IDC School of Design
अभिकल्प विद्यालय

A MOBILE SOLUTION FOR MITIGATING PLASTIC WASTE ON MUMBAI'S BEACHES

DESIGN PROJECT II | SHUBHAM MEHTA - 186390003 - MOBILITY & VEHICLE DESIGN
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Shubham Mehta

Date:

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PROJECT BACKGROUND

1. Background

Image 1: Mumbai as a place of heritage, lifestyle and luxury

Image 2: The home of Bollywood, film and music industry

Mumbai's culture is a blend of traditional festivals, food, music, and theatres. The city offers a cosmopolitan and diverse lifestyle with a variety of food, entertainment, and nightlife, available in a form and abundance comparable to that in other world capitals.

Mumbai is the financial, commercial and entertainment capital of India. It is also one of the world's top ten centres of commerce in terms of global financial flow, generating 6.16% of India's GDP and accounting for 25% of industrial output, 70% of maritime trade in India (Mumbai Port Trust and JNPT), and 70% of capital transactions to India's economy. Mumbai's billionaires had the highest average wealth of any city in the world in 2008. (1)

The city houses important financial institutions such as the Reserve Bank of India, the Bombay Stock Exchange, the National Stock Exchange of India, the SEBI and the corporate headquarters of numerous Indian companies and multinational corporations. It is also home to some of India's premier scientific and nuclear institutes like Bhabha Atomic Research Centre, Nuclear Power Corporation of India, Indian Rare Earths, Tata Institute of Fundamental Research, Atomic Energy Regulatory Board, Atomic Energy Commission of India, Department of Atomic Energy and the Indian Institute of Technology Bombay. The city also houses India's Hindi (Bollywood) and Marathi cinema industries. Mumbai's business opportunities, as well as its potential to offer a higher standard of living, attract migrants from all over India, making the city a melting pot of many communities and cultures and as a result it has led to Mumbai becoming one of the most populated city in the world. It further led to massive construction and commercial boom for housing and providing ameneties. (2)

Traffic Index 2018: how Mumbai congestion was measured at world high

SRINATH RAO
MUMBAI, JUNE 9

A RECENT study has ranked Mumbai as the most traffic-congested city in the world for the second straight year, and Delhi at fourth place. How was this determined, and what do the findings say of traffic across the world?

The study

The findings, published Tuesday, are part of the Traffic Index 2018 published by TomTom, an Amsterdam-based company that offers traffic solutions, uses location technology to collect traffic information, and has been publishing city rankings for eight years. The latest index ranks 403 cities across 56 countries, including 13 new cities.

The measure

For this study, congestion has been defined in terms of the additional time taken to reach a destination as opposed to when the road would have been clear of traffic. Mumbai's 2018 congestion level of of 65%, therefore, means that the extra travel time is 65% more than an average trip would take during uncongested conditions. For Delhi, by the same yardstick, the extra travel time is 58% more.

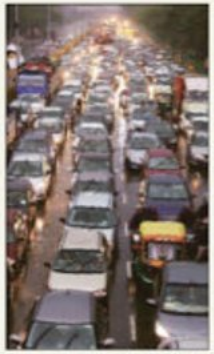
Average times are of actual taken trips, across every vehicle in the entire network, 24/7, TomTom explains on its website. This is worked out by establishing a baseline of travel times during uncongested conditions across each road segment in each city; travel times are analysed across the entire year (24/7) for each city, the company website states.

TomTom states that it factors for peak hours, accidents, inclement weather, construction work and all other factors likely to cause disruptions. It adds that its statistics are "calculated using GPA data from navigation devices, in-dash systems and smartphones".

MOST CONGESTED CITIES

RANK	CITY	CONGESTION LEVEL 2018	2017
1	Mumbai (India)	65%	66%
2	Bogota (Colombia)	63%	62%
3	Lima (Peru)	58%	50%
4	New Delhi (India)	58%	62%
5	Moscow (Russia)	56%	57%
6	Istanbul (Turkey)	53%	59%
7	Jakarta (Indonesia)	53%	61%
8	Bangkok (Thailand)	53%	55%
9	Mexico City (Mexico)	52%	52%
10	Recife (Brazil)	49%	47%

Source: TomTom Traffic Index 2018



Prem Nath Pandey

Mumbai and Delhi

In both Indian cities, traffic congestion during morning and evening peak hours varies between 73% and 102%. Last year, August 8 (83%) was the worst day to drive in Delhi, owing to the movement of VIPs and restrictions put in place in the run-up to Independence Day celebrations. In Mumbai, August 21 (102%) was the worst day on the road, because of heavy showers and work on multiple Metro rail lines. The index found that traffic flows most freely between 2 am and 5 am in both cities. The least congestion last year happened on March 2 (-16%), the second day of Holi.

Around the world

Nearly 75% of the cities part of the 2018 index had increased or stable congestion levels between 2017 and 2018, with only 90 cities showing measurable decreases, states the report. Congestion in Jakarta, for example, decreased by 8 percentage points while that in Lima rose by the same number of points. "Globally, traffic congestion is rising. And that's both good, and bad, news. It's good because it indicates a strong global economy, but the flip side is drivers wasting time sitting in traffic, not to mention the huge environmental impact," said Ralf-Peter Schaefer, TomTom's Vice President of Traffic Information.

Globally, Christmas Day resulted in the least traffic congestion. Overall, the index showed that an individual stuck in traffic in 2018 could have completed listening to one audio-book per week. Drivers in Tel Aviv and Istanbul stood to save the most time by avoiding driving during morning and evening rush hours.

Due to the same reason, the congestion, economic imbalance and consumerism has taken toll on the quality of life in Mumbai. Unprecendented traffic jams and unbelievable amount of waste from several industries/sectors are produced each day. Municipality is fighting hard to manage the waste and dispose it efficiently. But to our surprise the many inland rivers, canals have contributed to the unaccounted waste reaching the sea through them, which presents a very horrifying picture.

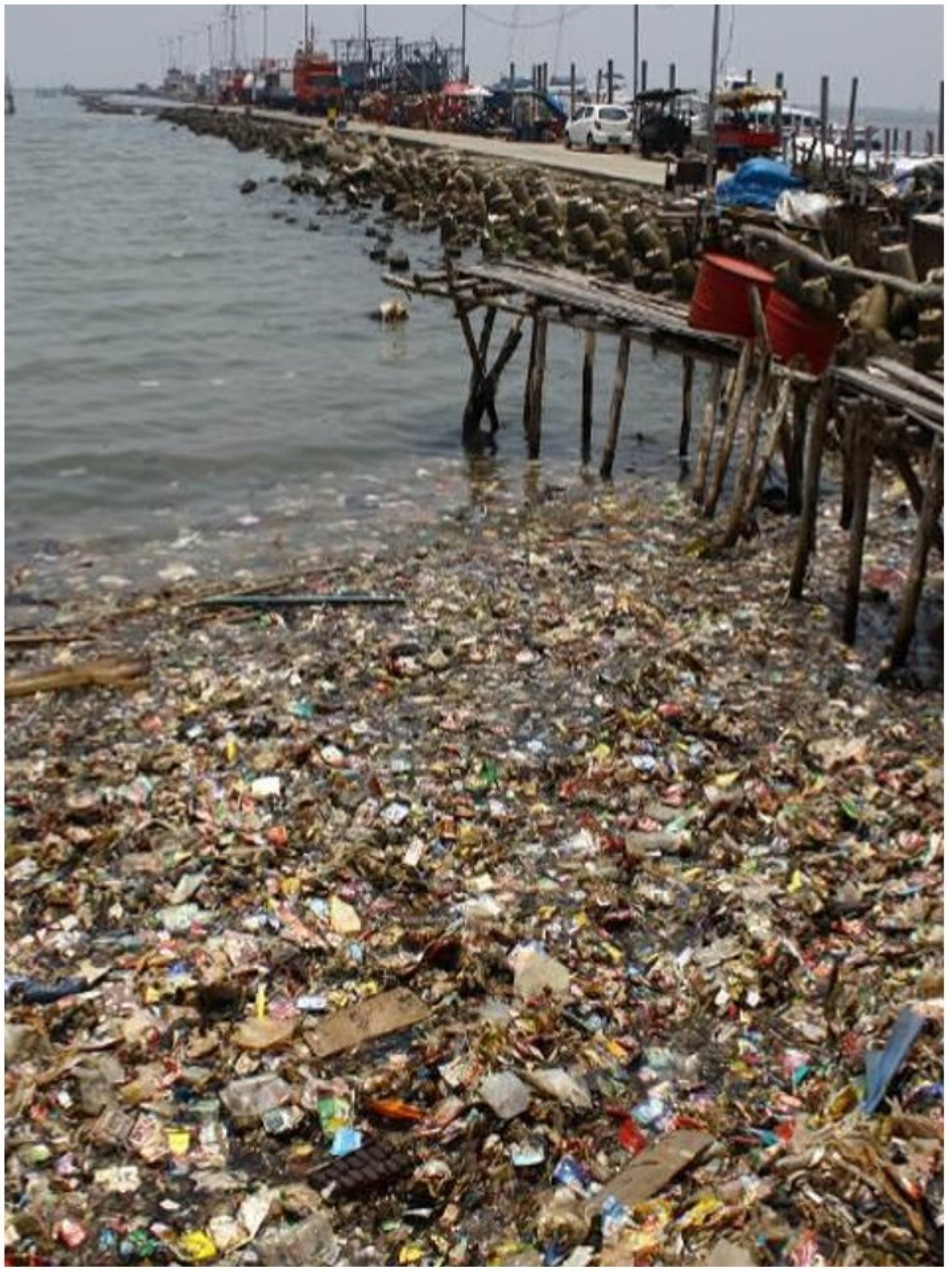
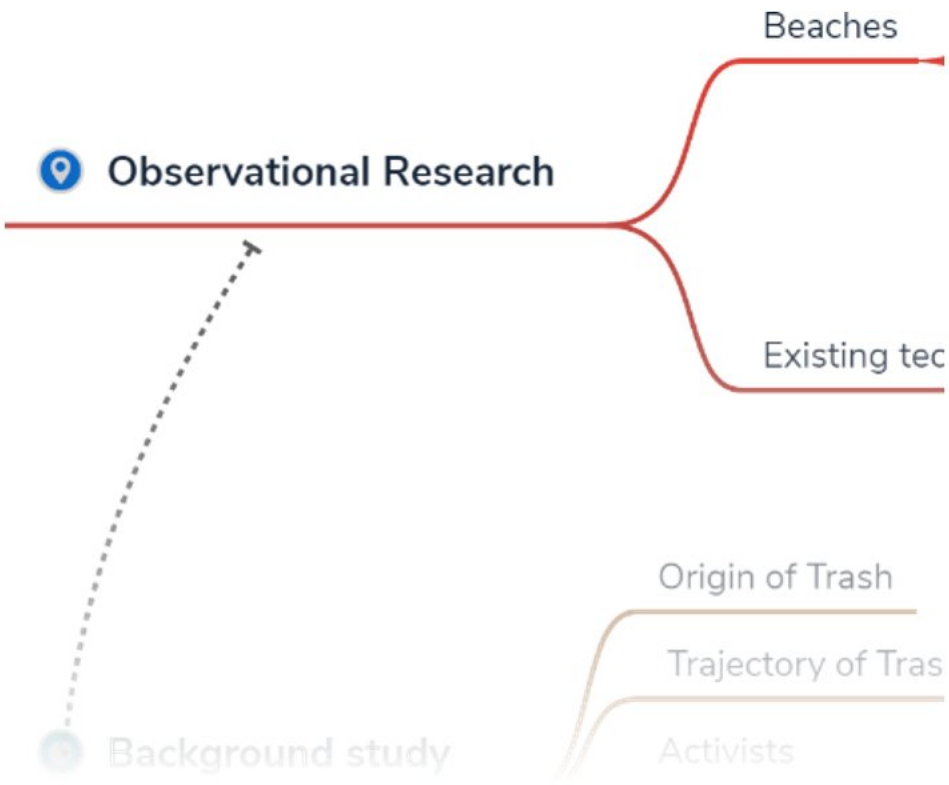


Image 3: Trash floating over water body, mostly comprise of plastics

In this project It was tried to discover the story of trash and particularly plastic as a waste travelling through our lives and reaching at its current unintened destination, our water bodies such as seas and oceans. It was researched upon that how it is affecting marine life and how is it affecting the beaches in various aspects. It was then thought upon how we can increase the efficiency at which we can take back the trash and recycle it.

RESEARCH



2.1. Observational Research

To understand the existance of the issue firsthand, several trips were made to the popular beaches in Mumbai. The duration of the visits were for the entire day. The objective of these visits were to observe how people engage with the beach, what activities and events happen, what is the food and beverage culture in that microenvironment, how is waste generated and where does it go.

Many important factors governing the state of the beach were also observed. The locality, the type of place (tourist/residential), weather conditions (monsoon), the demography of the visitors, businesses at the spot and presence of public infrastructures were some of the key points.

The initial engagement brought plenty of insights and provided sufficient relevance for the project by helping in identifying problems. The problem discovered are already being tackled worldwide through technology and innovation but it was discovered that solutions to a problem can be very contextual and can be goverend by various unique factors.

2.1a An observational study of Girgaum Beach

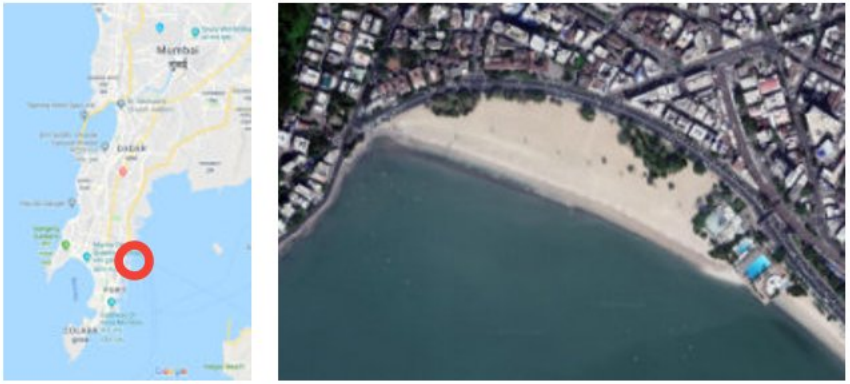


Image 4: Location of Girgaum Chowpatty Beach in South Mumbai

Image 5: Entry, Exits and Interest points

Girgaum Chowpatty is a public beach along the Queen's Necklace adjoining Marine Drive in the Girgaon area of Mumbai, India.

