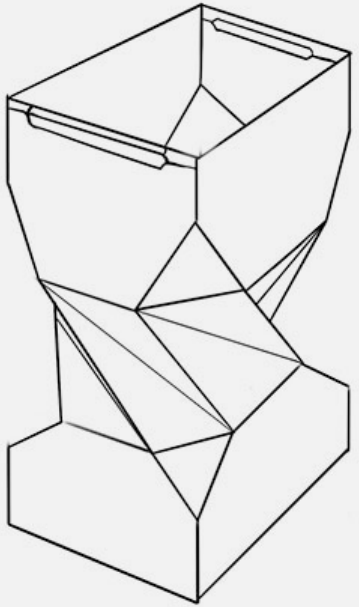
This concept is based on the twist pattern of origami. This concept will only work if the top and bottom part has more than 6 faces for the twisting action to take place. having more than 6 sides will complicate the overall design. But this compression and expansion action happens in a poetic way. The concept is verified by making a quick mockup using paper and glue.

Concept 2





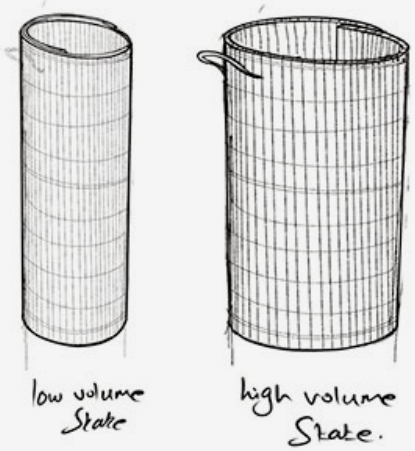


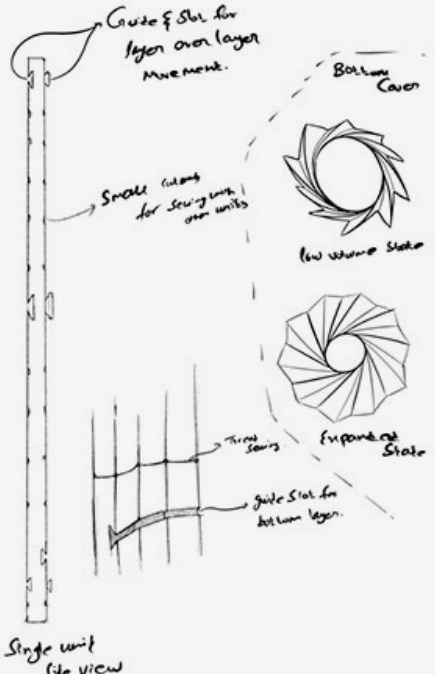
# Concept 3:

THINK! DESIGN

This concept is done with a different approach, instead of vertical compression. What if the product will look like when it is twisted inside itself like rolling a paper. The two main problems in this design is guiding the layer over another layer and the bottom cover should be such that it should change dimension as well as not be stuck between layers. For layer over layer guiding each pieces are made with slots and for bottom cover the inspiration is taken star shade model of NASA. But because of the slot the entire structure get weakens.

Concept 3

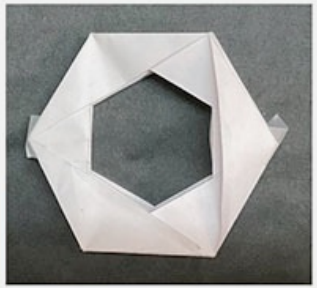


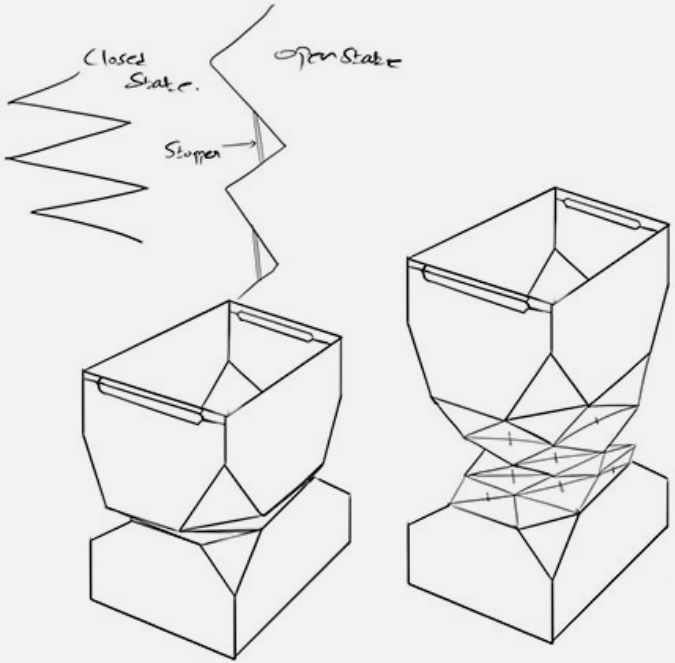



# Concept 4:

This concept is inspired from the bellows and using origami to form a rigid structure. Yet this incorporation once again requires more than 6 sides to work. Quick mock up is done to check the feasibility of the concept and it is found that it requires an additional component to keep it in the expanded position.

Concept 4

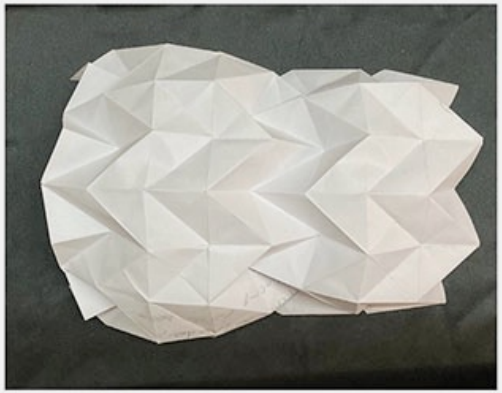




# Concept 5:

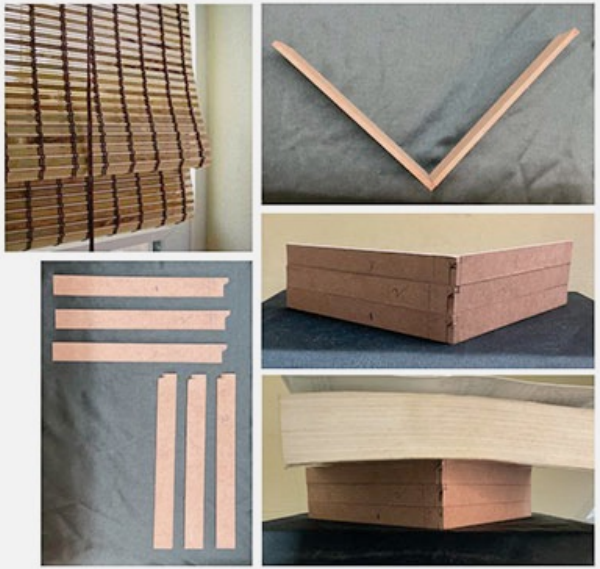
In this concept, the approach is made to work at the individual surface level instead of having a connected four sides. but the structural rigidity cannot be achieved and it requires a thicker section to work which will abruptly increase the weight of the actual product. Quick mock up ideations are done for surface patterns.

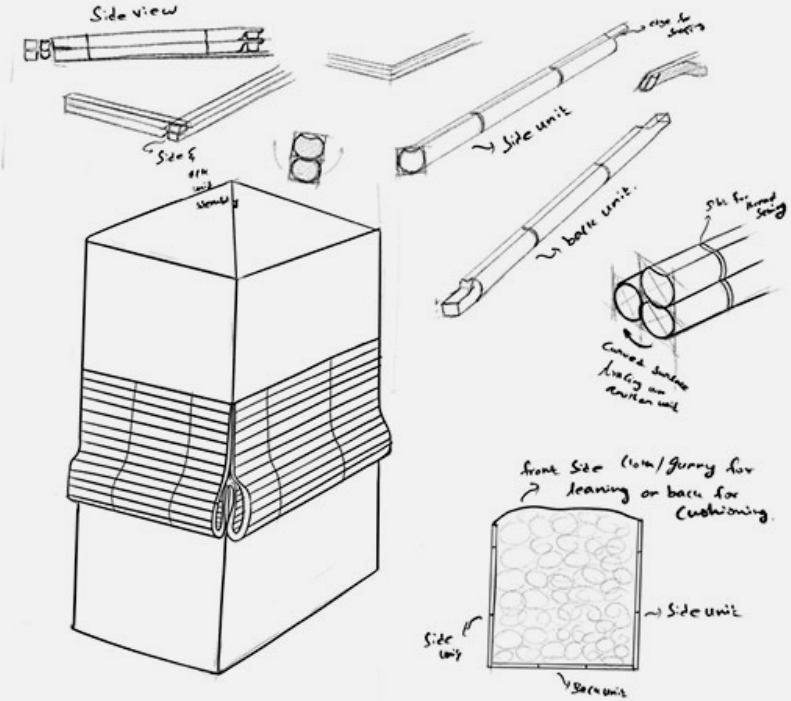
Concept 5



# Concept 6:

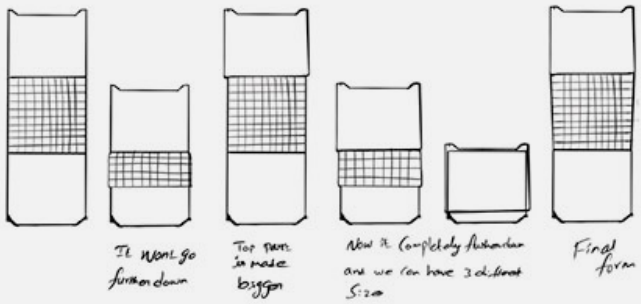
This concept is developed after taking insights from the previous concepts and it is inspired from window bamboo blinds where individual blinds are connected with ropes which makes it easy for sliding and the idea is when these blinds are held together in a single plane it becomes a solid rigid structure. This idea is verified by doing a quick mock up with a mdf sheet and it is load tested with a heavy book. This concept is finalised and taken further for product detailing.