Date: 03/08/2019.

Time: 09:00 - 18:00 hours.

Season: Monsoon.

Weather: Discontinuous heavy rains.

Observational plan:

1. To study the engagement of people with the beach and the sand.
2. Observing litter generation and waste manegement in the area.
3. Understanding the role of Food Court in waste generation.
4. Dynamics and demographics of the visiting crowd.
5. Activities, events, games, businesses.

Sitting at sidewalks

Walking

Break from school

Games/Sports

Enjoyng street food

Local dish served with paper plate and palstic spoon

Major Observations:

- People visit beaches for recreational purposes mostly.
- Certain areas of the beaches are more populated depending on the activity.
- The immediate shores are majorly occupied by people experiencing the sea.
- Socializing spaces are created where people can wait e.g. food courts.
- Food courts are the most probable cause of litter generation. However, they are the spaces that are most well equipped with dustbins.
- Games and sports happen at some distance from the sea. The sandy patch provides safety while falling down in contact sports.

Local vendors

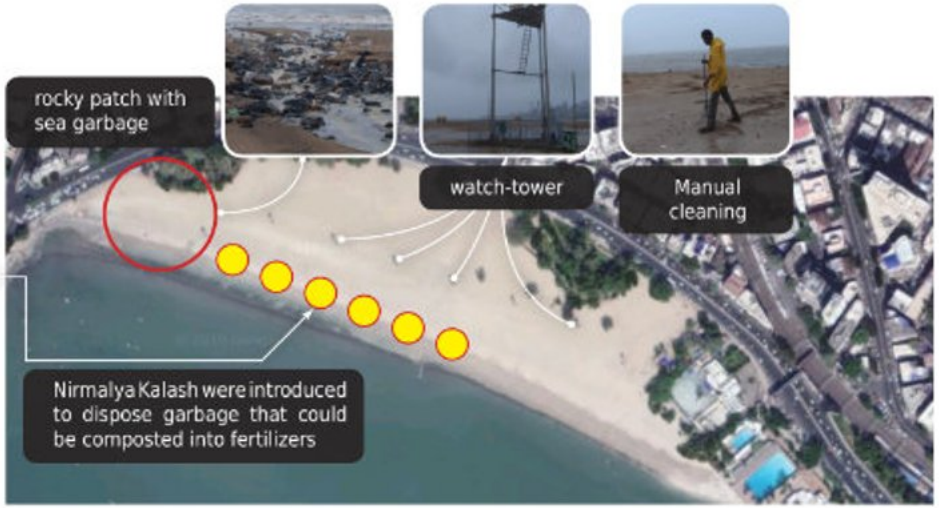
Bottle caps (plastic)

Glass bottles

Plastic footwear

Metal cans

Plastic coated wires



Human generated litter

There are two types of garbage at Girgaum Chowpatty beach. The first type is the human litter. Being a popular hub for food and recreational activities, the possibility of human littering increases in this area. One can easily find disposable discards, containers, shoes, fabric etc. while navigating on the beach as well as in the food court.

Maintainance services

A lot of dustbins and garbage collectors have been deployed throughout the beach at various points. There is also a beach cleaning machinery which is a tractor attachment (Cherrington 4600 XL). It is a seiving machine which collects polluted sand and separates the garbage from it, spraying the sand back into the beach.

Image 6: A mix of various types of trash washed ashore containing plastic waste

Image 7: Fishing net filled with plastic waste threatning marine life

Image 8: Sheets of plastics trapped on the rocky patch near the shoreline

Sea garbage

Unfortunately there are tonnes of grabage floating in the sea already. Its the garbage that was disposed off into the sea, and with each high tide, it is washed ashore. Fishing nets can be seen lying around on the beach that have caught the garbage while attempting to catch fishes. It comprises of various household discards, fabric, plastics and much more.

It shows how worrying the situation is underwater. Fishes and marine creatures cannot differentiate between food and plastics. Most turtles ingest plastic sheets thinking it to be jellyfish. Plastic pollution leads to mass death of marine species.

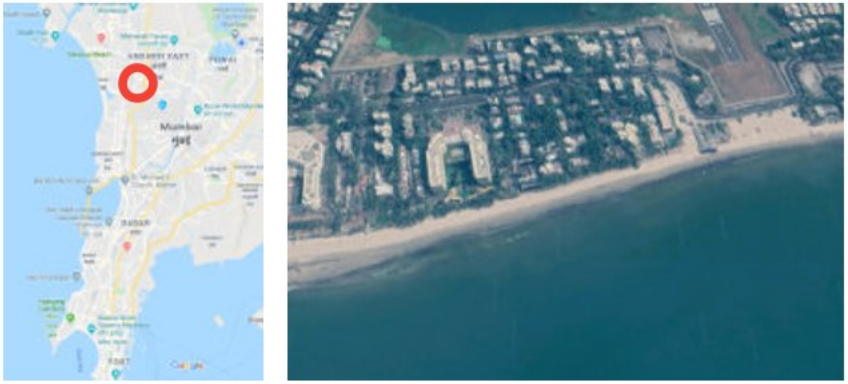


Image 9: Location of Girgaum Chowpatty Beach in South Mumbai

Image 10: Entry, Exits and Interest points

2.1b An observational study of Juhu Beach

Juhu Beach is located on the shores of the Arabian Sea, just near the CST international airport, Mumbai. It stretches for six kilometres up to Versova.

Date: 04/08/2019.

Time: 09:00 - 18:00 hours.

Season: Monsoon.

Weather: Discontinuous heavy rains.

Observational plan:

1. To study the engagement of people with the beach and the sand.
2. Observing litter generation and waste manegement in the area.
3. Understanding the role of Food Court in waste generation.
4. Dynamics and demographics of the visiting crowd.
5. Activities, events, games, businesses.

Walking along the shore

Morning Jogs

Visiting private beaches

Picnic spots

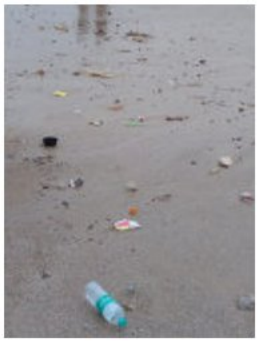
Enjoyng street food

Photography

Major Observations:

- People visit beaches for recreational purposes mostly.
- Juhu beach is generally much more dirtier than the Girgaum beach.
- People visit this beach for experiencing the waves and wetting their feet.
- Social spaces are mostly near food courts. People take pictures of the waves from there. There are photographers who provide on-spot photos as well.
- Juhu beach has a series of premium hotels aligned to it and visitors come out frequently to experience the beach.
- Locals play cricket and football at distant spots regardless of poor cleanliness.

Plastic sacks



Plastic bottles

Polymer bags

Plastic wrappers

Bottles

Bottle caps

Human generated litter

Juhu beach caters to much larger crowd as it is more popular but does not have dustbins along the long sand patch on which people accumulate. This leads to a variety of litter. Mostly disposable items and wrappers, food packets etc. During high tides the entire sand patch comes underwater hence the waste management is also not possible at all times.

Maintainance services

Most of the dustbins and garbage collectors are deployed on the high grounds at Juhu, away from the spot affected from the high tide. When the tide is low, beach cleaning machines are working non-stop to lift up as much garbage as they can. However very small-scale pollutants are impossible to be removed by those machines.

Image 11: A mix of various types of trash washed ashore containing plastic waste

Image 12: Wet torn plastic sheets with sand filled inside them

Image 13: Smaller wrappers and microplastic content can be found everywhere

Sea garbage

Juhu is also not untouched with truckloads of garbage washed ashore every single day. The problem arises because the entire sand patch of Juhu comes underwater during the high tide and the garbage settles down on the beach. The authority cleans upto 50,000 kg trash on some days but the situation remains unchanged.

2.2. Preliminary Research

To understand the background we need to dive into various factors that are interconnected to the issue. The plastic that reaches the ocean in such huge amount are discarded single use plastic materials/packaging etc. The sources of such waste can be from residential to industrial to commercial. Understanding the source and type of waste can help us understand its morphology, trajectory and we can build better strategies on how to design our tools and systems to intercept them at different points.

This research is also focused upon the current situations where NGOs and NPOs manually clean the beaches by hand with help of hundereds of volunteers. Along with that, it put light on various innovations like machines, tools and vehicles designed specifically for this purpose. It debated their efficiency and practicality in Indian context.

2.2a Research map

This map connects observation and background study to understand the core issue related to plastic pollution. The issue is then verified on the field with real world application, meeting people working in this area and understanding their issue. This gives us a spot where we can map the intervention to bring the most benefit in a certain context.

2.2b Types and sources of MSW in Mumbai

Source	Waste generators	Solid waste content
Residential	Single and multifamily dwellings	Food wastes, paper, cardboard, plastics, textiles, leather, yard wastes, wood, glass, metals, ashes, special wastes (e.g., bulky items, consumer electronics, batteries, oil, tires), and household hazardous wastes.
Industrial	Light and heavy manufacturing, fabrication, constru tion sites, power and chemical plants.	Housekeeping wastes, packaging, food wastes, construction and demolition materials, hazardous wastes, ashes, special wastes.
Commercial	Stores, hotels, restaurants, markets, office buildings, etc.	Paper, cardboard, plastics, wood, food wastes, glass, metals, special wastes, hazardous wastes.
Institutional	Schools, hospitals, prisons, government centers.	Paper, cardboard, plastics, wood, food wastes, glass, metals, special wastes, hazardous wastes.
Construction and demolition	New construction sites, road repair, renovation sites, demolition of buildings	Wood, steel, concrete, dirt, etc.
Municipal services	Street cleaning, landscaping, parks, beaches, other recreational areas, water and wastewater treatment plants.	Street sweepings; landscape and tree trimmings; general wastes from parks, beaches, and other recreational areas; sludge.
Process (manufacturing, etc.)	Heavy and light manufacturing, refineries, chemical plants, power plants, mineral extraction and processing.	Industrial process wastes, scrap materials, off specification products, slay tailings.
Agriculture	Crops, orchards, vineyards, dairies, feedlots, farms.	Spoiled food wastes, agricultural wastes, hazardous wastes (e.g., pesticides).

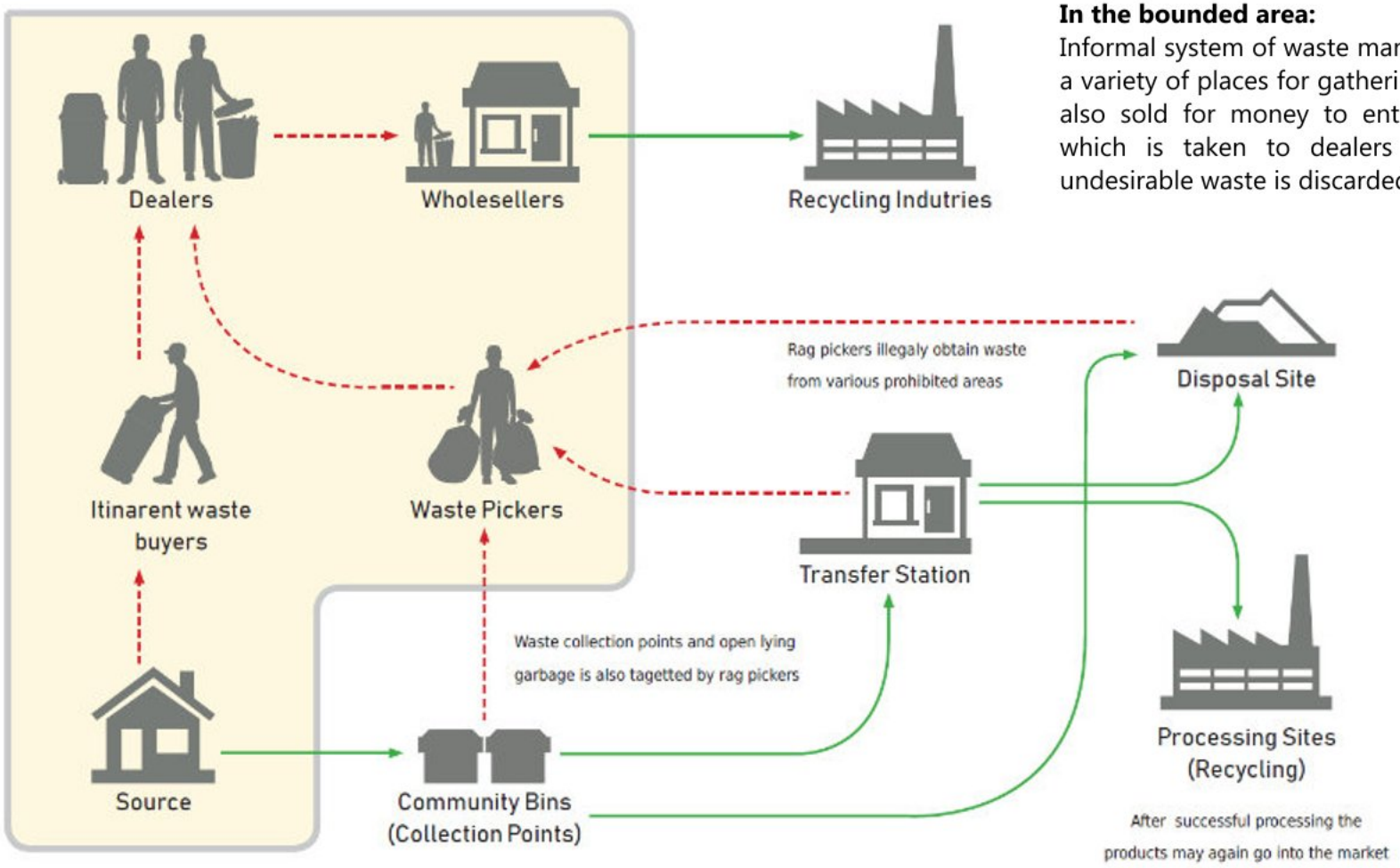
Municipal Solid Waste (MSW)

Municipal solid waste comprises of wastes from households including garbage and rubbish, sanitation waste and street sweepings. MSW also includes wastes and discarded materials from institutions and commercial complexes and debris from construction and demolition activities.

MSW can be broadly categorized into five broad categories as-

1. **Biodegradable waste:** food and kitchen waste, green waste (vegetables, flowers, leaves, fruits), paper (can also be recycled).
2. **Recyclable material:** paper, glass, bottles, cans, metals, certain plastics, etc.
3. **Inert waste:** construction and demolition waste, dirt, rocks, debris.
4. **Composite wastes:** waste clothing, Tetra Packs, waste plastics such as toys.
5. **Domestic hazardous waste** (also called "household hazardous waste")
   toxic waste: medication, e-waste, paints, chemicals, light bulbs, fluorescent tubes, spray cans, fertilizer and pesticide containers, batteries, shoe polish.

2.2c The trajectory of garbage and the role of rag pickers



In the bounded area:
Informal system of waste management. Rag pickers source a variety of places for gathering garbage. Some wastes are also sold for money to entrant/mobile waste collectors which is taken to dealers where they are paid and undesirable waste is discarded. (3)

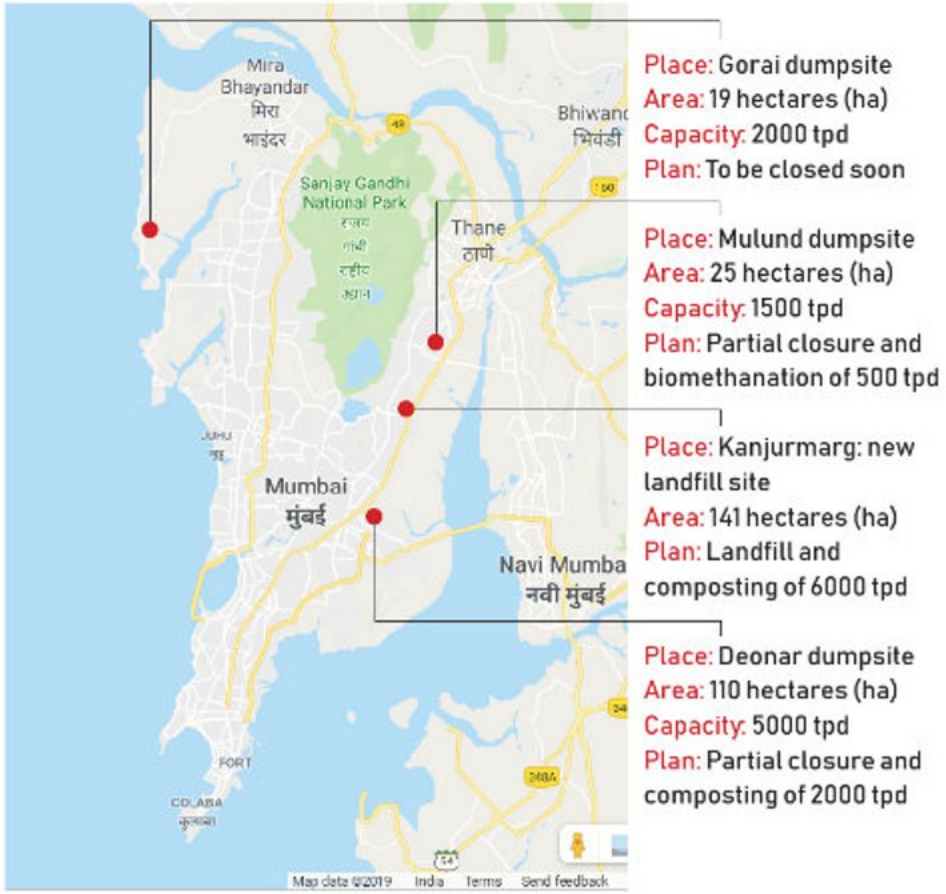


Image 14: Dumpsites and landfills in Mumbai (capacity: tonnes per day)

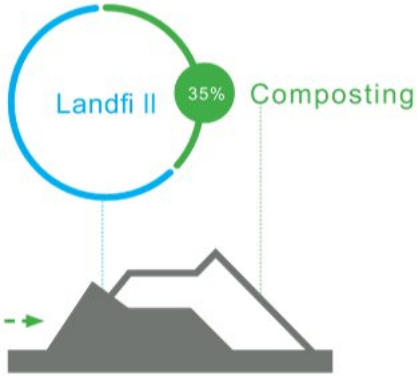
2.2d Waste segregation and disposal processes in Mumbai

About **7700 metric** tonnes of garbage is produced in Mumbai every single day. It is catered by these four landfill sites: Gorai dumpsite, Mulund dumpsite, Kanjur Marg landfill, Deonar dumpsite.

- **Latest Data (2018):** Mumbai produces 7700 MT garbage every single day. Out of which only 4407 MT/d is actually treated. (57%)
- **Segregation**: BMC claims 100% transport and 82.92% segregation of waste.
- **MSW Facilities:** Bioreactor landfill (microbial breakdown), composting, Refuse Derived Fuel (RDF) and Leachate Treatment.
- **OCT 2017:** BMC will not pick up solid waste from complexes over 2 lac sq. feet or producing waste over 100kg/day.
- **ESR 2017:** BMC finds in their Environment Status Report (ESR) that 73% of MSW was food waste. Experts say all of that should be composted so that the load on landfills can be reduced.
- **ESR 2017:** The organic content in MSW has increased from 62% in 2004 to 73% percent in 2017.
- **ESR 2017:** BMC discovers 17% construction debris, 3% plastics, 3% organic dry waste, 4% paper and metals in the remaining 27% MSW. Out of which only 8% was successfully segregated and 5% composted, that too by private agencies.
- **ESR 2017:** All the landfill sites in Mumbai have almost exhausted their capacity.
- **2018:** BMC was reinstated to pick all garbage regardless of weight/ left in the open or such by Bombay High Court's order. (5)

Waste is trasported to one of 32 segregation centers in the city

Only 53%of the collected waste is successfully segregated



Dumping Ground

Municipal workers collect 95%of waste from different establishments.

Even if 5% waste is unaccounted for, it makes up 385 tonnes of garbage per day

It could be ending up on the beaches and in the sea

2.2e The ocean plastic pollution and its causes.

Image 15: Floating plastic waste in the water

It is estimated that around 12.2 Million tonnes of plastic enter our oceans per annum. 9 million tonnes of them are spewed from coastal areas and 0.5 million tonnes of plastics are added by inland river streams. (6)

94% of the ocean plastics have settled down destroying the marine ecosystem at the base, while 1% of it floats on the ocean and constitutes an average of 18 kg/sq km. The rest 5% of the plastic trash ends up on the coastline and beaches worldwide, which amounts to almost 2000 kg/sq km. It presents a huge opportunity in front of us. (6)

Removal of plastic waste from beaches and preventing further addition of trash in ocean can help mitigate the damage caused by micro-plastics (the breakdown of plastics under UV and environment)

Micro-plastics is extremely hazardous waste for all life forms. It comes from deteriorating plastics as well as the following: Marine paints, Cosmetics, Road paints, Building paints, Textiles, Spilled pellets, road dust. Micro-plastics are positively charged particles that can cause brain adverse effects on our vital organ system if it gets inside the blood stream. The marine life is already perishing by ingestion of plastics and micro-plastics, and is soon to reach humans as well.

Possible points of intervention

1. Source:
The problem can be traced back to the source, which is use of plastic itself, exploded by consumer culture and its single use typology. From a report it is estimated that only 9% of the 8.4 Billion tonnes of plastic produced till date has been recycled. The heavy reliance on plastic in today's world for almost all our needs has escalated the problem of its waste management.

Remedy:
A huge shift in behavior is required on consumers and producers end, to take responsibility of their waste/reduce the amount waste generated by downsizing the lifestyle and consumption. Recycling and reuse of plastic should be made available for each individual and cheaper than virgin plastic. Waste segregation at the user's end is required.

2. Poor Waste Management:
Due to the scale at which it is produced nowadays, authorities are becoming less efficient in properly collecting waste, leading to a huge amount of unattended trash which finds it way to water bodies. Remote areas and slums have low awareness about waste management and contribute to the problem.

Remedy:
A shift in business models by monetizing plastic wastes and spreading awareness among the uneducated/unaware communities can help. We need to empower the rag pickers by providing them good tools so that we can utilize the huge manpower while enhancing their income.

3. Existing Trash on Beaches and in the Ocean:
This problem is the emergency in the biodiversity and marine life as it is causing damage every passing second. We need to intervene in this area with immediate effect and bring back as much plastic we can take out when the ocean sends it back on the beach.

Image 16: Sand sifting machine

Image 17: Sand raking machine

Image 18: combined sifting and raking machine

2.2f Existing tools and machines worldwide.

There are various machines and tools that are designed to take out trash from beaches specifically. They are supposed to be sand cleaners (taking out debris and leaving sand behind)

Raking machines: can be used on dry or wet sand. When using this method, a rotating conveyor belt containing hundreds of tines combs through the sand and removes surface and buried debris while leaving the sand on the beach. Raking machines can remove materials ranging in size from small pebbles, shards of glass, and cigarette butts to larger debris, like seaweed and driftwood. By keeping the sand on the beach and only lifting the debris, raking machines can travel at high speeds.

Sifting machines: is ran on dry sand and soft surfaces. The sand and waste are collected via the pick-up blade of the vehicle onto a vibrating screening belt, which leaves the sand behind. The waste is gathered in a collecting tray which is often situated at the back of the vehicle. Because sand and waste are lifted onto the screening belt, sifters must allow time for the sand to sift through the screen and back onto the beach. The size of the materials removed is governed by the size of the holes in the installed screen.

Combined raking and sifting machine: differs from pure sifters in that it uses rotating tines to scoop sand and debris onto a vibrating screen instead of relying simply on the pick-up blade. The tines' position can be adjusted to more effectively guide different-sized materials onto the screen. Once on the screen, combined raking and sifting machines use the same technology as normal sifters to remove unwanted debris from the sand.

Image 19: Combined Sifting and Raking machine (pull type) - has a roller which rakes the sand, then a screen sifts the sand down and the hopper collects the trash.

Image 20: A walk behind sand sifting machine which screens sand and is very manueverable and easy to operate.

Image 21: Heavy pressure rake (pull type) used to turn the sand.

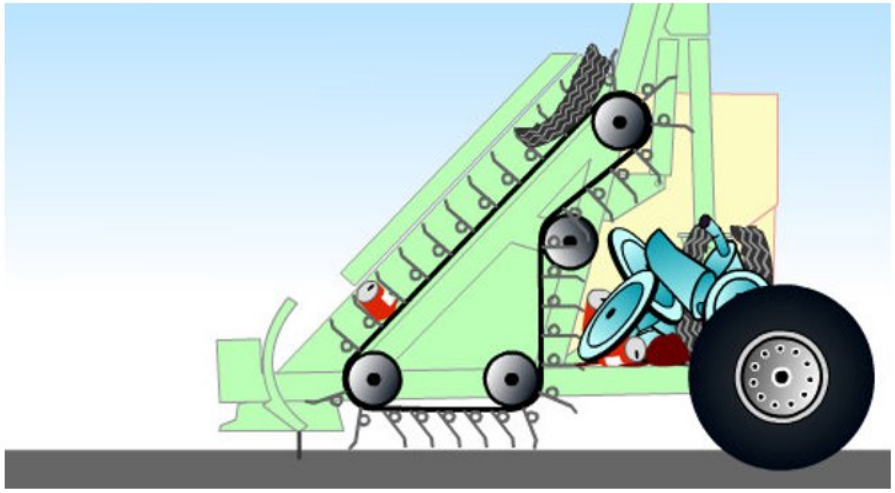


Image 22: Raking machine schematic schowing it's working mechanism.

Image 23: sand cleaning shovel for dry conditions

Image 24: Trash needle for litter removal

Image 25: Rake for dragging smaller trash

Image 26: Multipurpose shovel for raking as well as carrying

Hand tools are very helpful and effective in cleaning the beach with minimal human effort. In Mumbai, it is mostly done by simple rake, that too is available only with the BMC. The volunteer use their bare hands and a small bucket and carry out the operation. Some of the tools that can help are:

Sand Cleaning Shovel: Used to remove tar balls and pebbles from sand. Can be effective while dealing with dry trash and plastics. It is usually heavy if it is strong. Lightweight strong shovels are costly.

Trash Picker Pin: Used to punch through objects and collect them. Effective against small sized trash but not too small. Eg. Toffee wrappers. It is also to be handled with care as the needle can be dangerous and cause injuries.

Garden Rake: It has tooth/combs at the end which sifts through the sand and drags the trash along with it. Due to less retention area, the trash can spill over the tool when pulled.

Rake Shovel: As the name suggests it can sift through sand and carry more trash more efficiently on its pan. When not carrying anything its long teeth can act as a rake.

Shake'n Rake: An American company developed a rake shovel that has a vibration setting so that the debris remains and the sand sifts down without human effort. It was initially designed to work in the barns for cleaning hay.

2.2g Recycling of plastic

Plastic recycling is the process of recovering different types of plastic material in order to reprocess them into varied other products, unlike their original form. An item made out of plastic is recycled into a different product, which usually cannot be recycled again. (7)

Sorting: It is necessary that every plastic item is separated according to its make and type so that it can be processed accordingly in the shredding machine.

Washing: Once the sorting has been done, the plastic waste needs to be washed properly to remove impurities such as labels and adhesives. This enhances the quality of the finished product.

Shredding: After washing, the plastic waste is loaded into different conveyor belts that run the waste through the different shredders. These shredders tear up the plastic into small pellets, preparing them for recycling into other products.

Identification and Classification of Plastic: After shredding, a proper testing of the plastic pellets is conducted in order to ascertain their quality and class.