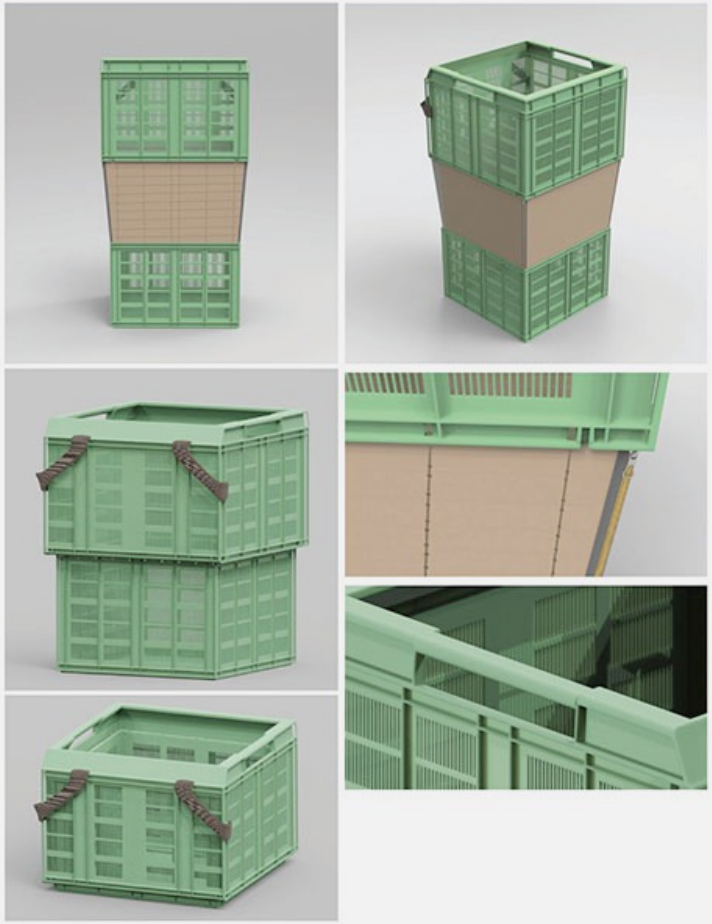




# Final Concept:

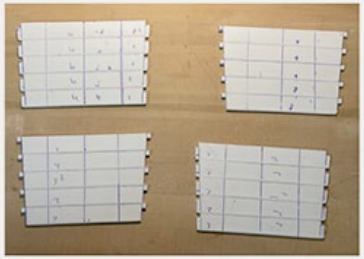
The window bamboo blinds mechanism is made as the functional mechanism for the final product. Then the feasibility is checked for that with sketching the dimensional aspect of the product and it is found that it is compressed till the top surface of the bottom part and if we increase the top part dimension it can be completely shrunken to the height of the bottom part and space is greatly reduced and it can have three different weight options. The form of the product is visualised by making 3d models and renderings. The zipper detail is given to hold the corners in position when it is in full erect mode.



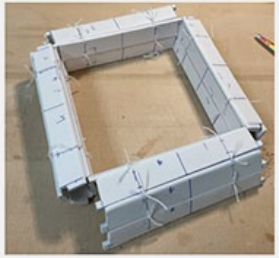



# Mockup Test:

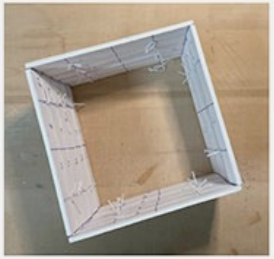
The difference in top and bottom box dimension are calculated and tapper is cut on the blinds



Blinds are holed and tied together and tested

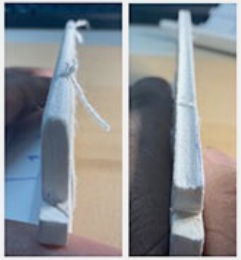


The blinds forms a perfect trapezium and stands rigid



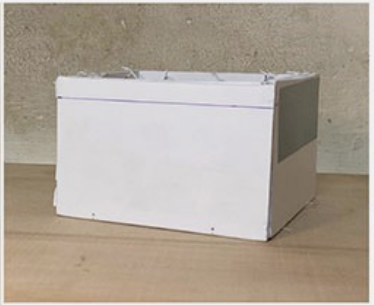
Corner detail which keeps the trapezium in position

Semi-circle shape crest and trough keeps the blinds in perfect position



Assembled to form 1st configuration

Pushed down to form 2nd configuration



Further pushed down to form 3rd configuration

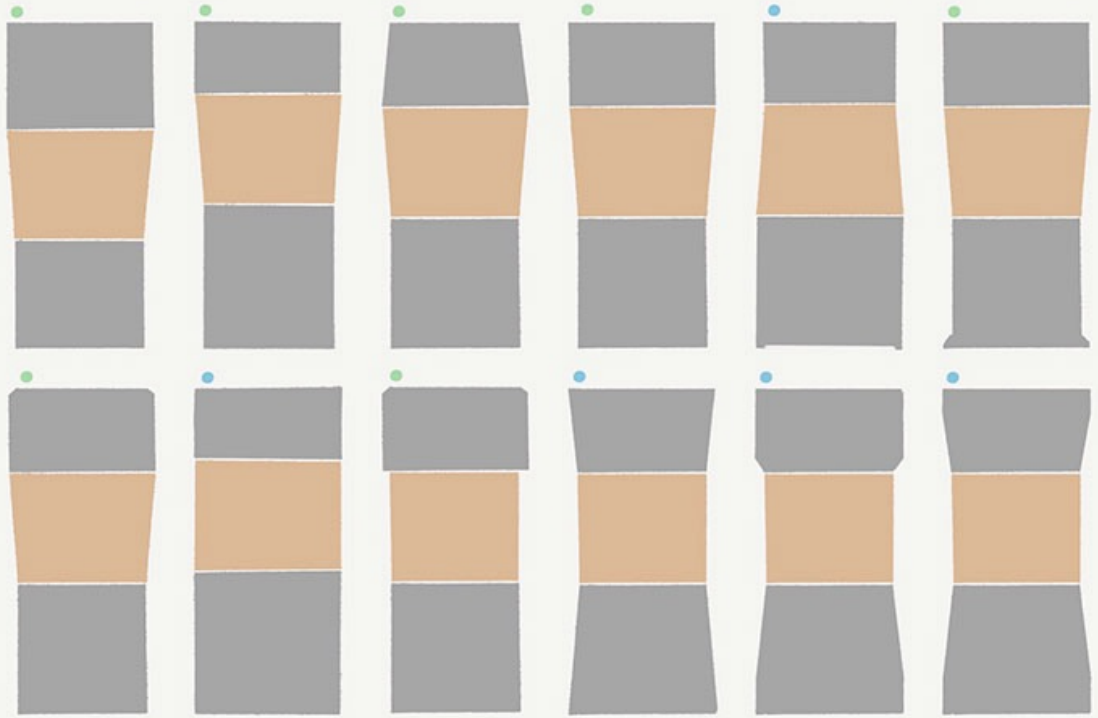
In 3rd configuration all the Blinds are perfectly flushed within gaps

The assembled mockup is load tested with 6kgs dumbell on top of it.

This is a rough mockup model to check the working of mechanism. Sunboard is used to make the mockup, the scale of the mockup is 1:3. The blinds works perfectly as conceptualized in the sketching phase.

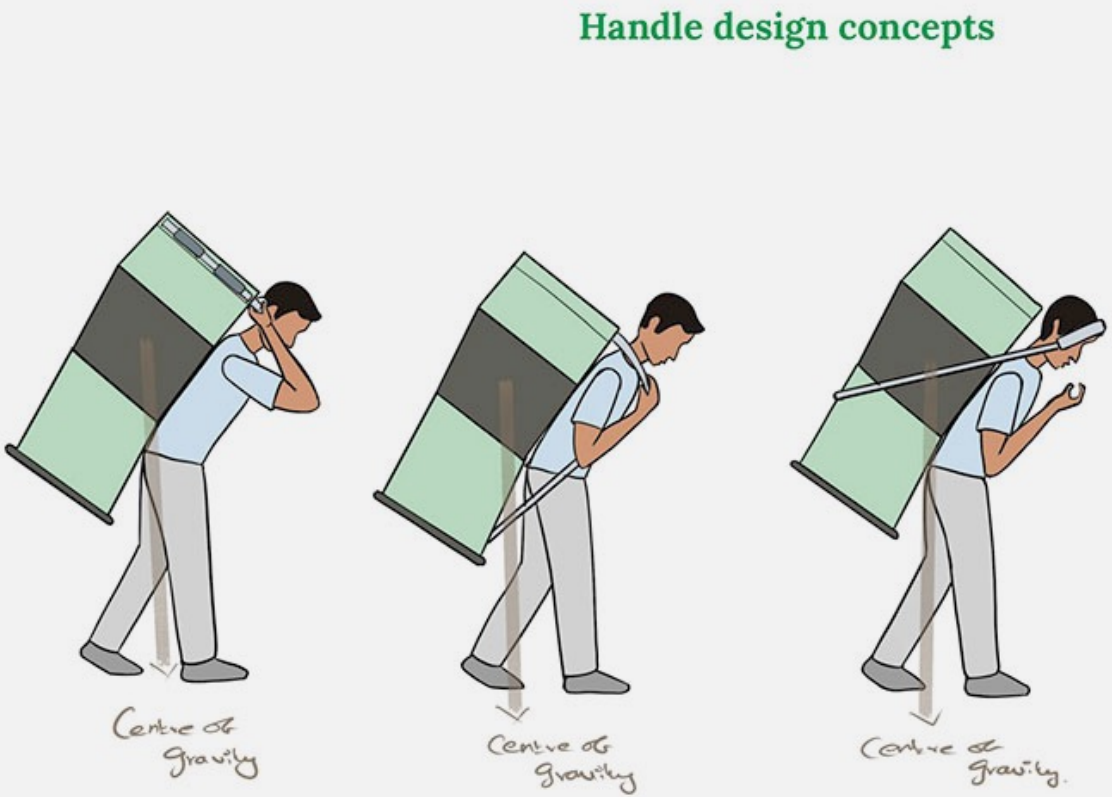
# Concept Details -proportions:

After confirming the working of the mechanism through a rough mock up. Series of ideations are made for the proportions of the overall form. The forms with green dots are more feasible to make while blue are less feasible and more complicated. These form ideations are made by keeping the insights from the mockups and posture in mind.



# Concept Details - handle design:

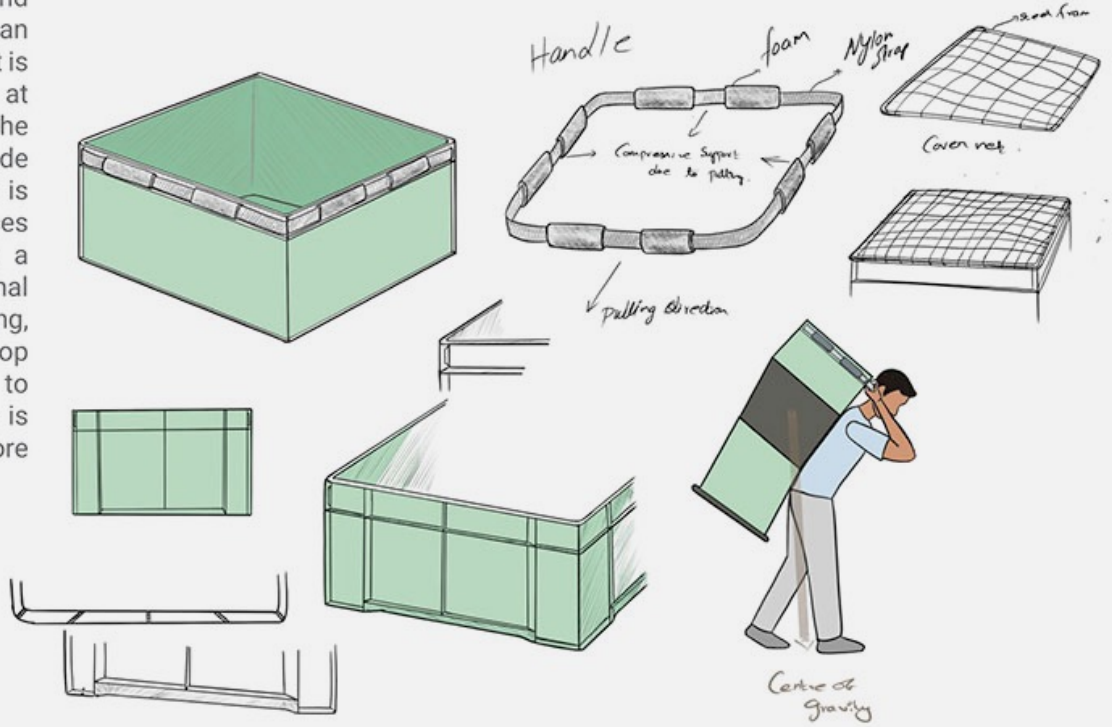
Handle Design is also one of the crucial parts of this product. since, it is a longish form when it is full erect mode and it is heavily loaded. Centre of gravity plays a huge role as to get a balance while carrying the product. The first concept is by holding the product near the ear level and it is held on the top part, this position makes the C.G to fall exactly at the centre of the body. The second is a backpack-like handle where both the top and bottom parts are connected. in this because of the longish form, the C.G falls way off. The third concept is inspired from the meghalaya people who carry heavy loads in steep mountains by holding the handle on their head. In our product to have such a handle design, the handle should be kept as a separate tool and this becomes a problem when unloading from a completely stacked vehicle.
So, the first concept is chosen.