Extruding: This involves melting the shredded plastic so that it can be extruded into pellets, which are then used for making different types of plastic products.

Image 27: Waste sorting at recycling center. Source: https://www.sciencephoto.com/media/613164/view/waste-sorting-at-a-recycling-centre

2.2h Sorting and processing difficulties with plastic waste

Most of the plastic is actually incinerated or land-filled because of the **massively complicated system of finding and sorting** the different kinds. Plastics have overlapping densities over a very narrow range. There are more than 50 different types of plastics, making them more difficult to sort and reprocess than other recyclable materials. (8)

Many plastic packaging also consist of more than one polymer type, which makes them more difficult to recycle. For instance, a bottle and a food tray can't be recycled together as they melt at different temperatures. Problematic plastics also include black plastic food trays, which are used by many supermarkets. They are generally not collected as sorting machines are not able to detect them; the carbon black makes them invisible. If they are collected, they are likely to be rejected at the sorting plant. (8)

2.2i The economics of recycling plastic

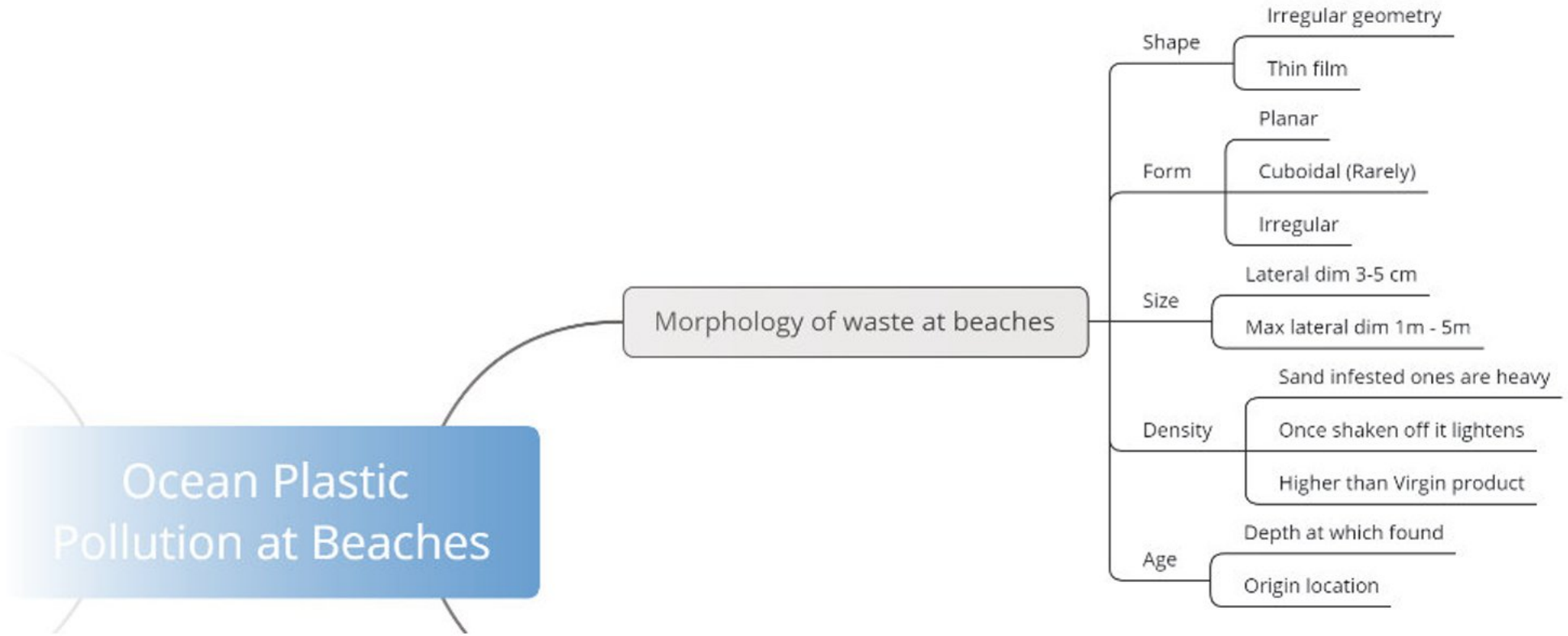
As oil prices fluctuate, so too does the price of plastic. **When those markets are depressed, virgin plastic becomes far cheaper to buy than recycled.** In addition, many plastic products degrade each time they're processed – unlike metal or glass, which can be perpetually recycled, making them progressively less valuable. Moreover, materials like plastic bags, polystyrene packaging, and coffee cups can in theory be recycled, but for logistical and economic reasons, recycling only makes sense when clean material is available in quantity. This is not the case for post-consumer household waste, so for most recycling plants these are impractical materials to collect for recycling. If they are collected, the extra effort and expense required to separate them from general waste means they often end up in landfill.

PRIMARY RESEARCH

2.3a Morphology of waste at beaches

The different sizes, volumes, weight and density of waste found at beaches govern how we pick them. Here on, the research was conducted on site working in beach cleaning drives and understanding the issue.

Studying morphology of waste is crucial for developing the mechanism for cleaning them. Various kinds of waste get clogged and render the tools unusable. In wet conditions it is more commonly seen because of the increased weight of the trash.



Evidently the diversity of trash is huge. Not all the trash is recyclable which poses threats to cleaning operations. The segregation of waste becomes very cumbersome and very costly process and most of the waste ends up in landfill sites anyways. In this cluster we can see individual and scattered trash. During cleaning operation only plastic is picked by people and assembled in a single pile.

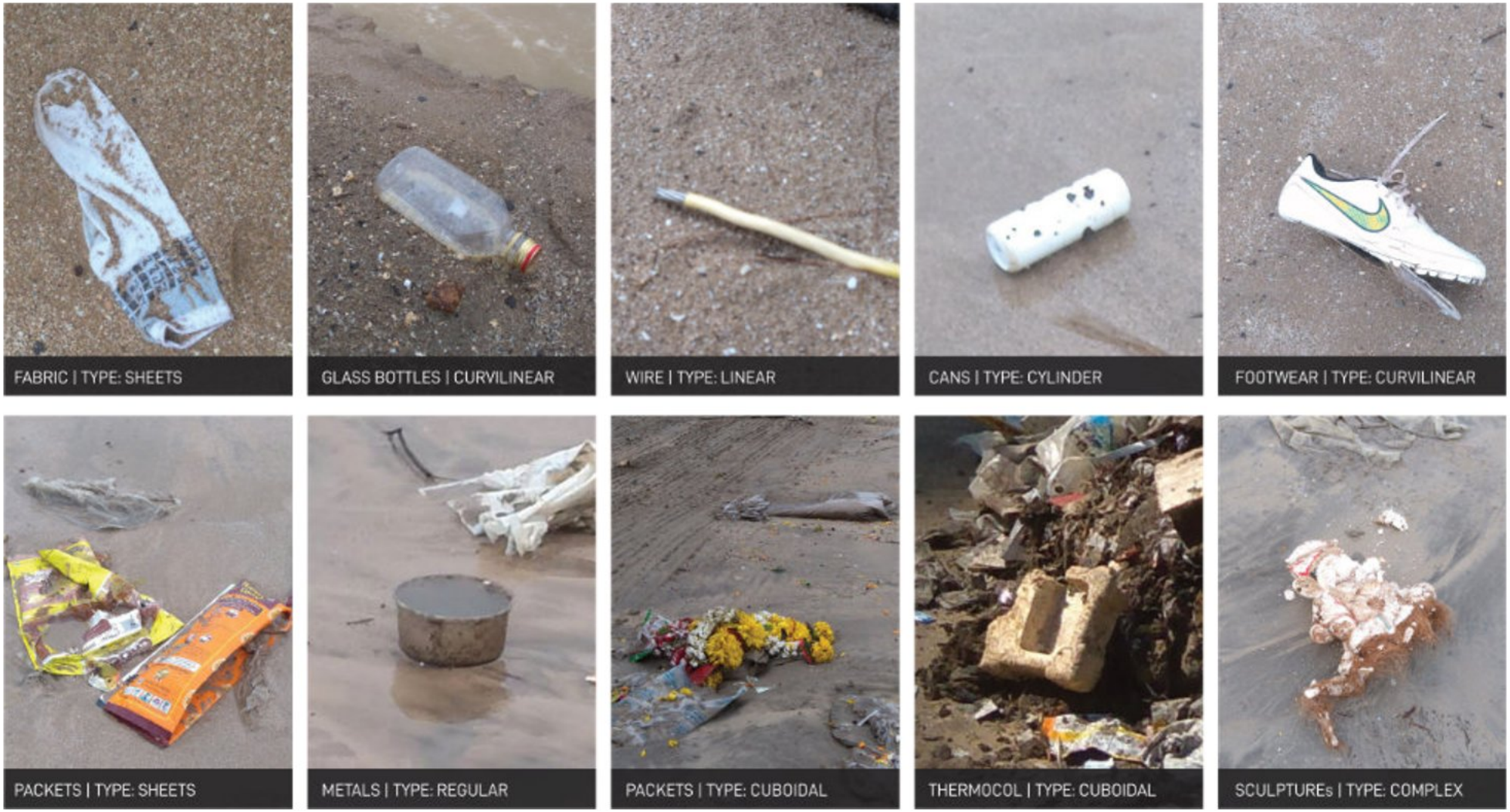


Image 28: Morphology of Waste at beach

When piled together the collection looks like this. It is very random and uncompacted. It is also laid out in the open for the BMC to pickup, which may get scattered again if there is rain or wind takes away the smaller plastic particles. There is a lot of sand infested in the pile which also increases the weight of the bunch a lot, making it difficult and inefficient to carry.

Image 29: Pile of plastic waste created during beach cleanups.

2.3b Other threats

The sand and plastic also becomes the breeding ground of various harmful bacteria and marine viruses which can turn into outbreaks if humans interact with the unclean condition.

The heavy metals and industrial pollutants like chemicals and incineration soot also reaches the beach if discharged into the sea water, making the cleaning process hazardous for the workers.

2017 Statistics (CPCB)

1.50 Lakh kg — of this trash washes ashore every day. The trash is carried into the sea and on to shores by the nullahs and drains that run across Mumbai.

43.7 — Water Quality Index at Juhu
Considered bad & polluted.

1600 /100 ml — The study found that the presence of faecal coliform (FC) bacterium found in human and animal excreta – was 16 times over the safe limit at Juhu. The faecal bacteria also thrives on the sands and sediments on the beaches.

19.7 kg/200 m — The litter comprises of plastic, clothing, fishing nets, toys, tyres, batteries, food wrappers, cigarettes and even vehicular parts. **1000 times during monsoons.**

IndustrialPollutants

IBA	Hg	Se	Ba	Fe	Sn
Incinaration Bottom Ash	Mercury	Selenium	Barium	Iron	Tin

2.3c Existing cleaning operation

Every weekend hundreds of volunteers assemble at different beaches across Mumbai to participate in beach cleanup drives. Everyone uses their hands only. For protection, gloves and sanitizers are provided.

Image 30: Beach cleanup underway.

To better understand the dynamics and extent of the issue, it was suggested that one should participate in the activity. Hence, on multiple occasions visits were made to various beaches in Mumbai and participation in cleaning drives happened. Of over 10 major beaches in Mumbai focus was on Juhu, Versova and Dadar. On participation, various new insights came to light. The effort, discomfort, hazards and risks were exposed. The following pictures were taken on-site. These images are powerful and tell us what they have to deal with on a daily basis.

Image 31: Heap of clogged waste pulled by roles to collect in a dump area

Image 32: A surprising amount of plastic sheets filled with sand were found underground

Image 33: State of Versova fishing colony beach. Taken on October 2, mega cleanup

Image 34: Verova beach is provoided with diggers and earth movers to take out plastic bags from underground

Image 35: Volunteers need to walk over the dug-outs and manually pull out the heavy sand bags

In India, Ganesha Chaturthi is primarily celebrated at home and in public by local community groups in the central and western states of Madhya Pradesh, Maharashtra, Gujarat and Goa and the southern states of Karnataka, Andhra Pradesh, Telangana, Tamil Nadu, West Bengal, Bihar and Odisha. In Maharashtra, it is a very prominent festival during which Idol worship is done all over the temples and homes. According to the holy procedure, the followers must immerse Lord Ganesha's Idol in the Sea.

Image 36: Organic waste collected during Ganesh Puja

Image 37: Plaster of Paris Idols wash out on the shores

Image 38: Girl in raincoat siting over trash and picking it while rain drizzles

Beach warriors is an NGO which have been working on the cleanliness of beaches for a few years. I had the opportunity to join them and get insights from their approach and process of cleaning. They operate in Dadar, Juhu, Madh Island, Erangle and Chimbai beach. Their way of cleaning is very simple and organic. On foot, by hand approach. They use baskets provided by BMC storehouses at beaches. They don't get any tools.

Image 39: Beach warriors working on Dadar beach.

Image 40: Dump being created, separate for plastic and organic

Image 41: Usually requires two people to carry a waste basket

2.3d User study: Issues in manual cleaning

Akshay Mandhare
Beach Warriors
2017-Present

Varsha
Beach Warriors
2019 Jan-Present

Image 42: Beach cleanup at Dadar.

I had the opportunity to work with Beach Warriors, an initiative by Khushiyaan foundation (NGO) - they work for providing safe drinking water in slums, education, food and shelter for stray animals and cleanliness of beaches. A few members of the foundation helped in gathering some invaluable insights about manual cleaning in beaches. Some of them are:

Location: Dadar Beach, Mumbai.

Insights:

1. Micro-plastics/tiny plastic pieces are the most difficult to spot among sand and shells.
2. Segregation is not possible on site. Volunteers only pick the plastic waste. However it is infested with other wastes.
3. Operation needs to be stopped during rains and tides. With raincoats it can be continued.
4. Hand sanitizers and surgical gloves are always used to ensure safety and hygiene of volunteers.
5. Just hands and baskets. Baskets are provided by BMC from the storehouses at the beaches. Sometimes they get rakes.
6. Usually collected waste is dumped at one point in form of a heap. BMC's tractors/trucks pick it up later.
7. Close to none. BMC's sand cleaning machines rarely work.