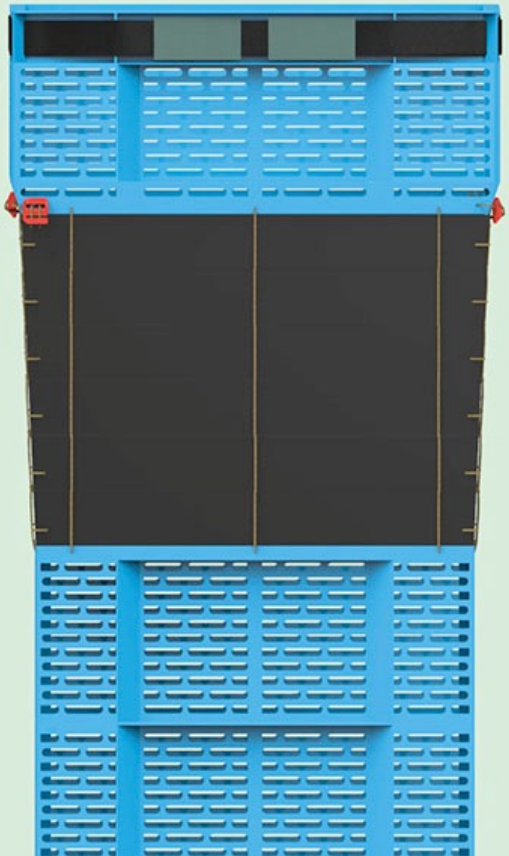
# Concept Details - handle + posture:

The top part of the product is further detailed for the chosen handle concept. The handle is proposed to be made of nylon strap and foam for grip . The nylon strap loops around all four sides of the top part. so it can be lifted from any position. When it is being carried the pulling action at one side leads to compression of the other three sides because it is made of a single loop, Thus the load is evenly distributed over the surfaces of the three sides unlike not at a single which are seen in normal handle designs. While lifting, because of the slant angle the top layer vegetables tend to slide to avoid that a separated net like is used to cover the product before lifting.

## Detailed Handle design

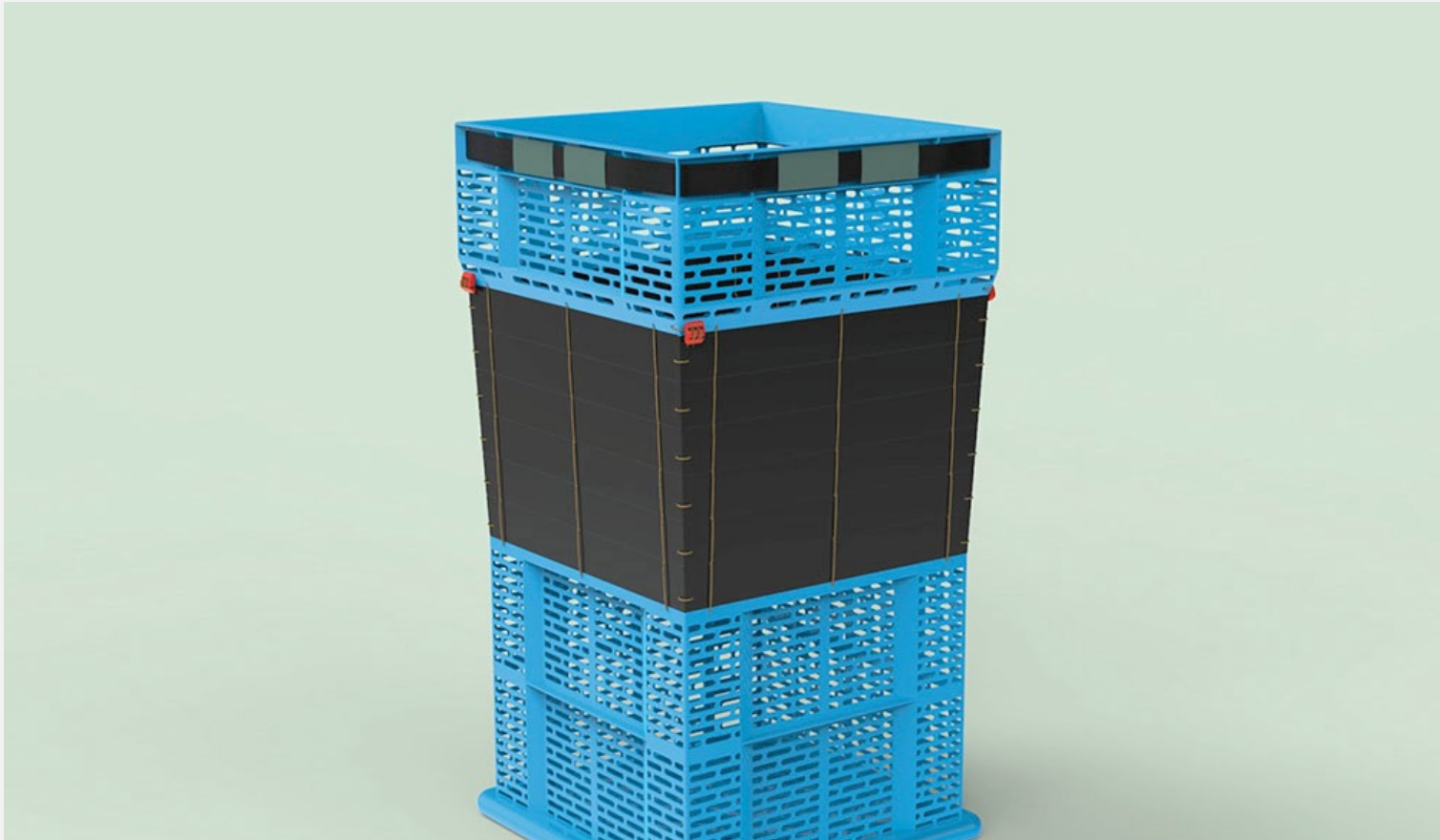


# Final Concept:

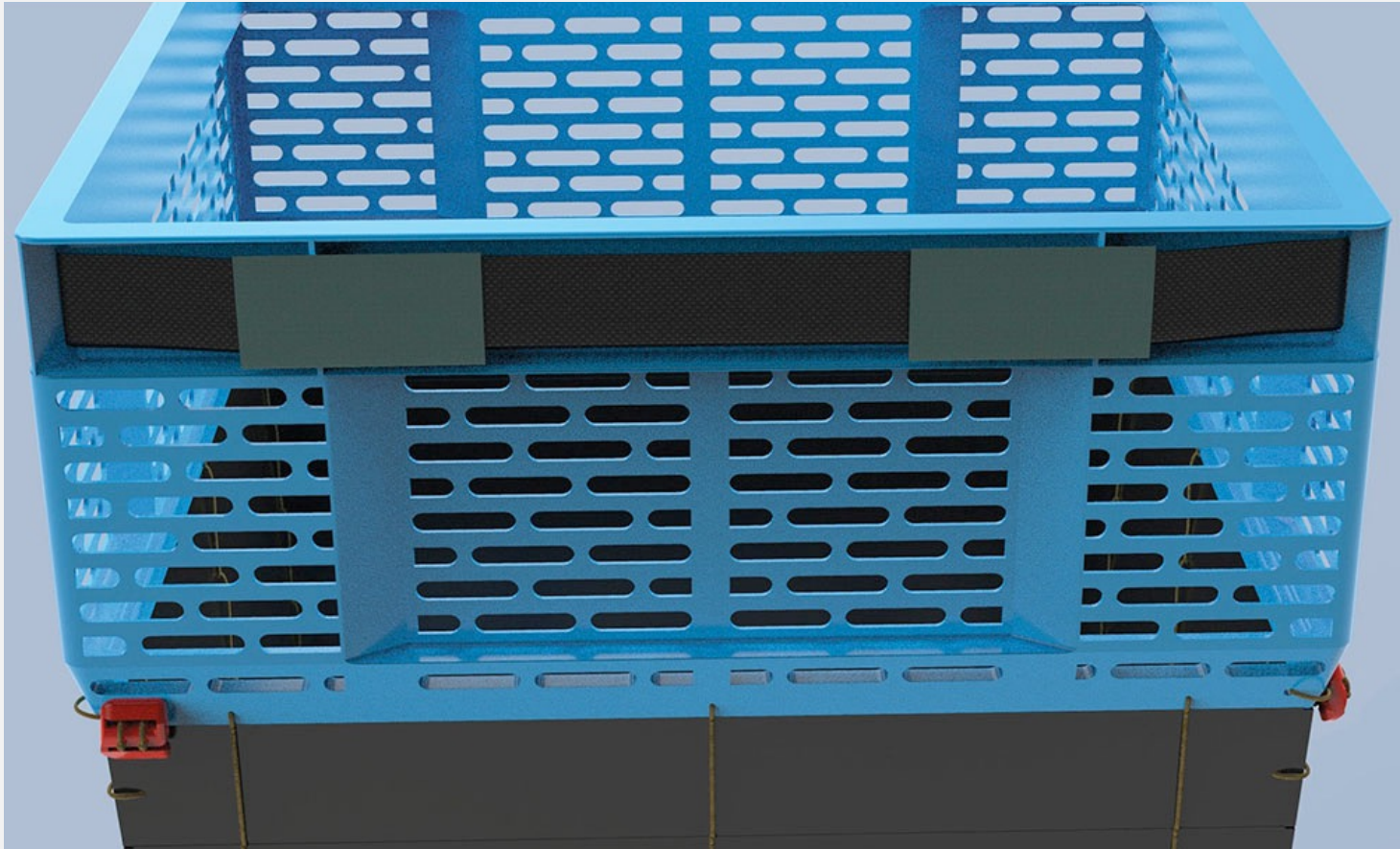


Flexi
Crate

# Final Concept:

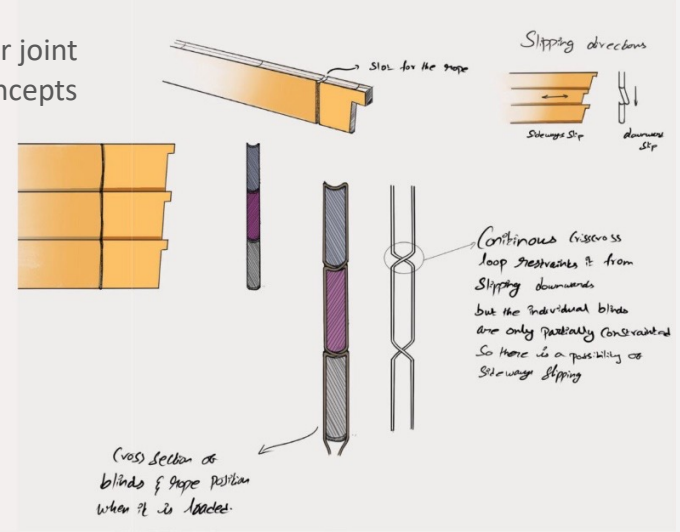


# Final Concept details:

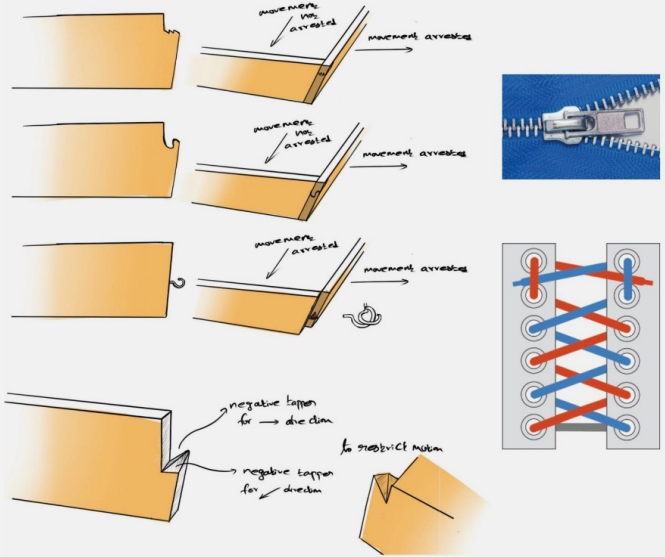


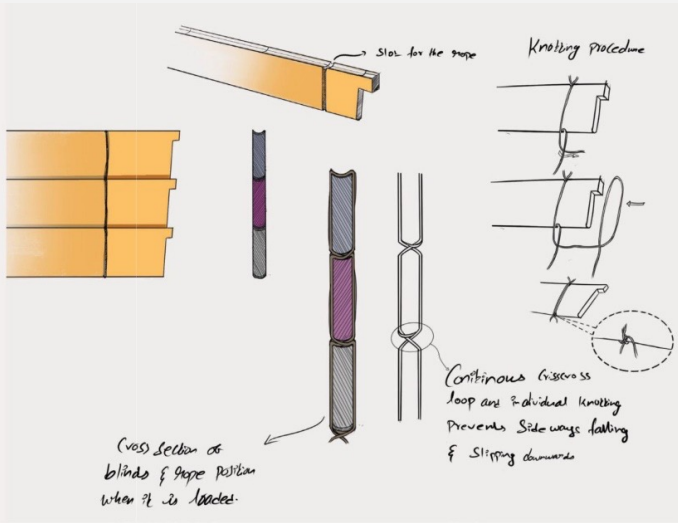
# Blinds Details:

Blinds corner joint
Design concepts




Blinds Knotting
detail concepts



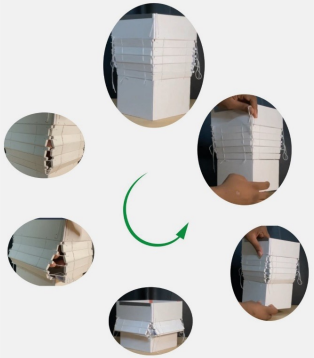
# Concept Details:

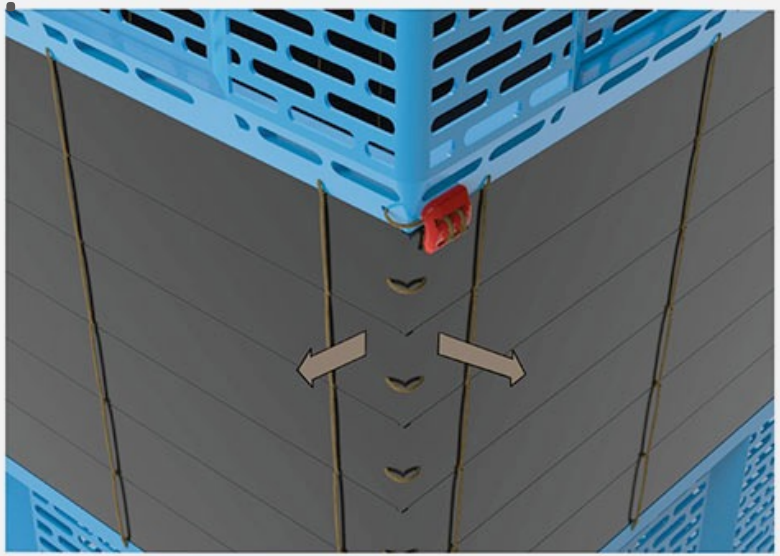
The blinds are a crucial part of the product, it creates the flexibility and rigidity of the product, the flexibility is inspired from the bamboo window blinds and the rigidity is achieved by keeping the blinds in a single plane and supported by other two sides, like that all the four sides support each other. The top and bottom side of each blind has a negative and positive curve profile so that while sliding it acts as a pivot and while kept at a single plane it helps in aligning the other blinds in the single plane. The left and right side of each blind is cut out in order to form the corner with adjacent blind just like the curve profile; the corners have a negative and positive cut out which complements each other and forms a corner. The blinds totally have 2 different profile sets. Opposite facing blinds have the same profile and adjacent facing blinds have different profile sets.

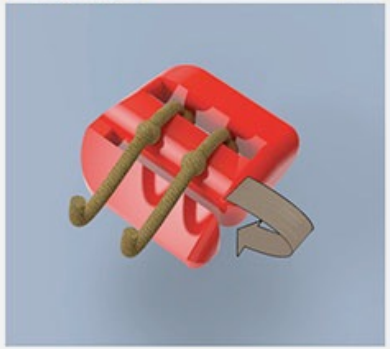
# Concept Details – corner details:

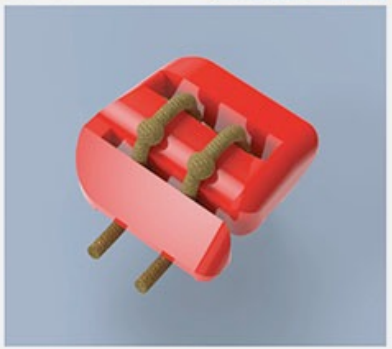
THINK!
DESIGN

The tieing of lace is another crucial aspect of the product. The lacing method serves the purpose of holding the blinds in position and ensures it from not being collapsed and getting tangles in between the blinds. But to hold the lacing, it has to be tied at the ends. If normal tieing methods is used, quick deployment and usage of product becomes questionable. For that a quick locking method is thought out. The concept is inspired from the buckles used in bags and belts. The two slots in the buckle have different dimensions. One has large slot and another has small slot. The knotted thread passes through the large slot and when it is slidded into the smal slot it gets locked.



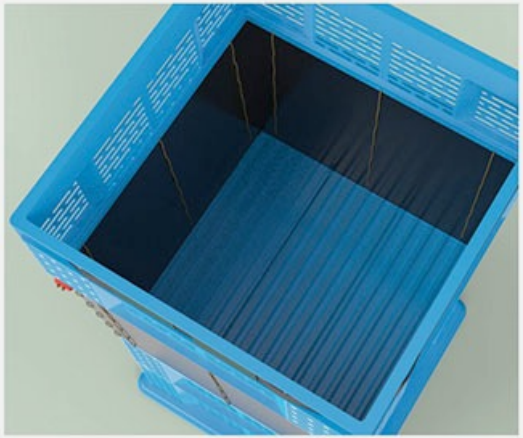


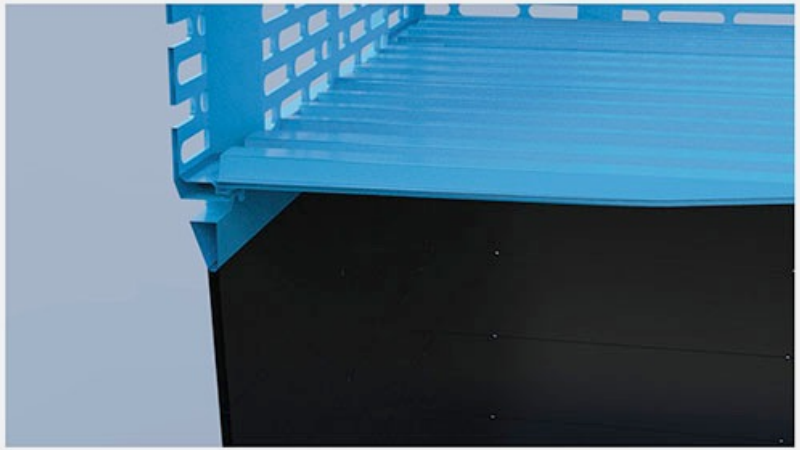




# Concept Details- rigidity:

The product is intended to have a structural rigidity, so that when stacked the load is transferred through the product not through the vegetables. But the maximum load capacity of the product is 80kgs, so there is a problem of vegetables at the bottom most layer getting damaged due to the self weight of 80kgs that to vegetables with low density like tomatoes easily gets damaged. So in order to avoid that 2 partitions are made.