2.3d User study: Issues in manual cleaning

Chintu Sharma
Beach Warriors
2018-Present

Anusha
Beach Warriors
2018-Present

Image 1\42: Beach cleanup at Juhu.

Juhu beach is probably the most popular and the longest beach in mumbai. It stretches from Versova to Santacruz area (appx. 7kms). The Koliwada region south of the Juhu is usually left unattended by the authorities. This is where the NGOs have adopted the responsibility to conduct cleanup drives.

Location: Juhu Beach, Mumbai.

Insights:

1. The plastic buried under the soil. The torn plastic packets gets filled with wet sand which becomes difficult to dispose.
2. Segregation is not possible on site. Volunteers only pick the plastic waste. A large amount of wet sand is always infested.
3. They usually continue working in rain. However it get very difficult as their baskets gets heavy with a lot of water content.
4. Hand sanitizers and surgical gloves are always used to ensure safety and hygiene of volunteers.
5. Just hands and baskets. Baskets are provided by BMC from the storehouses at the beaches. Sometimes they get rakes.
6. Usually collected waste is dumped at one point in form of a heap. BMC's tractors/trucks pick it up later.
7. Machines run but they just flatten out the surface with the plastic still inside. Their mechanism is clogged and hence they require manual labor.

Afroz Shah, a young Indian lawyer from Mumbai, is synonymous with the world's largest beach clean-up project. In October 2015, Shah and his neighbor Harbansh Mathur, an 84-year-old who has since passed away, were frustrated with the piles of decomposing waste that had washed up and completely overwhelmed the city's Versova beach. Determined to do something about it, the pair started cleaning up the beach themselves, one piece of rubbish at a time.

Image 43: Afroz Shah at his cleaning operation. Source: facebook | CNN Heroes Award

2.3e Insights from Ocean Activist: Afroz Shah

HOW DOES HE DO IT:

- Using machines, the sand patches are tilled and then manually people pick the plastic and other waste.
- Initially manual hand digging was used to take out the trash.
- It is collected and sent to segregation centers.

ON TYPES OF WASTES:

- Rag pickers avoid picking wrappers and packets as they are too lightweight and provides them no value.
- According to EPR (Extended Producer's Responsibility) the companies producing wrappers must process that waste.
- Multilayered packaging items are un-recyclable e.g. Chips packet.
- The shinier the packaging the lesser is it recyclable.
- Even 100% recyclable products are unnecessarily produced.
- Rag pickers focus of bottles and intact items as it gives them good value in money.

ON SEGREGATION:

- Waste washed ashore by oceans cannot be segregated on-site.
- Ocean waste can be potential bio-hazard as it can contain excreta, corpses, algae and other micro-organisms.

ON THE CHALLENGES:

- Problem of waste is a socioeconomic and mindset problem.
- Volunteers face resistance from garbage mafias and sometimes it is required to shut down operation for safety.
- Spreading awareness among people to not defecate on the beach. It makes the cleaning process very dangerous and repulsive.

2.3e Issues in cleaning with existing machines

Despite advanced technologies and complicated machinery, the problem is not being solved effectively. The dynamics and diversity of waste and other factors doesn't allow a particular innovation to work in a certain context. The beach cleaning machines can be seen heavily clogged up and dysfunctional. The clogging agents contain wet fabric, large plastic sheets, mud, sand and organic waste.

Due to dysfunctional state of beach cleaners the contractors utilize manual labor to scrape, rake and pick waste by hand and manually put it into the machine's trash collector. The inability of cleaning by machine makes the investment a failure. This machine is only used to level the dug and scraped surface of the beaches after manual cleaning.

Image 44: Clogged trash picking machine at Dadar

Image 45: Workers manually collecting trash and putting in the hopper by hand

Image 46: Machines cannot differentiate what they are picking. Clog on the screen.

Image 47: In a disorganized way manual cleaning equipements are always kept. In this case they are kept in the screen itself which is contaminated and harmful.

Image 48: Picked waste is clogged and present in the open. It may be flown away by wind.

2.3f Key insights from the research

1. The technology for picking all types of trash mechanically is very complicated, expensive or does not exist.
2. Volunteers find beach cleaning exhausting and inefficient, however they are motivated for the cause.
3. Municipal corporation has large manpower to work side by side with machines. They utilize them for manual labor and faster cleaning when the beaches are crowded near shoreline. The machines are run mostly when there is little to no crowd.
4. Machines are unable to collect very fine pieces of plastic (eg. Micro-plastic, plastic peels-offs)
5. Specialized tools and collection methods are not in use at scale.

2.3g Strategy towards solution

With the problem identified, waste analyzed and advanced technology we can add new layers in the solution for a fresh perspective. eg. Human factor, context, economy, usability and maintenance, to innovate something new.

DESIGN BRIEF

3.1 Design brief

Mobile solution for mitigating ocean plastic waste on Mumbai's beaches through joint effort of human and machine

The product can be cleaning tool and waste transportation module -

- Human propelled
- Carry cleaning equipment
- House a vacuum cleaner
- Simple operations
- Storage for necessary items

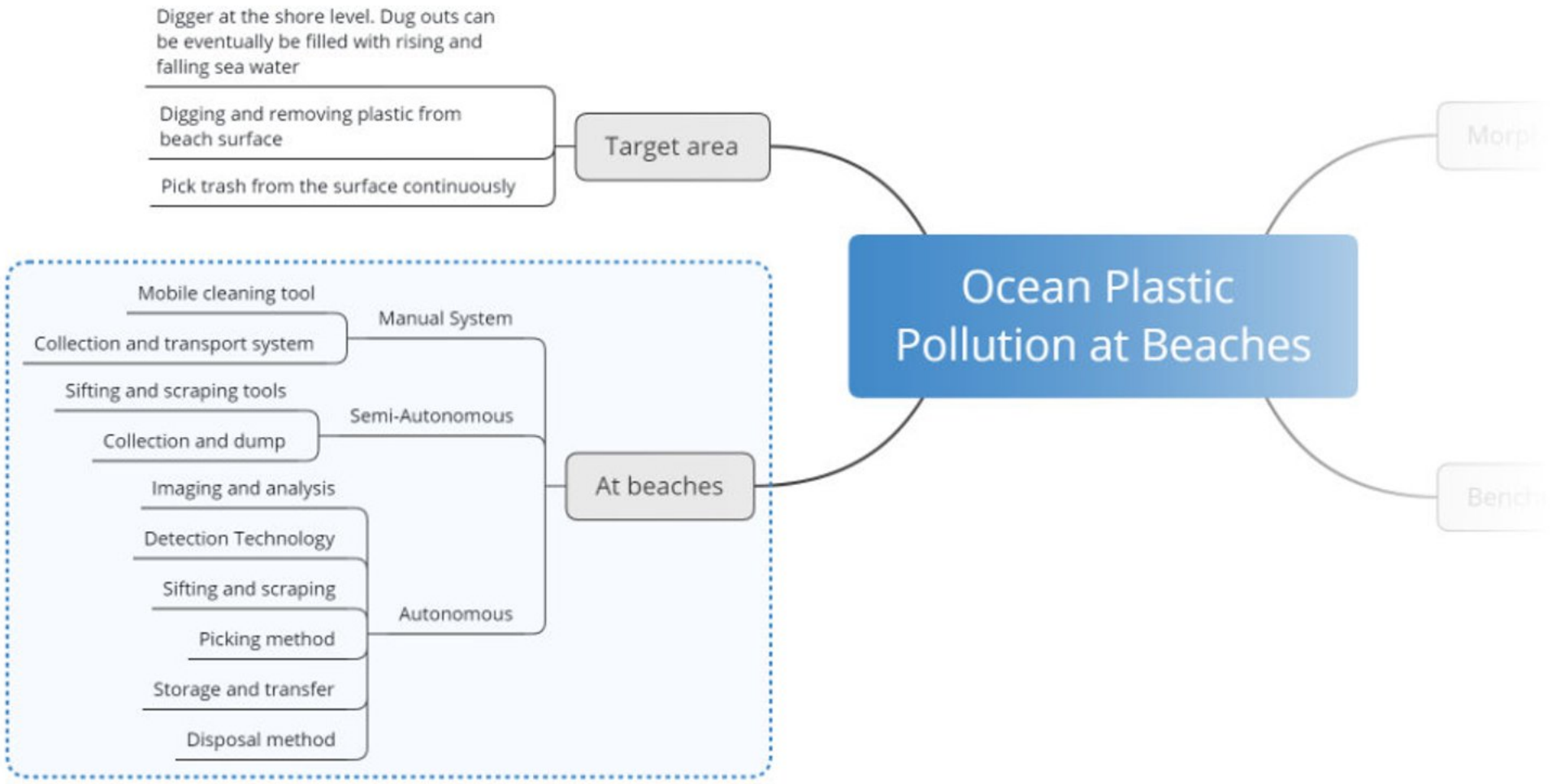
Dimensions:
The size of the unit should be small and compact, so that it can be propelled easily by a human.

Boundry conditons:
- The product should be able to pick lightweight trash and surface litter
- The product should be scalable for mass use.

DESIGN IDEATION

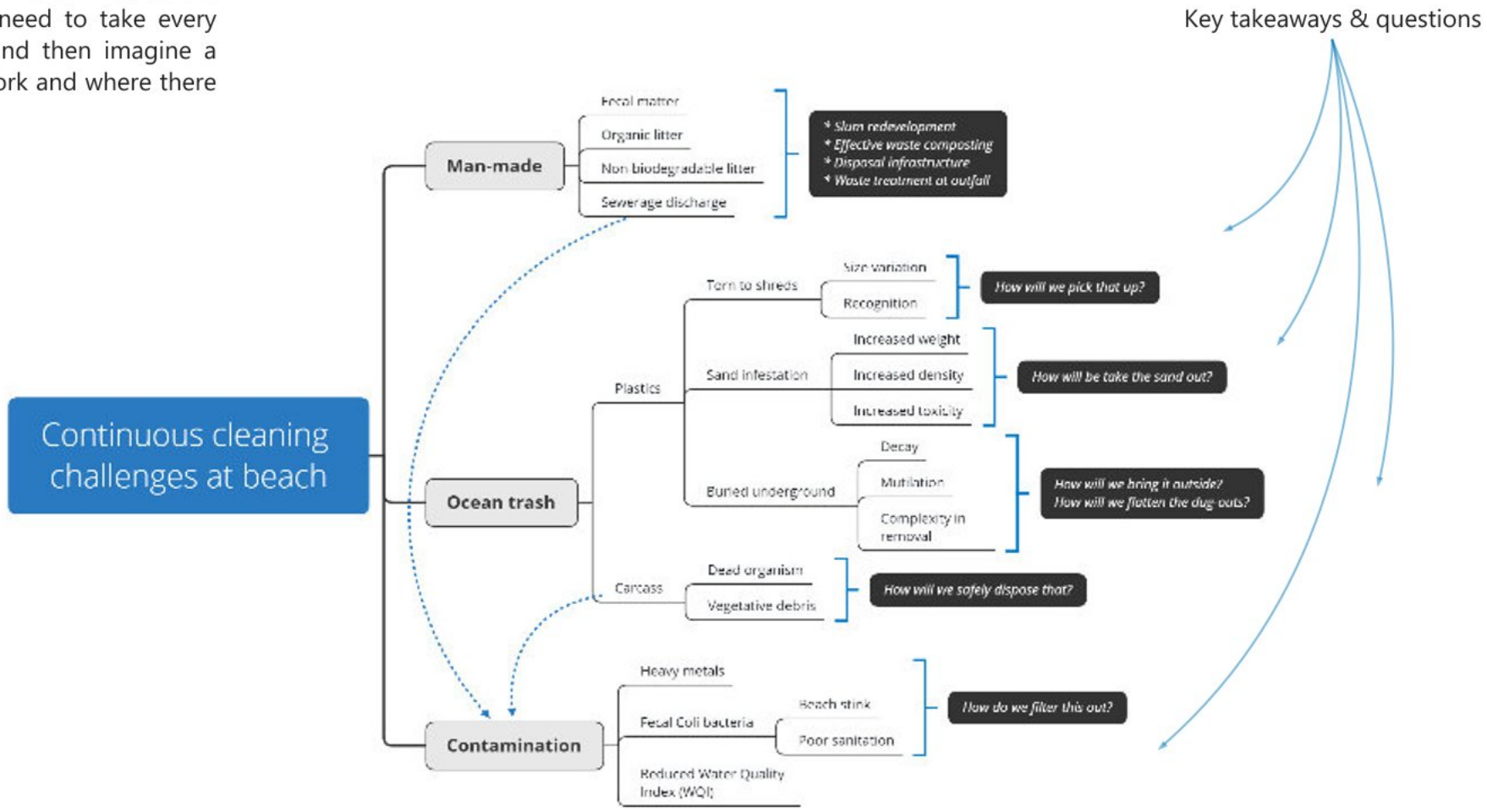
4.1 Ideation map

The initial stage of Ideation began by identifying the target area that we want to focus on and various possible systems in which we can imagine a possible solution keeping the context and other constraints in mind.