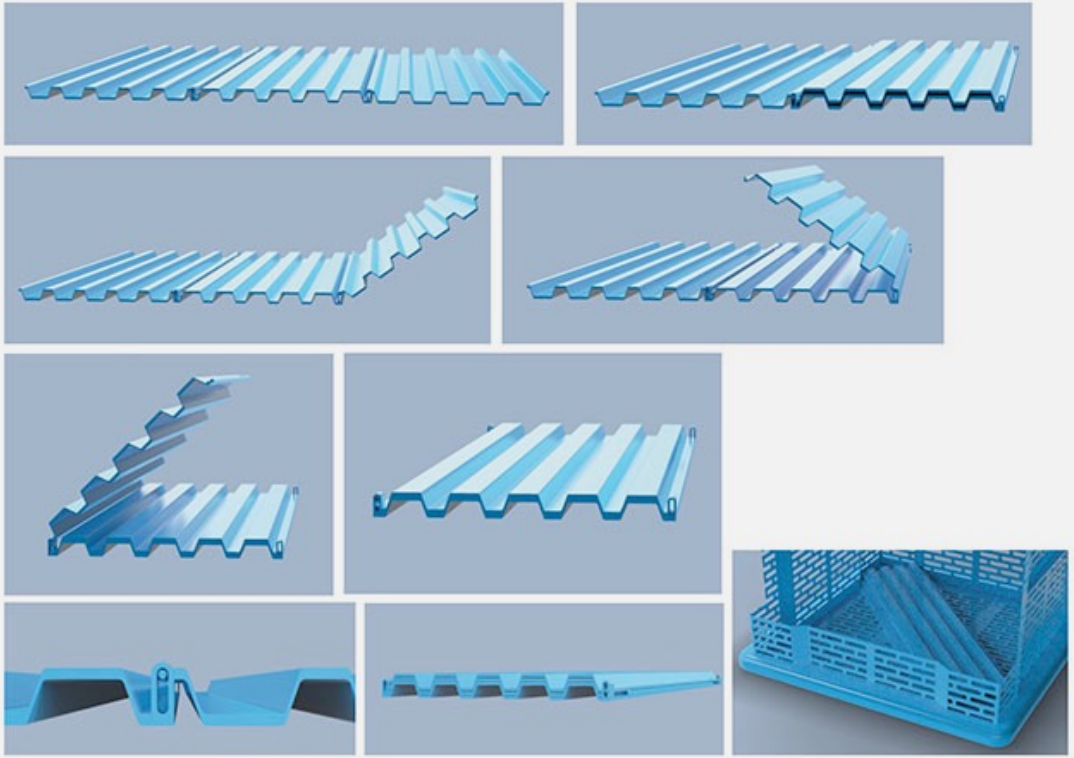




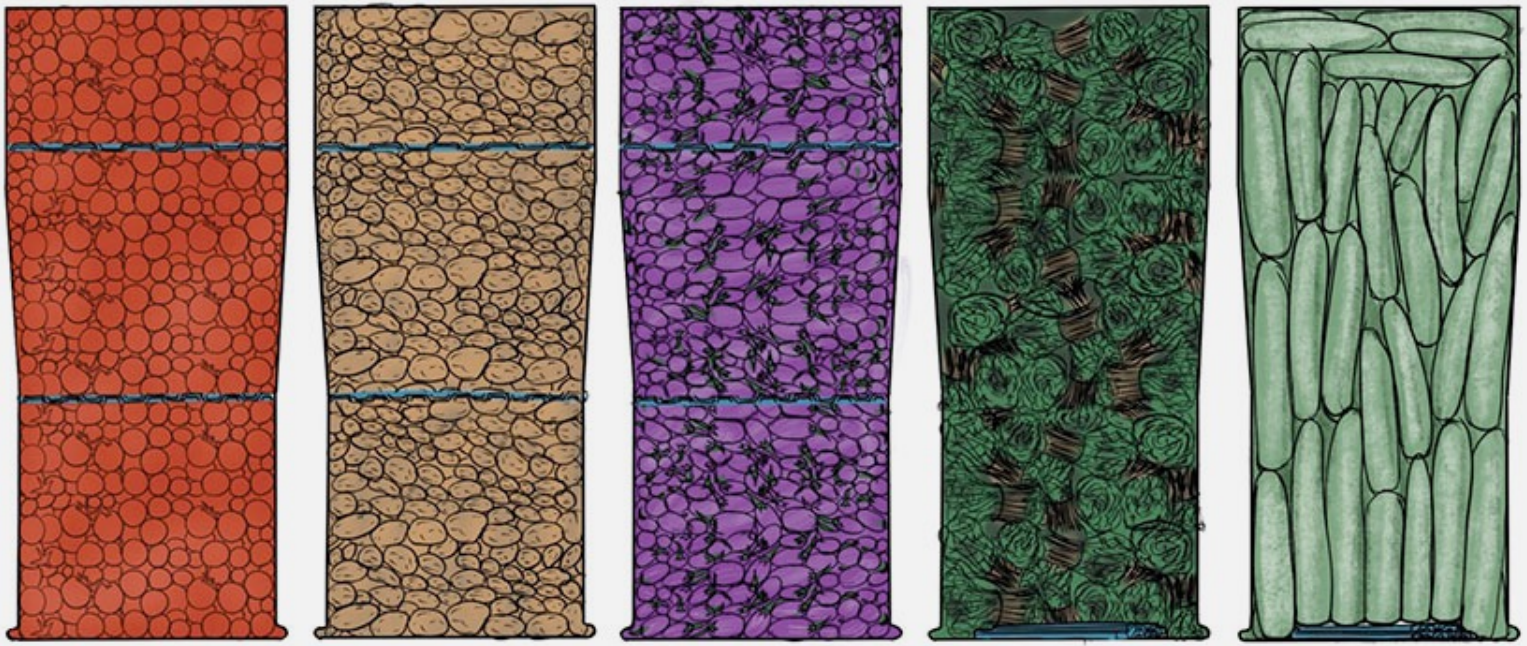
# Concept Details- partition plate:

THINK!
DESIGN

The partition plate is foldable and when it is not used it can be snapped to the bottom of the product. The partition plate is designed in a wave pattern so that with 1mm thickness it can withstand the load. The hinges are designed in a way that folds and settles perfectly in a single stacked layer.



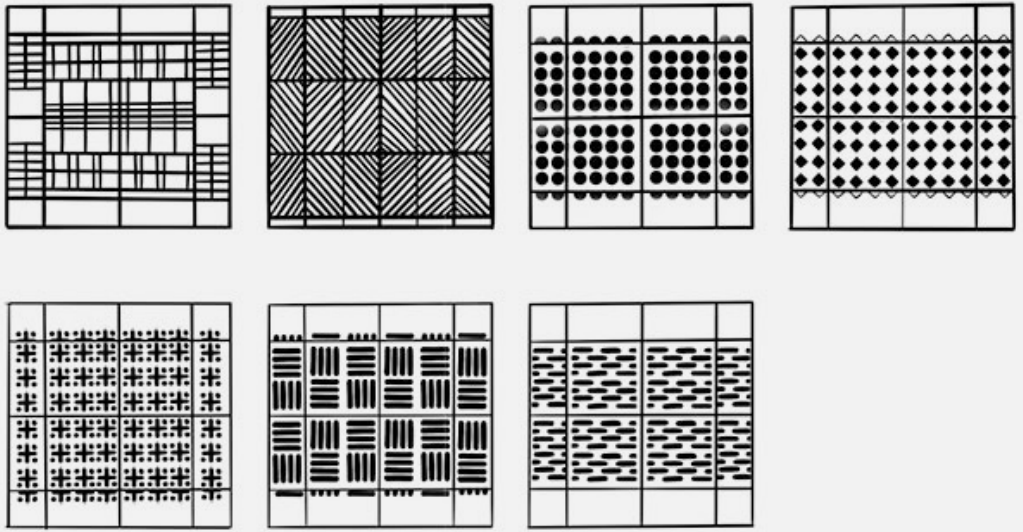
# Concept Details- Stacking different vegetables:



# Concept Details- Grill Hole pattern options:

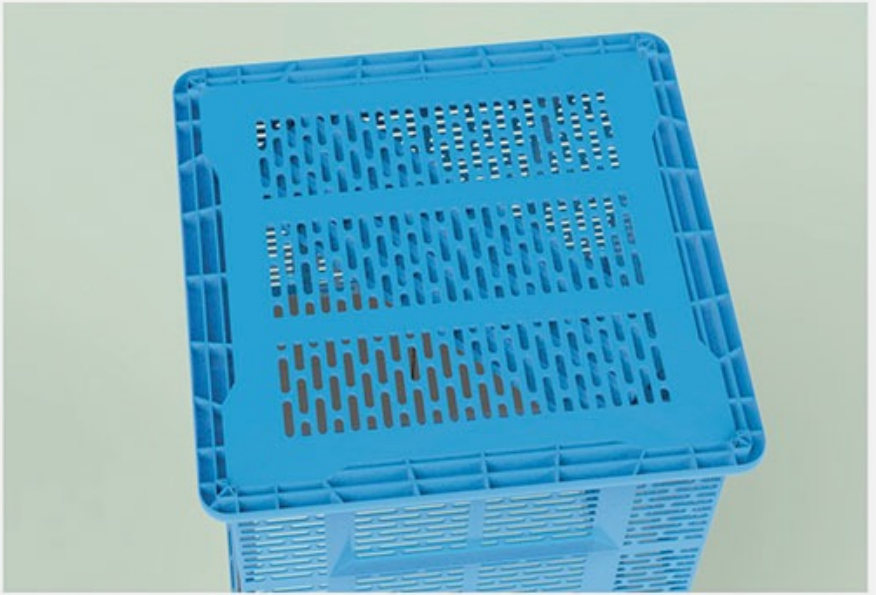
THINK!
DESIGN

The grill holes are one of the important features of the product. It gives both cooling air to p[ass through and also it creates the aesthetics to the product. The desirability of the product is also dependent on it. Considering all these different patterns are drawn. While doing this, it should also be considered the structural aspect, because too many holes will make the surface more flimsy. Thickness of the holes should also be considered. If too large a hole, vegetables will get stuck and cover the holes, if too small a hole, air will pass through it efficiently. With all these taking it into account the last two designs are chosen to further develop.



# Concept Details- small extension for rigidity:

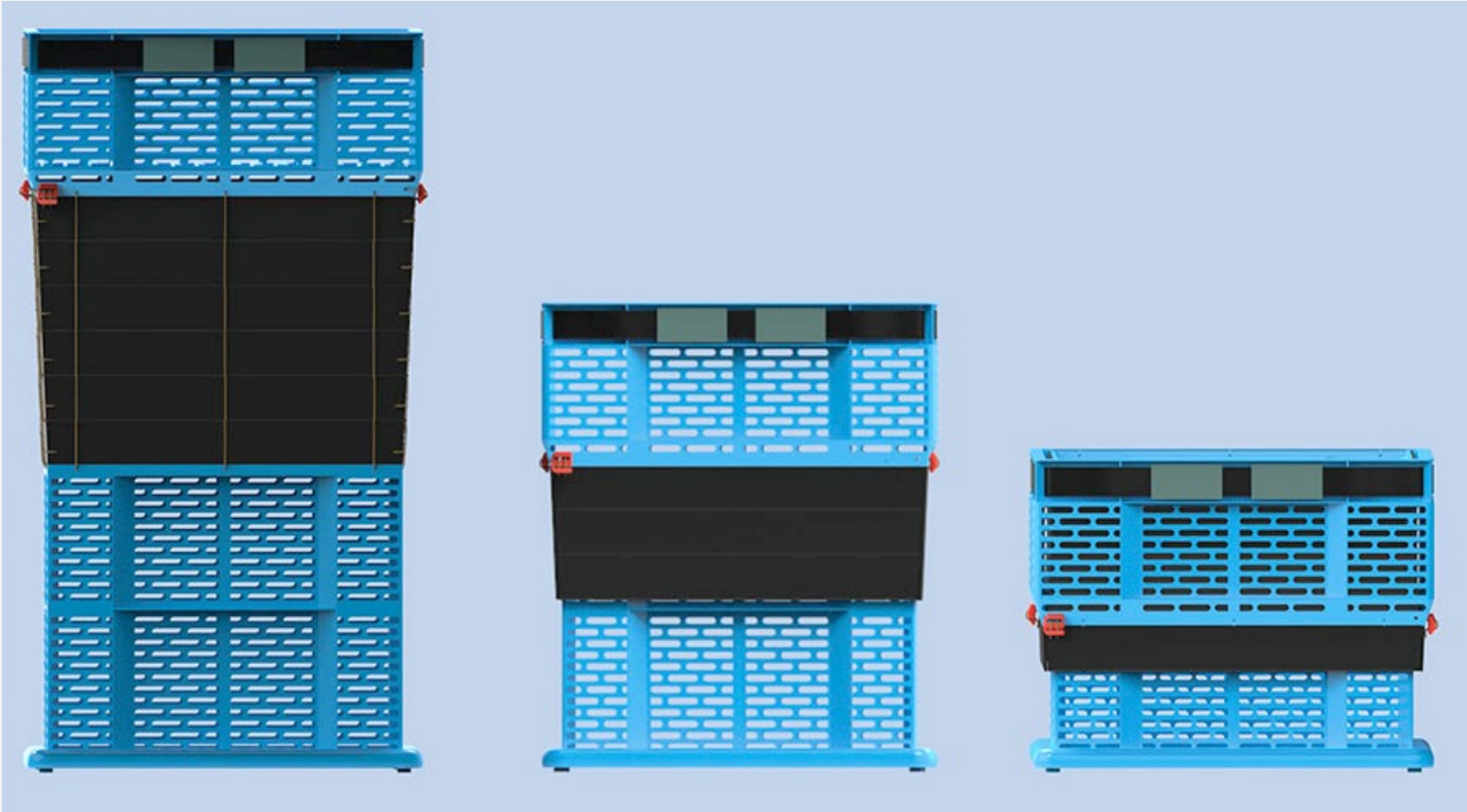
The product is intended to have a structural rigidity, so that when stacked the load is transferred through the product not through the vegetables. Since the form of the product is having a big volume on the top and small volume at the bottom. when it is stacked the small and large gets interacted. To make it perfectly fit and easily stackable. A small curved extension is given at the bottom part for stacking purpose.



# Concept Details- small extension for rigidity:

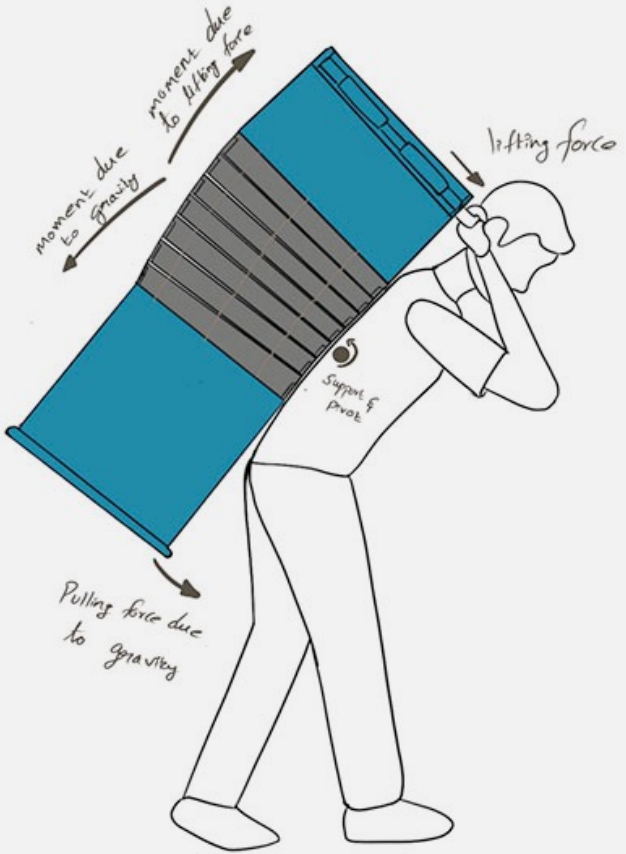
The main purpose of this product is to make it flexible and structurally rigid. With the flexibility feature, the product can bring in more options to the volume adjustment. To make standard volume settings in order to avoid problems in stackability and logistics calculations. The product is made to be set only for 3 volume options. The 1st configuration has a capacity to carry 80kgs, the 2nd configuration is adjusted to carry 50kgs and the final compressed configuration can contain 30kgs.

# Concept Details- 3 size options – 80, 50, 30 kgs:



# Concept Details- Force analysis:

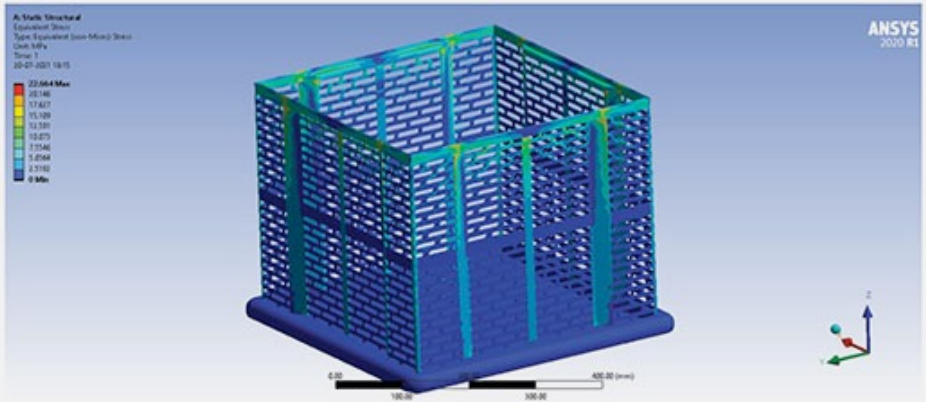
When the product is lifted by using the handle and being supported at the back. two forces acts which leads to formation of two moments with a single pivot. The back acts as the pivot, the handle provides a lifitng force and at the bottom another force is formed due to self weight and gravity. these two create two moment and two different direction. These moment forces are withstood mostly by ropes and partially by blinds.

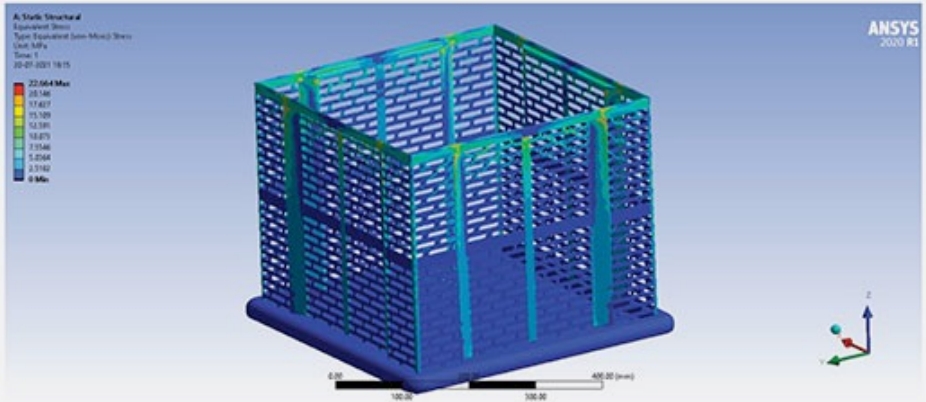


# Concept Details- Force analysis at 240 kgs:

THINK!
DESIGN

The product is load test using ansys structural analysis by applying three times the products maximum load carrying capacity (i.e 80kgs x 3 = 240Kgs). The maximum stress formed is within the maximum tensile strength of the material. There was no buckling been observed in the analysis.

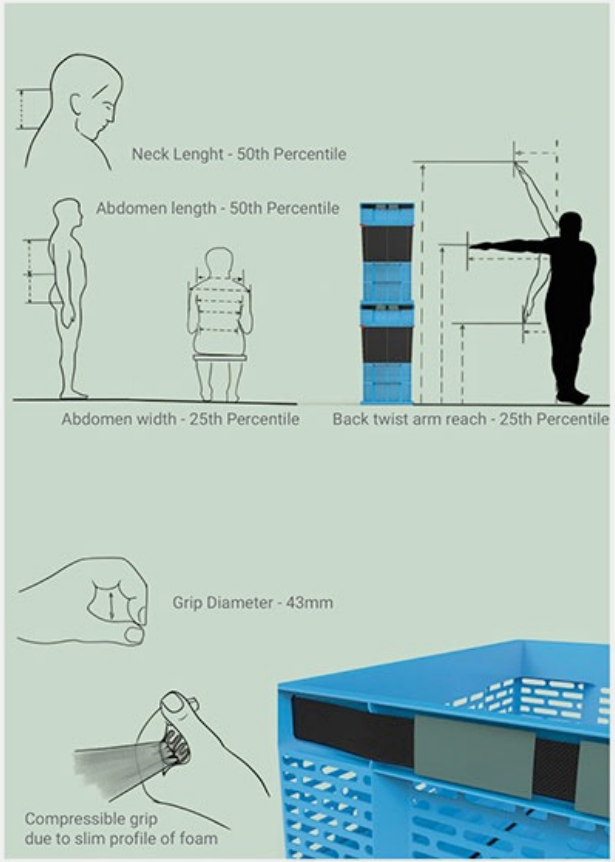


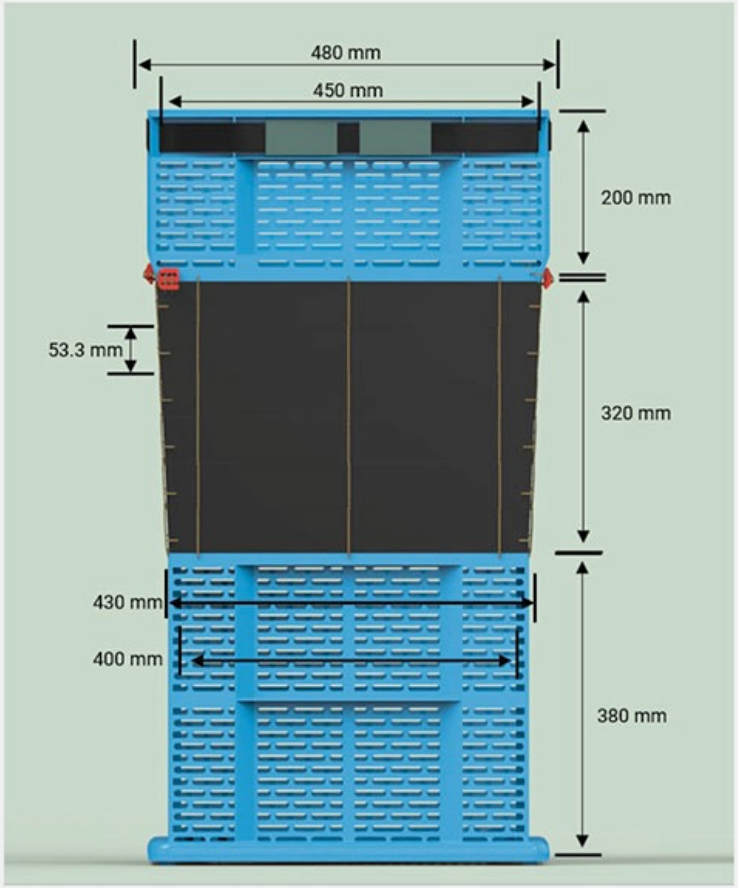
# Concept Details- Anthropometric factors:

THINK!
DESIGN

The Length, width and height of the products are determined by carefully considering the need and usage aspects and based on the percentile is determined and according to that the relevant anthrometric dimensions are used in defining the dimensions of the product.