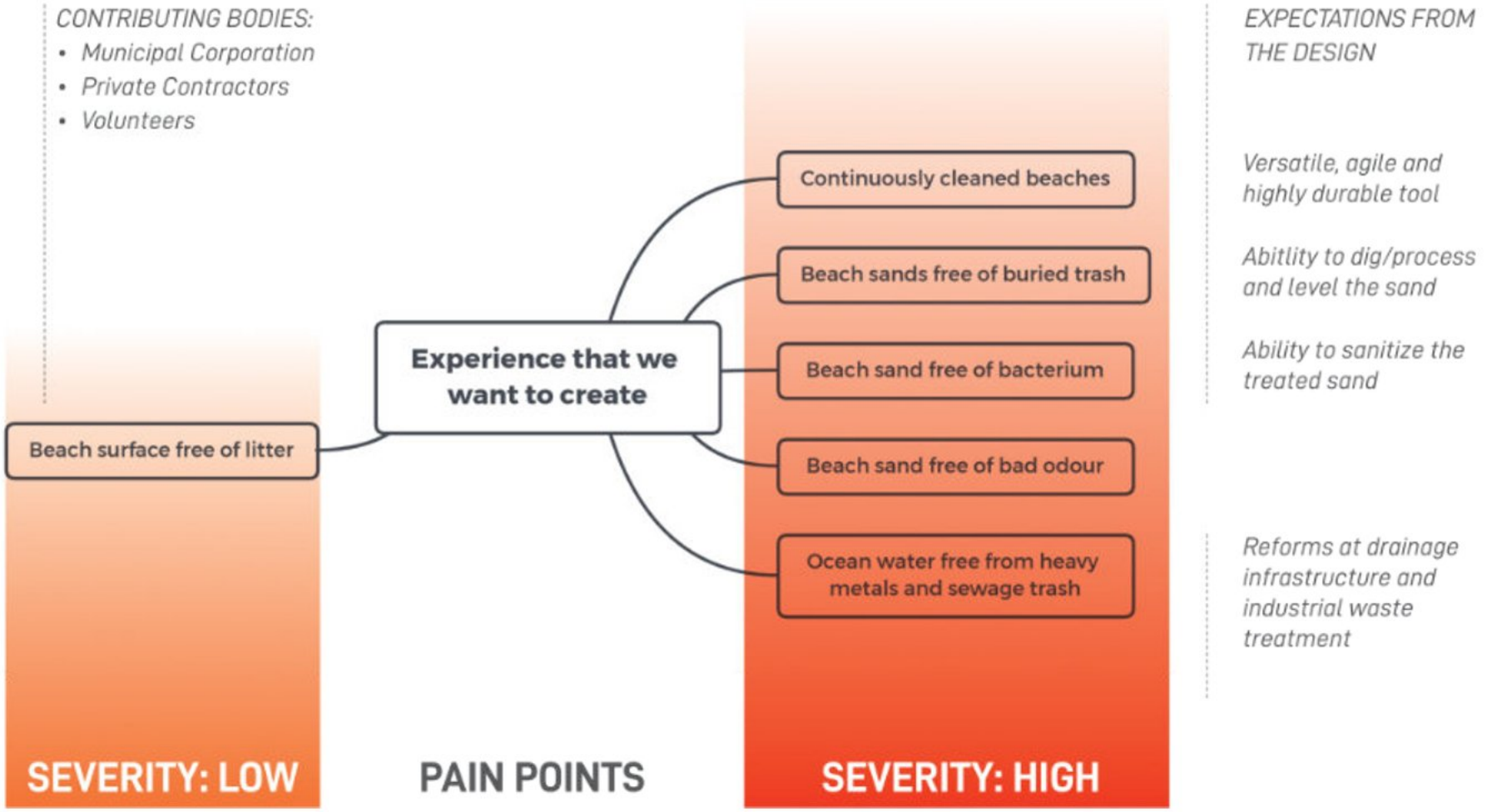


4.2 Challenges in continuous cleaning of beaches

The first challenge was downsizing the research to obtain a focus area, as the issue is huge. We need to take every factor in account and then imagine a solution that can work and where there is a need.

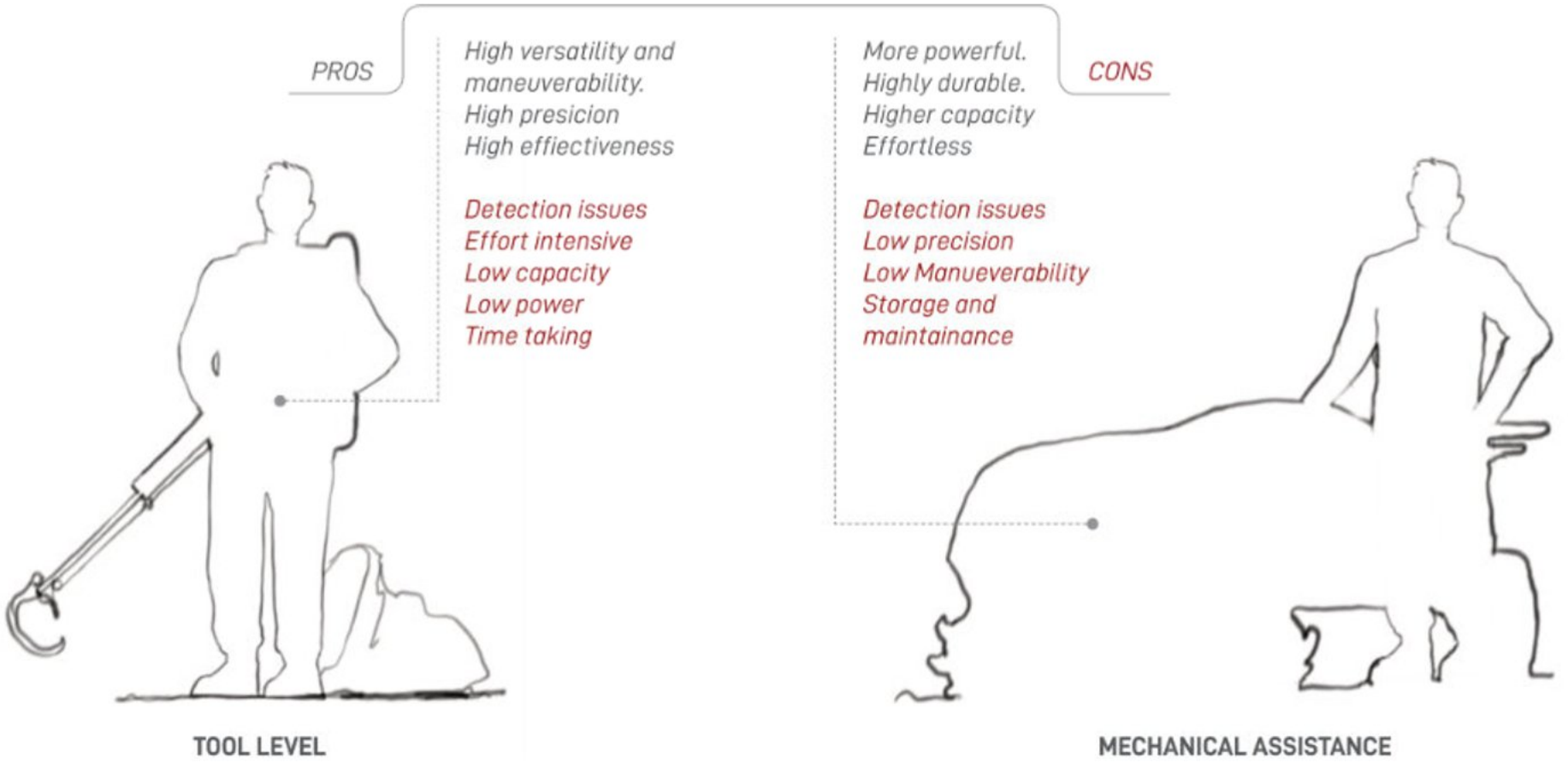


4.3 Pain points and opportunities at various levels



4.4 Ideas and Discussions

Interventions at both levels present their own challenges. At human scale it is precise, cheap and easy, but effort intensive. At vehicle level the power and capacity increases, but accuracy is reduced. To improve accuracy the cost increases in designing complicated mechanisms.



If we closely look at the process of beach cleaning the most effective order would be like the following:

1

Scraping the waste from the top surface

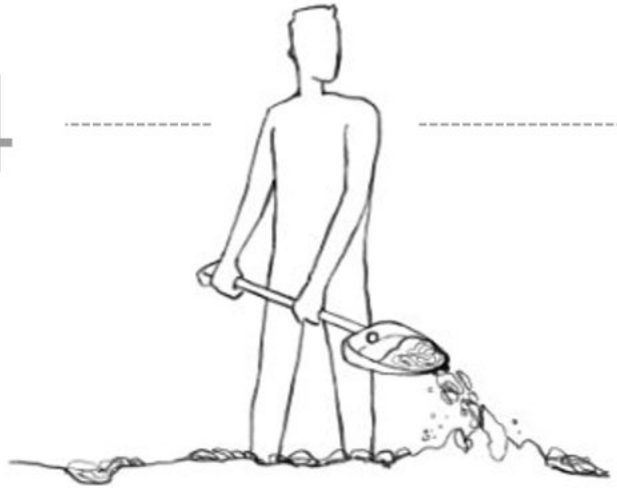
2

Storing it up properly

3

Digging the surface for partially sunken waste removal

4



Spreading it evenly on the surface

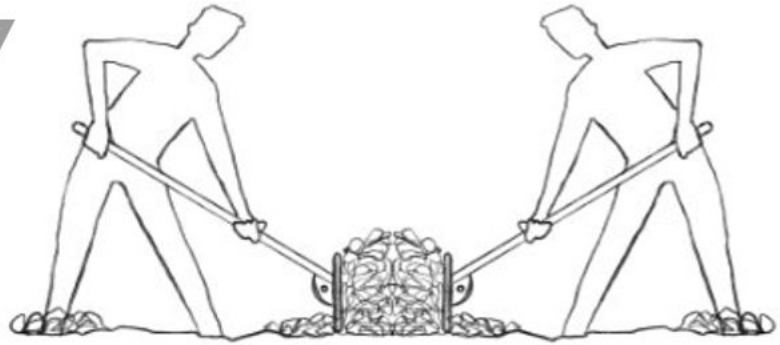
5

Storing and carrying the heavy load to the dump spot

6

Dumping the waste

7

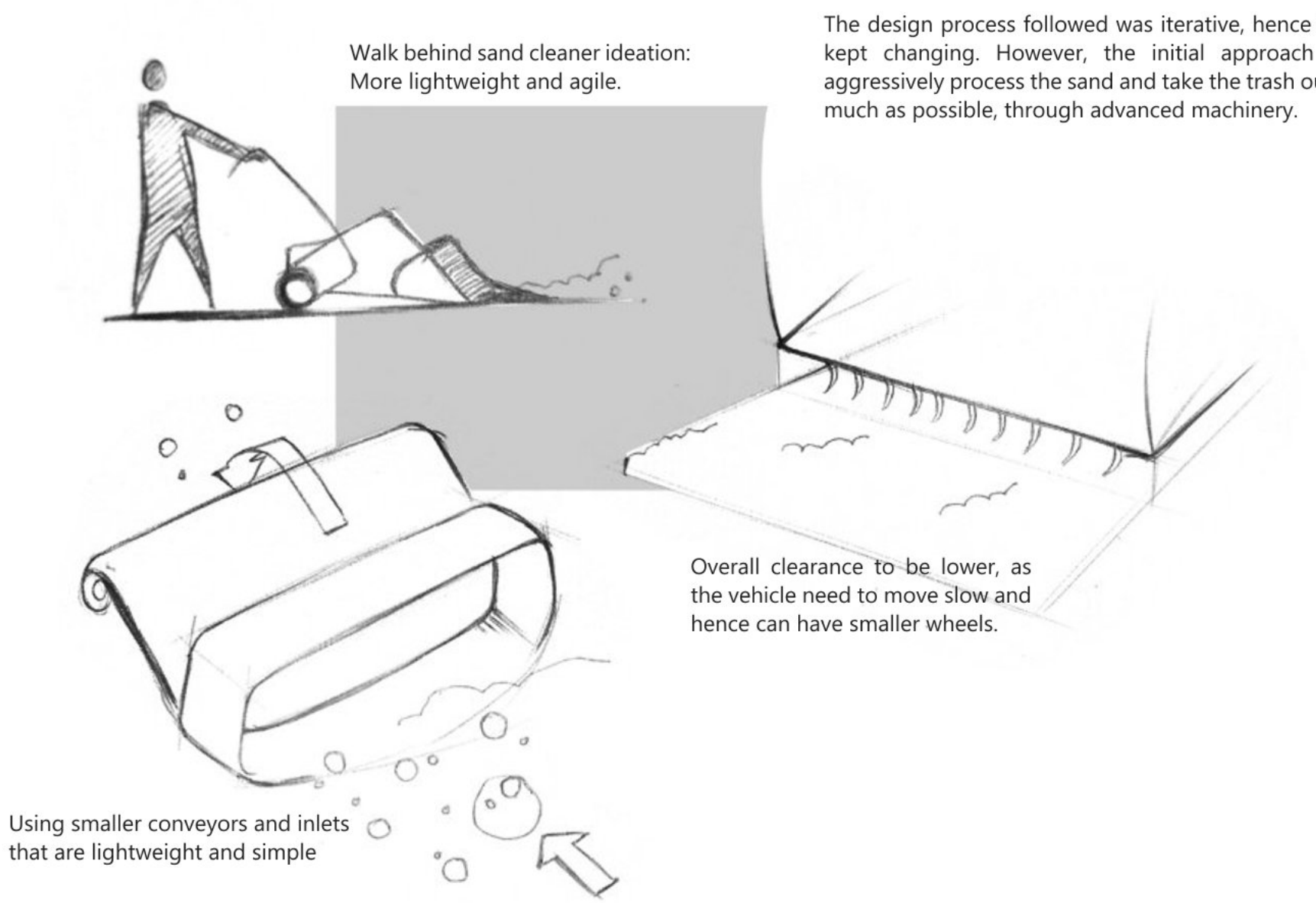


Compacting the waste to avoid re-spreading and spill

While developing the final concept keeping these basic activities in mind and using the same to inspire the mechanism and build around it.