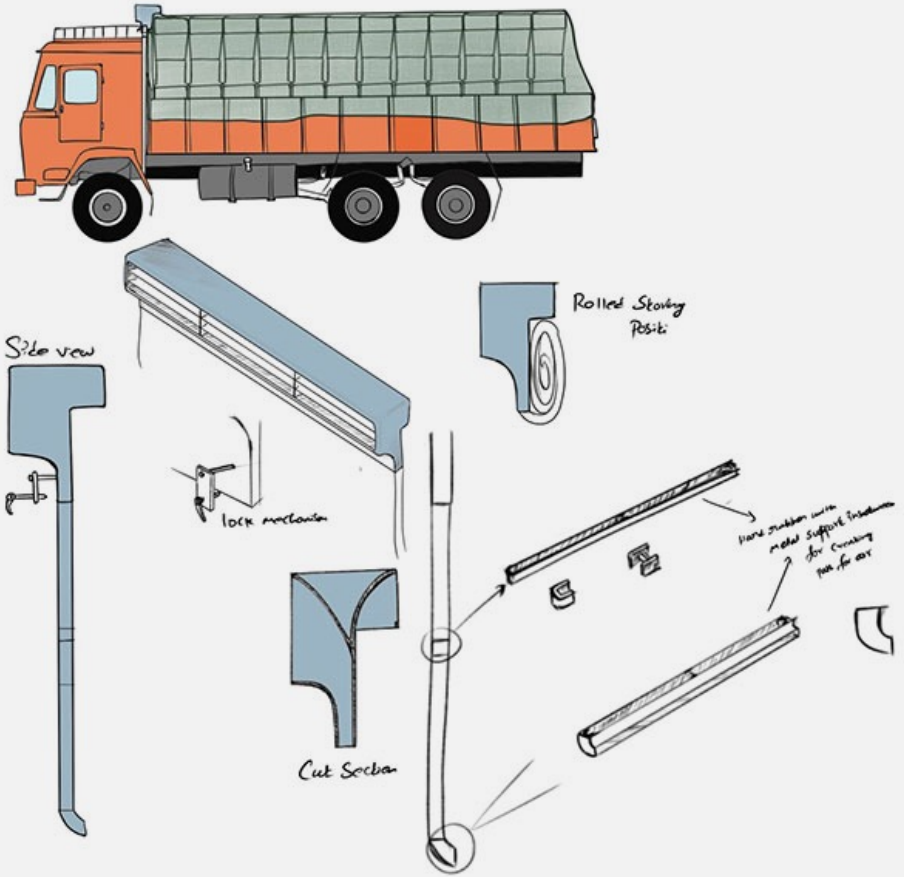


# Concept Details- dimensions:



# Concept Details- Cooling options:

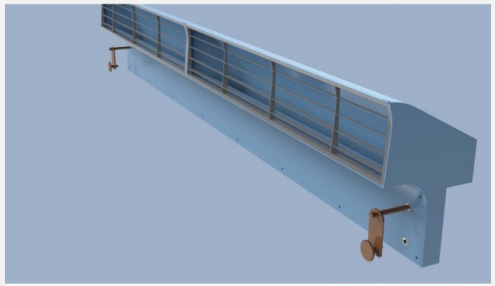
Cooling is also part of the requirement and also a main component of the design brief. It was highly not practical to incorporate cooling in the product itself, because when it is stacked they are tightly packed with only ample space for air flow. So a separate product for cooling is designed which forms as a system with the proposed product. As mentioned in the ideation this cooler uses the wind catcher concept. The cooler is attached to the payload area's front face.

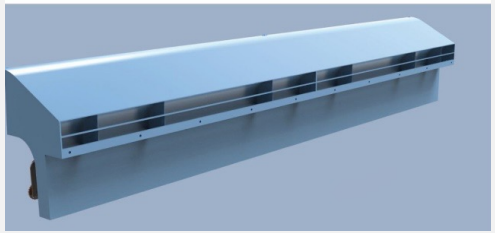


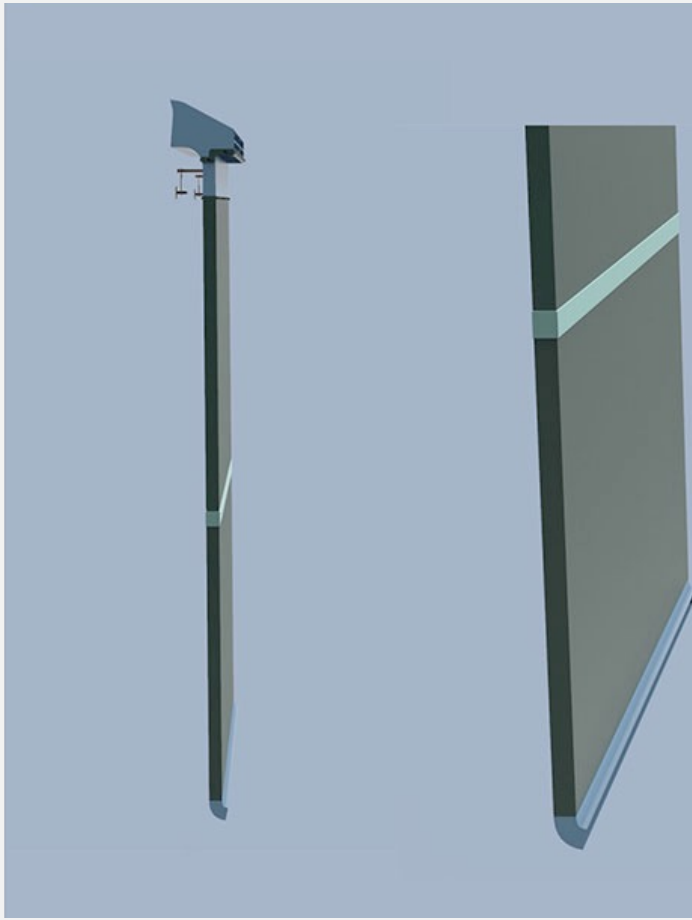
# Concept Details- Cooling options:

THINK!
DESIGN

The main cooler part is made of plastic and the inlet passage is made of tarpaulin which has 2 supports made of rubber reinforced with metal pieces. It is kept so that while stacking, users should not block the inlet passage by pushing the container against it and compressing it.



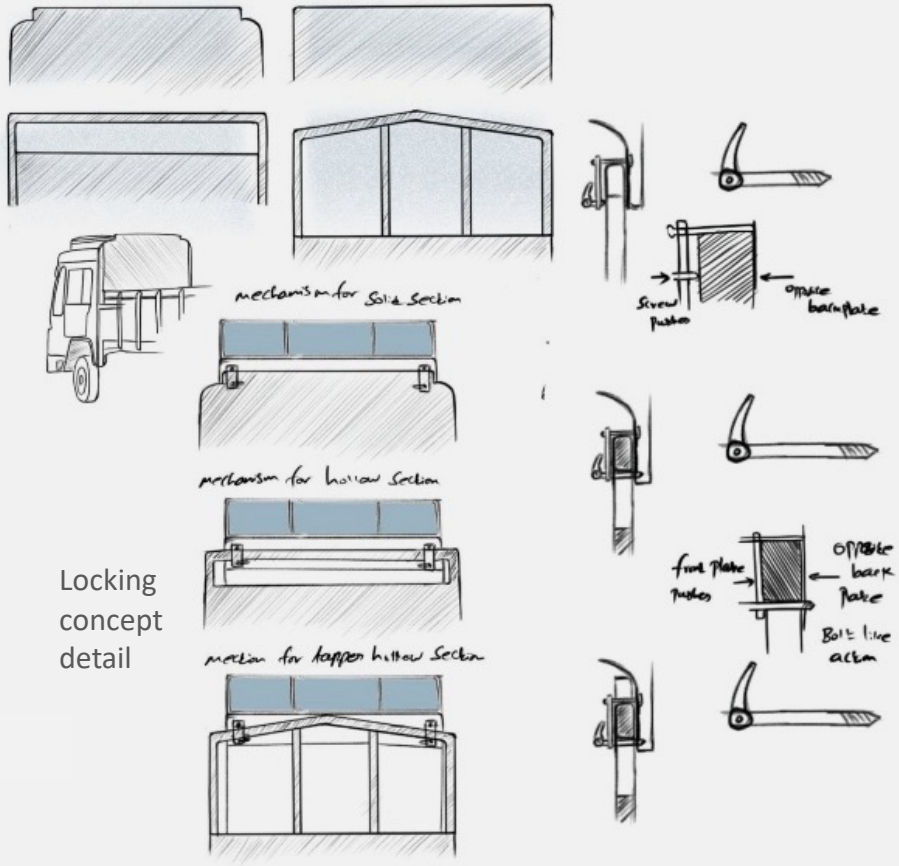




# Concept Details- Cooling options:

THINK! DESIGN

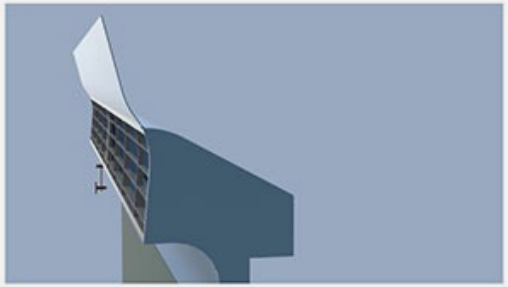
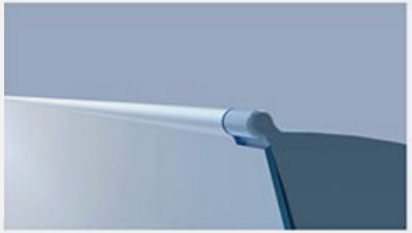
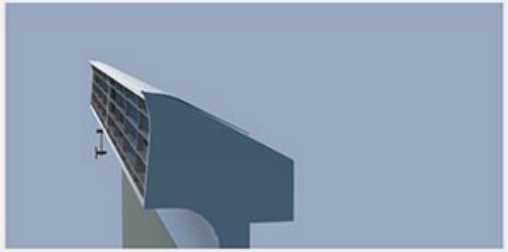
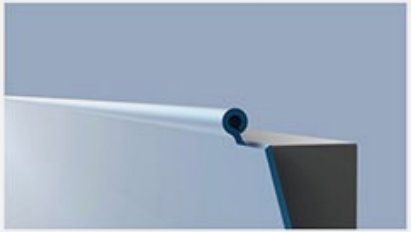
The users use different companies' lorries and trucks. All the trucks and lorries are analysed and it is found it has these four common shapes of payload front surface. Half of them are fully solid and half of them are hollow made of metal frames. A locking mechanism should be designed to lock both hollow and solid shapes with minimal changes to the mechanism. This is solved by having a sliding plate and two different length bolts. In the case of a solid section the bolt will tighten against the solid section and lock it. In Case of the hollow section, a long screw will pass through the section and get screwed on the cooler part so the sliding plate is tight against the frame and completely locks it.




Locking concept detail

# Concept Details- Cooling options:

The live hinge design is prone to failure when it is used repeatedly for large structures. so the standard hinge design is used. The cover profile is made such that it perfectly takes the profile of inlet and as well as the top surface when it is opened. This cover profile doesnt a lock to keep it in place because the profile keeps in position when air flows against it either in opened or closed position. The cover is made of stainless steel considering the harsh environmental usage and aesthetics of the truck.

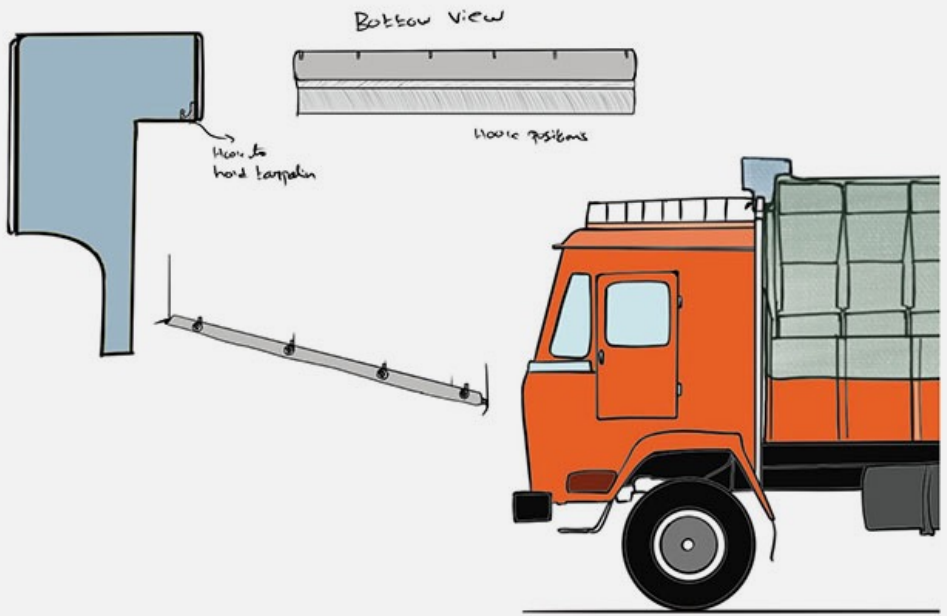






# Concept Details- Cooling options:

THINK! DESIGN

The Tarpaulin which covers the storage container is connected to the cooler on the outlet area. There are hooks in the cooler and holes on the tarpalin it is simply hanged on the hooks and tied around the cooler and the storage just like the users actually do. So, that it will form closed system.