Initial Ideas: Fully Machine Based

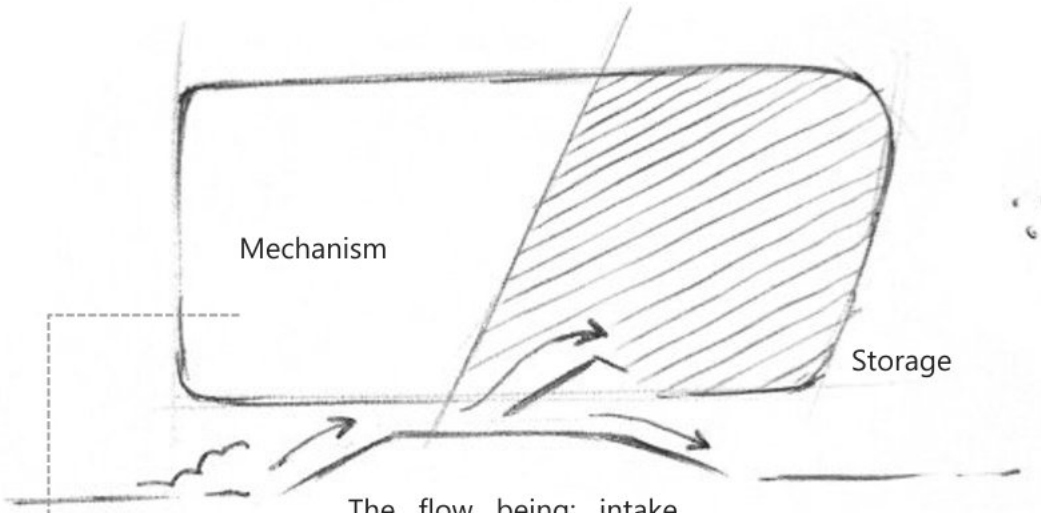
The design process followed was iterative, hence the brief kept changing. However, the initial approach was to aggressively process the sand and take the trash out of it as much as possible, through advanced machinery.

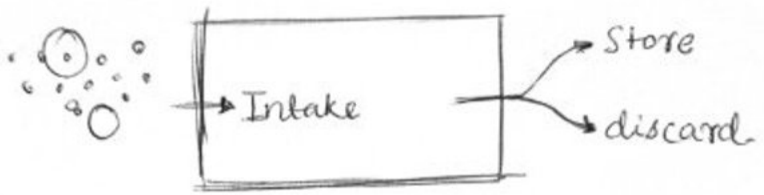


Walk behind sand cleaner ideation:
More lightweight and agile.

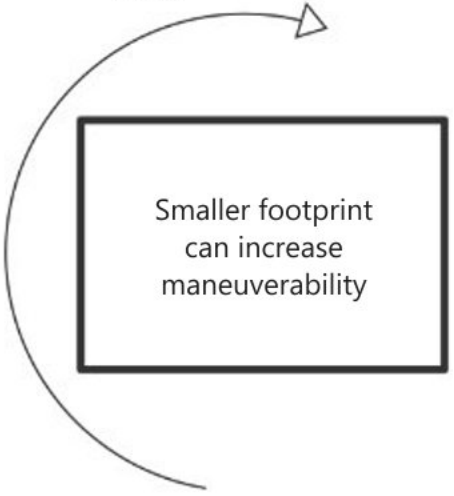
Overall clearance to be lower, as the vehicle need to move slow and hence can have smaller wheels.

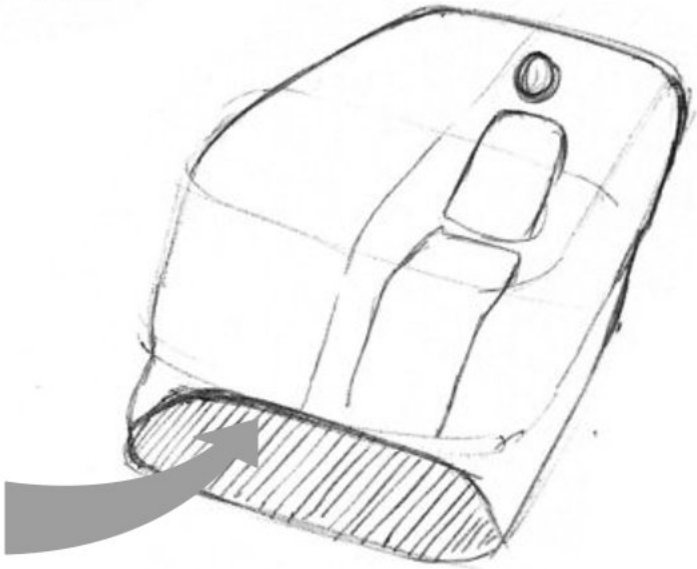
Using smaller conveyors and inlets that are lightweight and simple



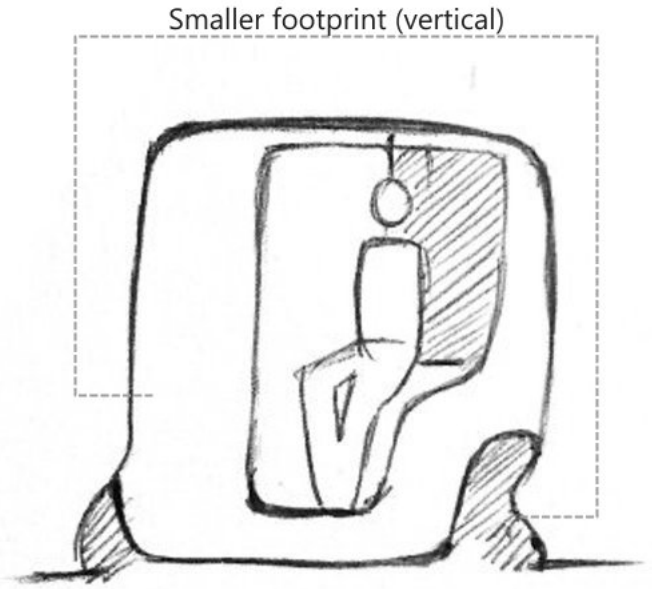


The flow being: intake, processing and discarding sand

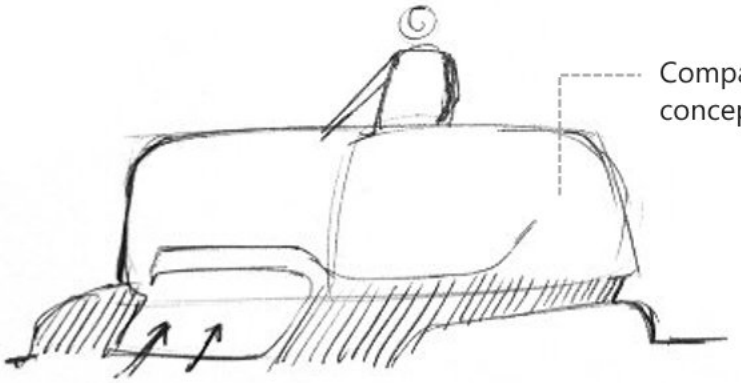


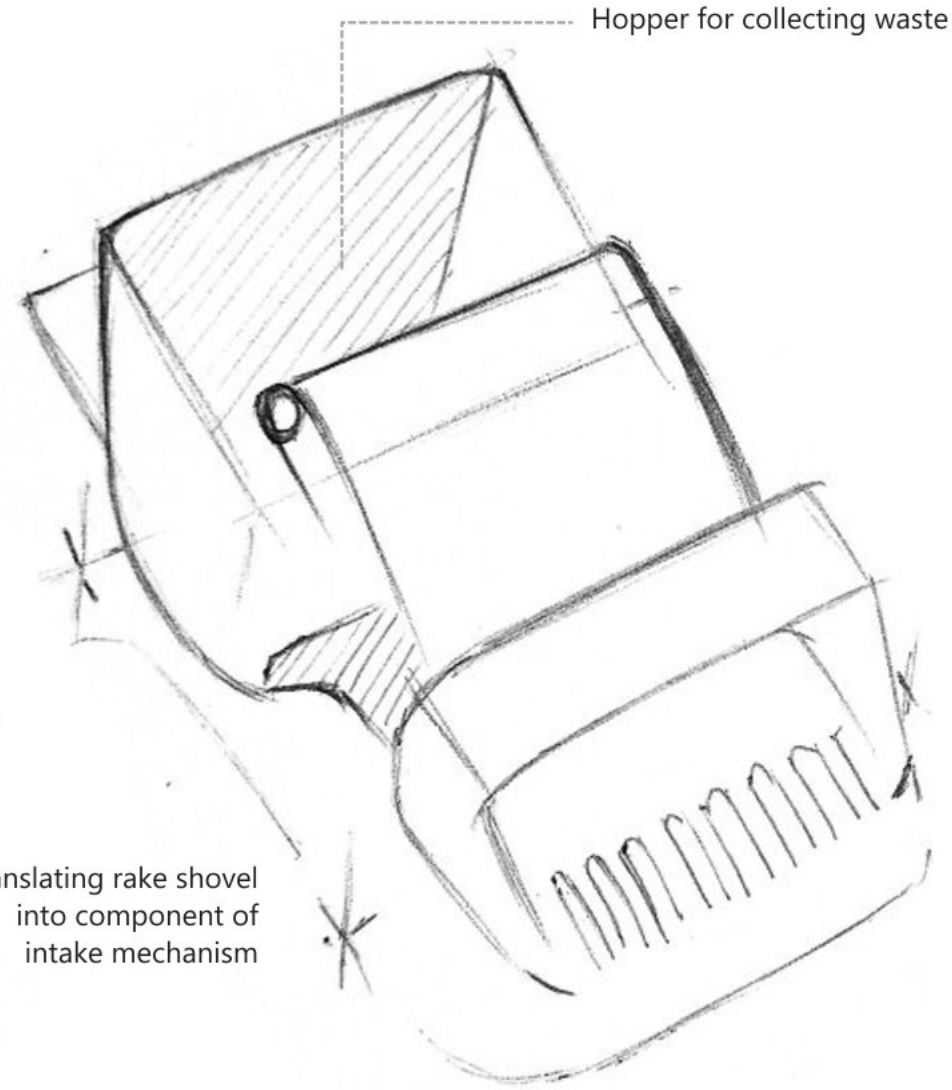


If driven from inside/ sitting over it the position should be such that the trash should be seen.



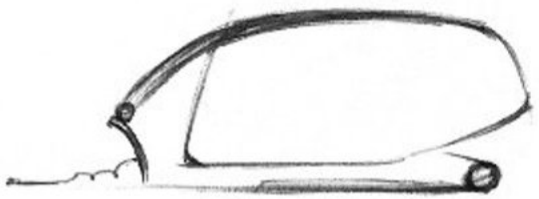
Experimenting sitting layout for comfort and situation awareness

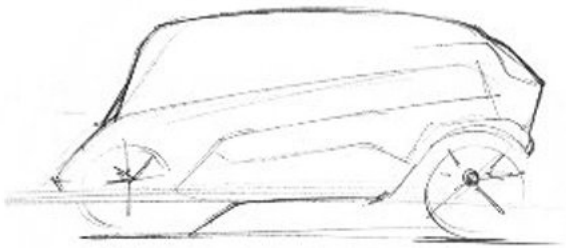


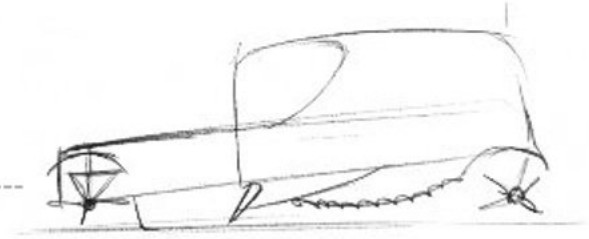


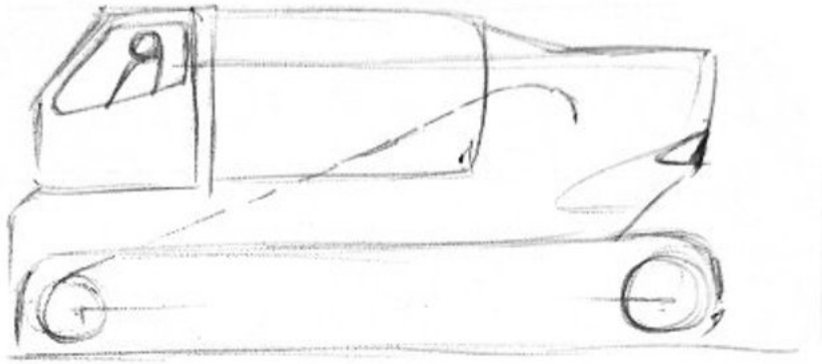
Translating rake shovel into component of intake mechanism