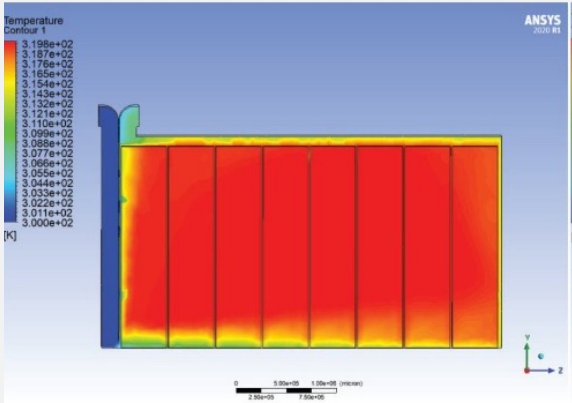
Cooler-Tarpaulin connection detail

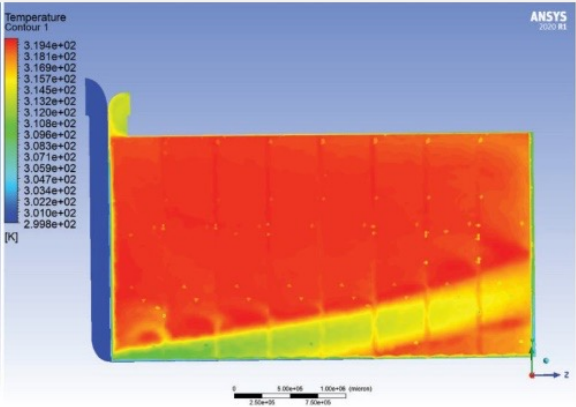


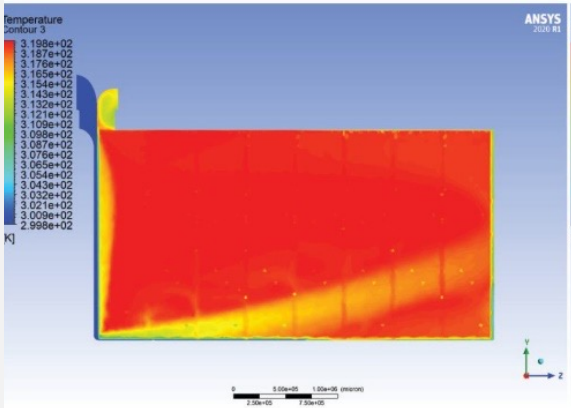
# Cooling analysis:

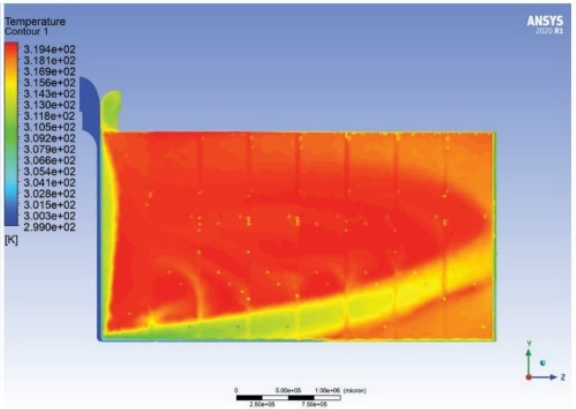
THINK!
DESIGN

The efficiency of the cooler is analysed using Flow analysis in Ansys fluent by making a simplified version of the stacked storage containers with inlet and outlet passage resembling the cooler setup. The first image has both inlet and outlet of same size and bottom of the storage containers are completely sealed only 10mm gap is left in between them which results in a poor air flow, The top second shows the result of increased inlet size and bottom of the inlet passage is funneled leading to force the air to the end and giving a gap of 5mm at the bottom of storage containers leads to taking the hot air out. The bottom two images are modelled as close as possible to the exact setup. The first image shows the air flow when the inlet receives 5 kmph of air and the second image shows the result of 20kmph. These results clearly show that the cooler is highly efficient, considering the electricityless design.

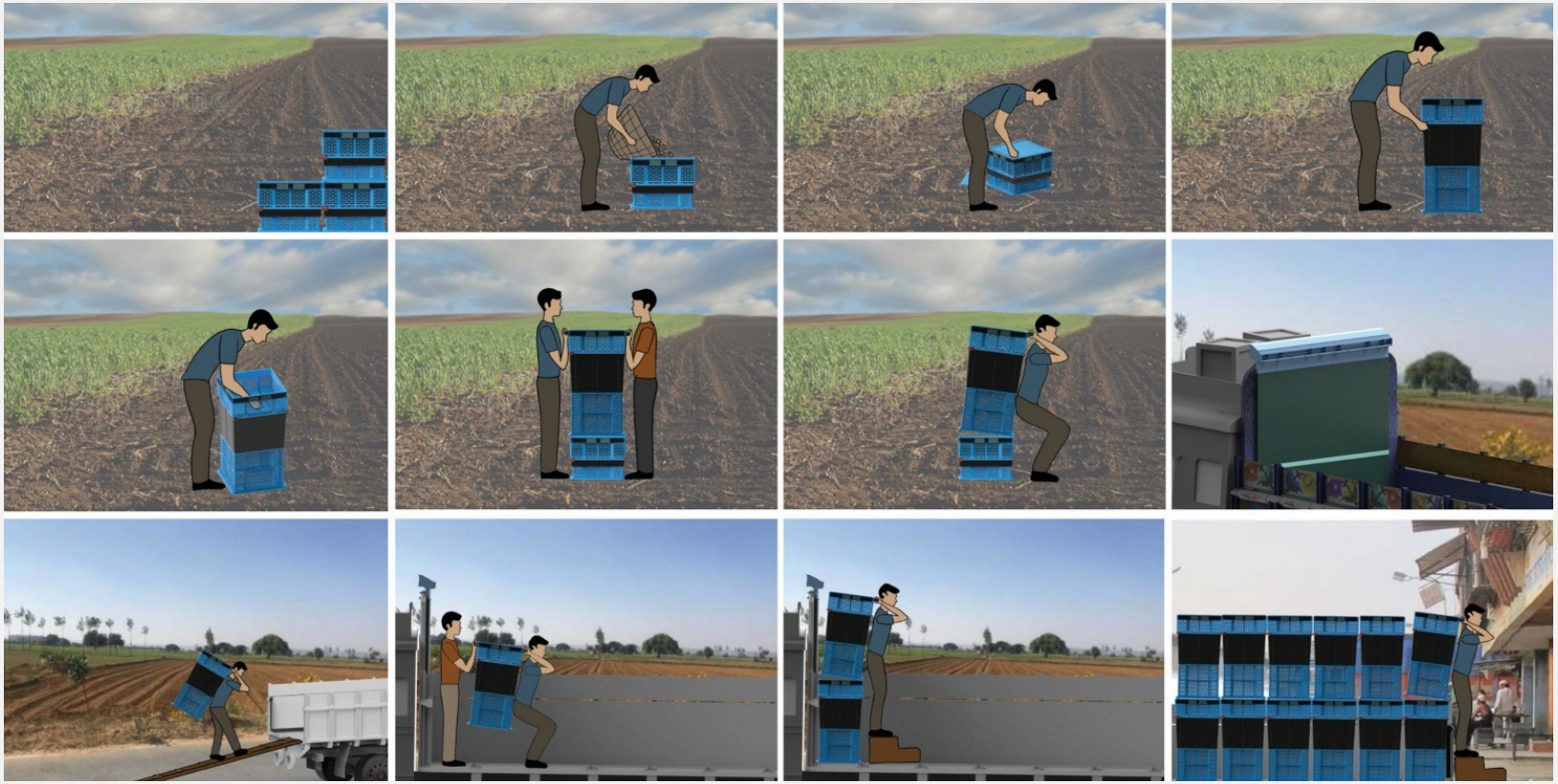


# System scenario of how the product is used:



# Material choices:

THINK! DESIGN

Considering the harsh environmental usage such hot sunny days, heavy rainy days, exposure to air pollution, etc and it shouldn't react in those conditions and as well as it should be food grade and high strengh requirements, polyethylene is suitable plastic for both container and cooler. The material for the rope is chosen as nylon since it has high tensile strength and can handle harsh situations. The stainless steel sheets are chosen for cooler cover and the rest is covered with tarpaulin.

# Credits:

## Storage Unit for Post Harvest Veggies

by

Arunprakash Ezhilarasan
(Master of Design Student)

Mentored by

Prof. Avinash Shende
(IDC School of Design, IIT Bombay)


# Thanks for Listening

**DT&I Case Study**

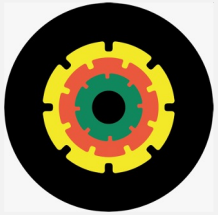
Section: C12

Week 12

# DT&I Course – Week 12:

## DT&I Process
(20%)

> MVP
> Proof of Concept (PoC)
> Info Architecture
> Experience Design



## DT&I Tools
(20%)

> MVP
> Proof of Concept (PoC)
> Info Architecture
> Experience Design

## DT&I Project
(50%)

> Apply MVP,
> Proof of Concept (PoC)
> Info Architecture
> Experience Design

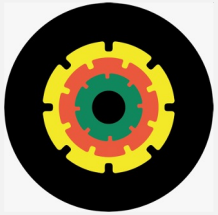
## DT&I Cast Study
(10%)

> Case Study Project:
**Storage Design to reduce Post-harvest loss of Vegetables**

# DT&I Course – Week 13:

## DT&I Process
(20%)

> Human Factors / Ergonomics
> Systems Mapping
> Hi-fidelity prototyping
> 3D Modeling & Printing



## DT&I Tools
(20%)

> Human Factors / Ergonomics
> Systems Mapping
> Hi-fidelity prototyping
> 3D Modeling & Printing

## DT&I Project
(50%)

> Apply > Human Factors / Ergonomics
> Systems Mapping
> Hi-fidelity prototyping
> 3D Modeling & Printing

## DT&I Cast Study
(10%)

> Case Study Project:
**Design Of Bamboo Sliver Furniture**

THINK!
DESIGN

## Supporting Organizations:

D’source

D’source Project

Open Design School

MoE’s Innovation Cell

THINK!
DESIGN

D'source Project

Open Design School

MoE's Innovation Cell

# Credits:

**Storage Unit for Post Harvest Veggies :**

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Arunprakash Ezhilarasan

**Mentor for Case Study:**
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IDC School of Design, IIT Bombay


# Credits:

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Open Design School

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# Credits:

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# Credits:

**Think Design Animation:**
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