Understanding form based
on basic configuration

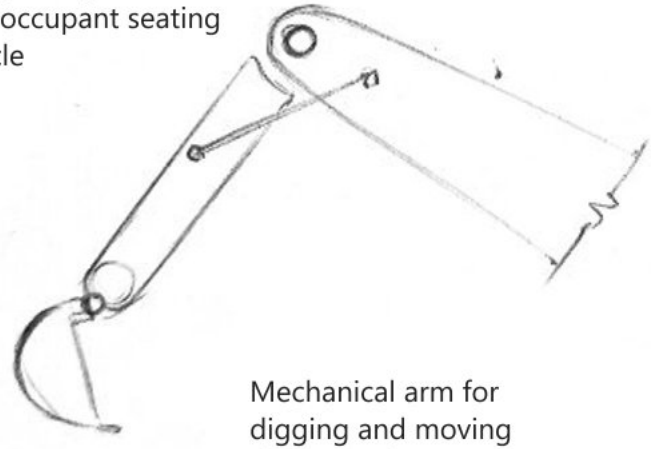






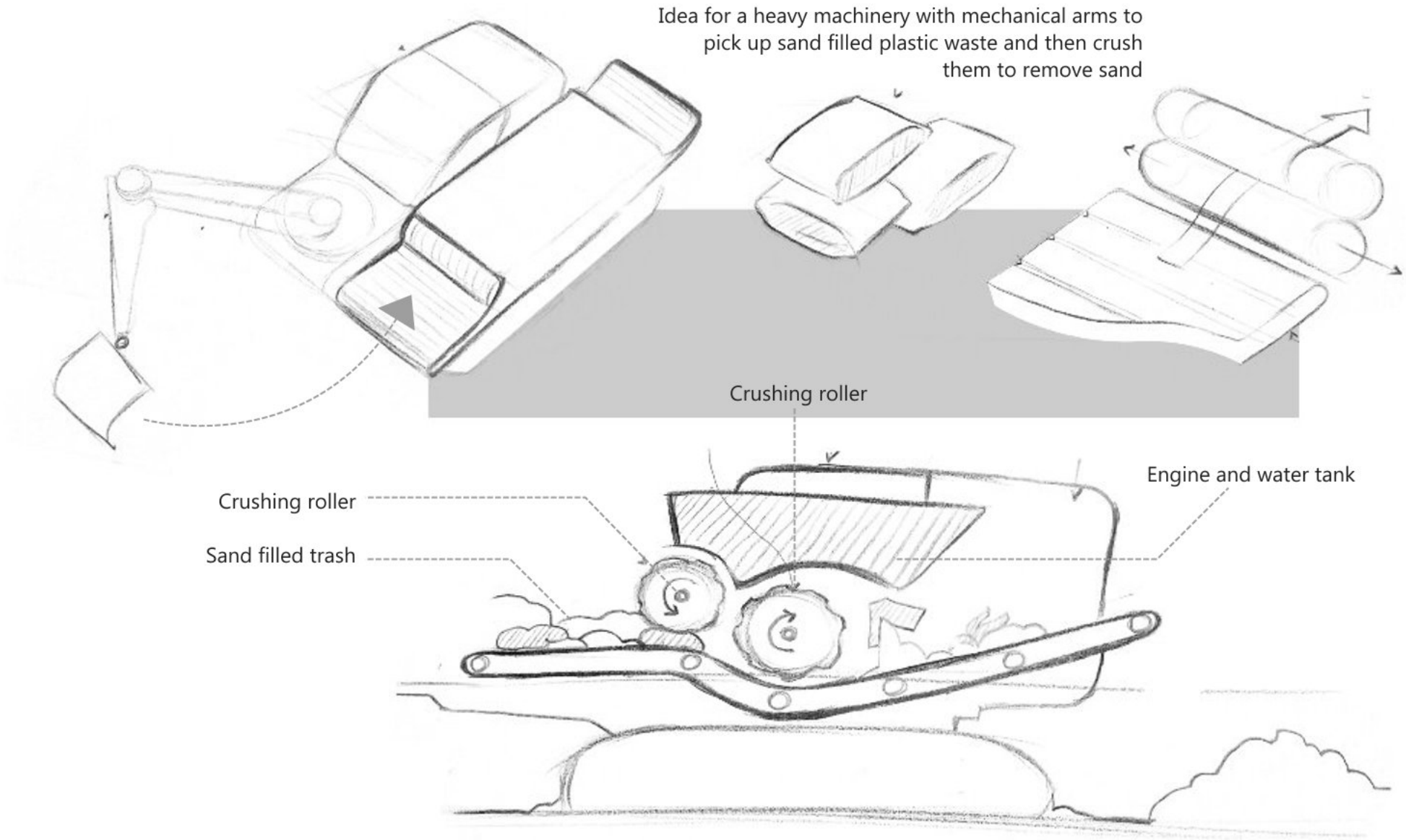


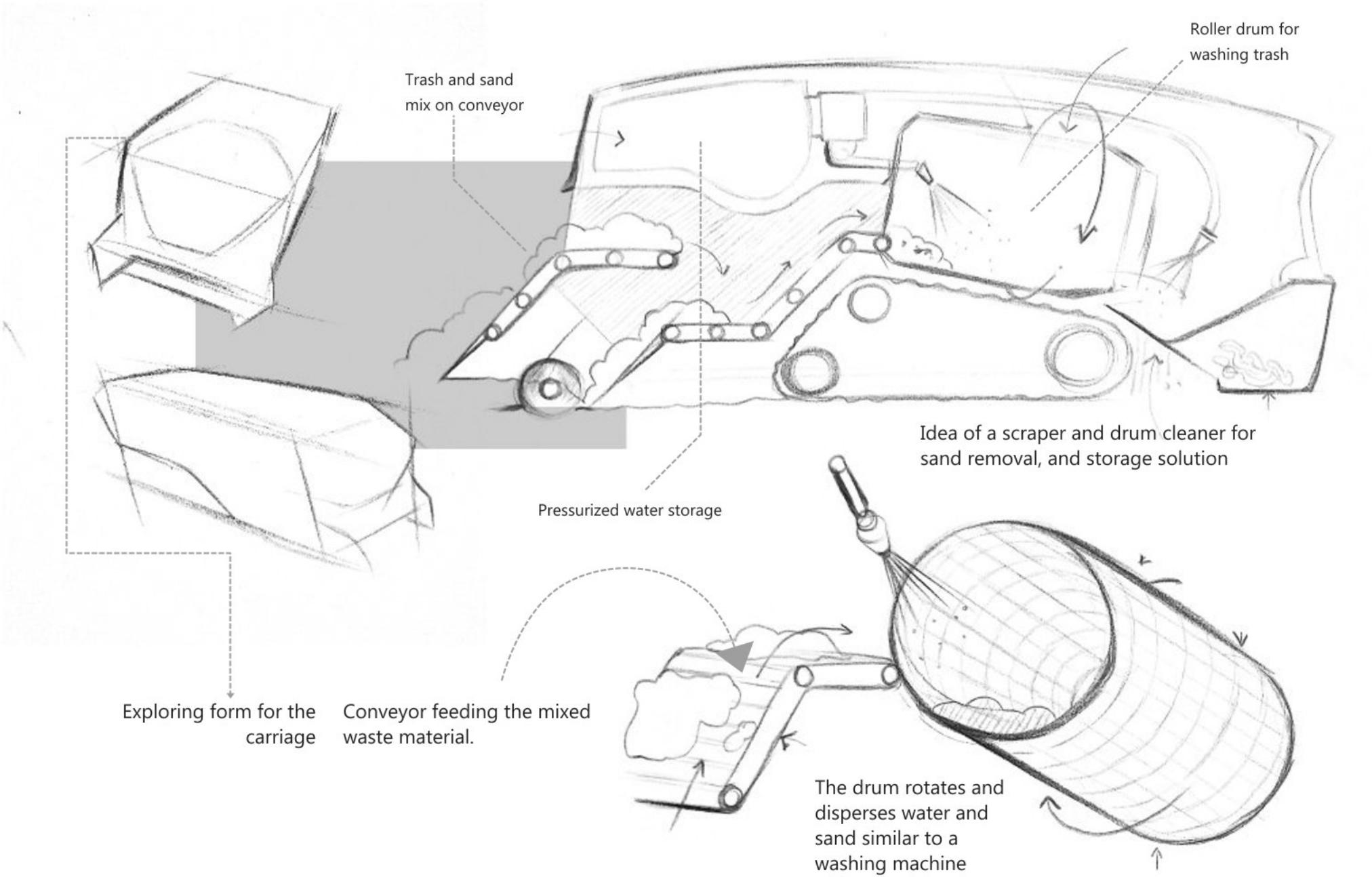
Unifying existing raking machine
framework and occupant seating
in a single vehicle



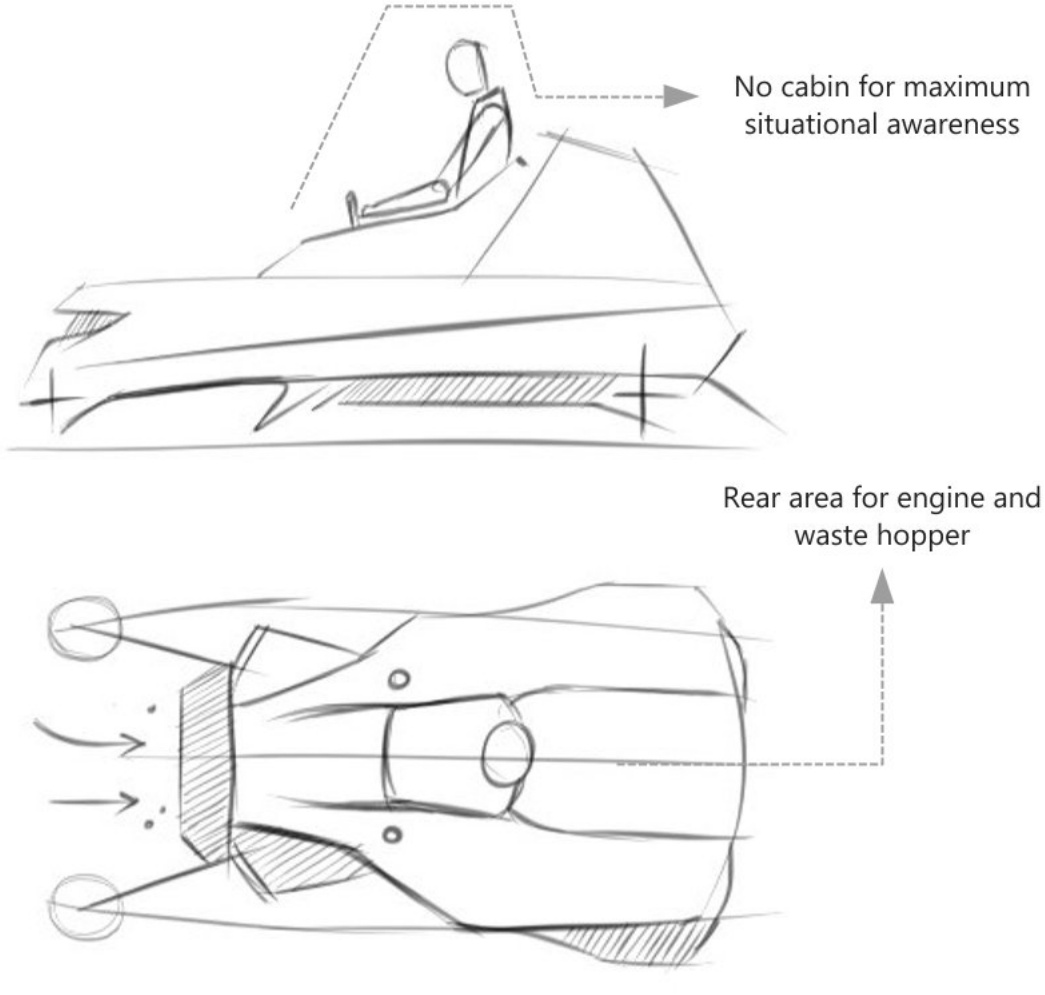
Mechanical arm for
digging and moving
the ground

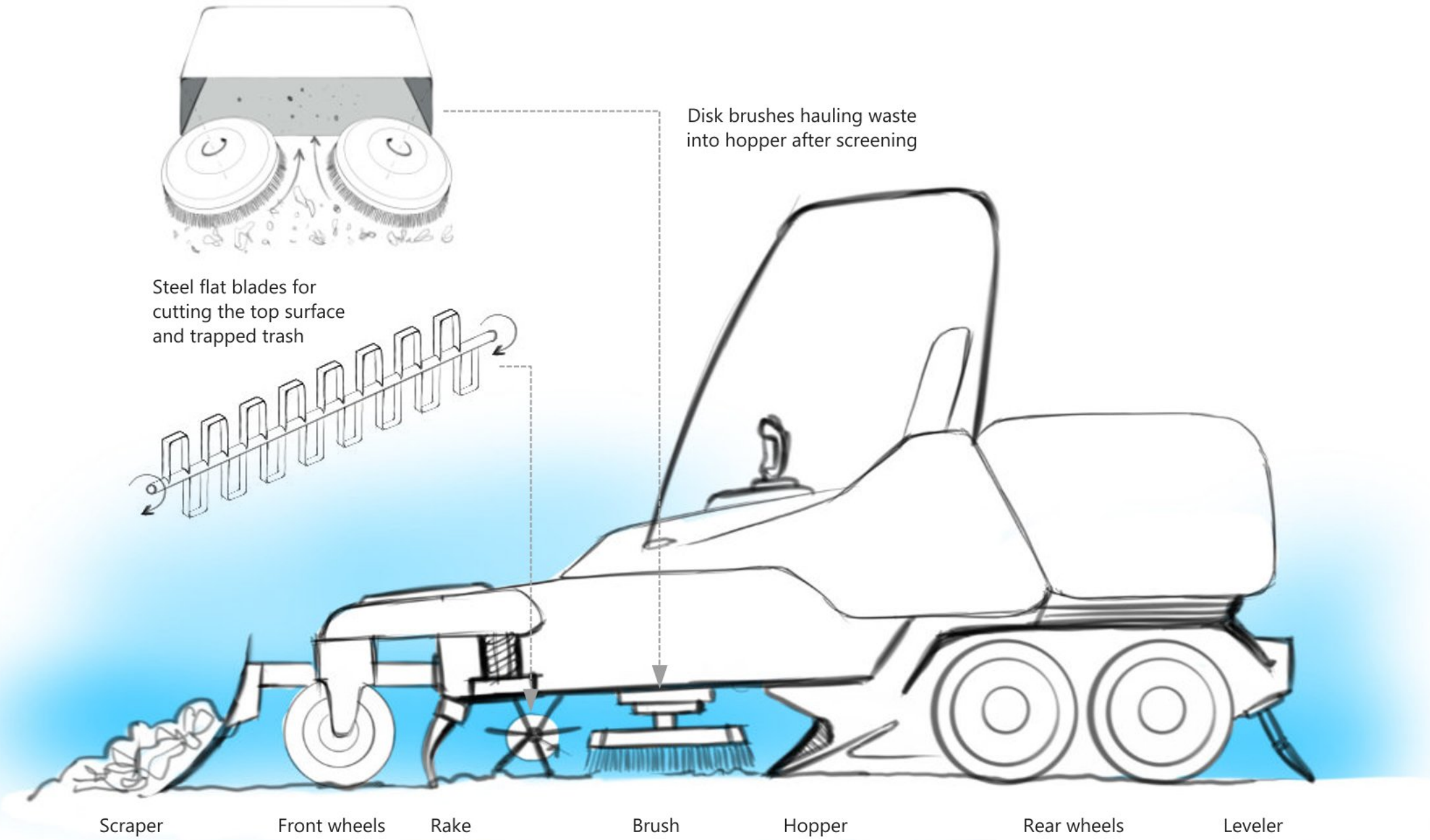
These machines are largely driven by one person and are highly complex and powerful. The approach is much more engineering driven than design driven.


Idea for a heavy machinery with mechanical arms to pick up sand filled plastic waste and then crush them to remove sand
Crushing roller
Crushing roller
Sand filled trash
Engine and water tank

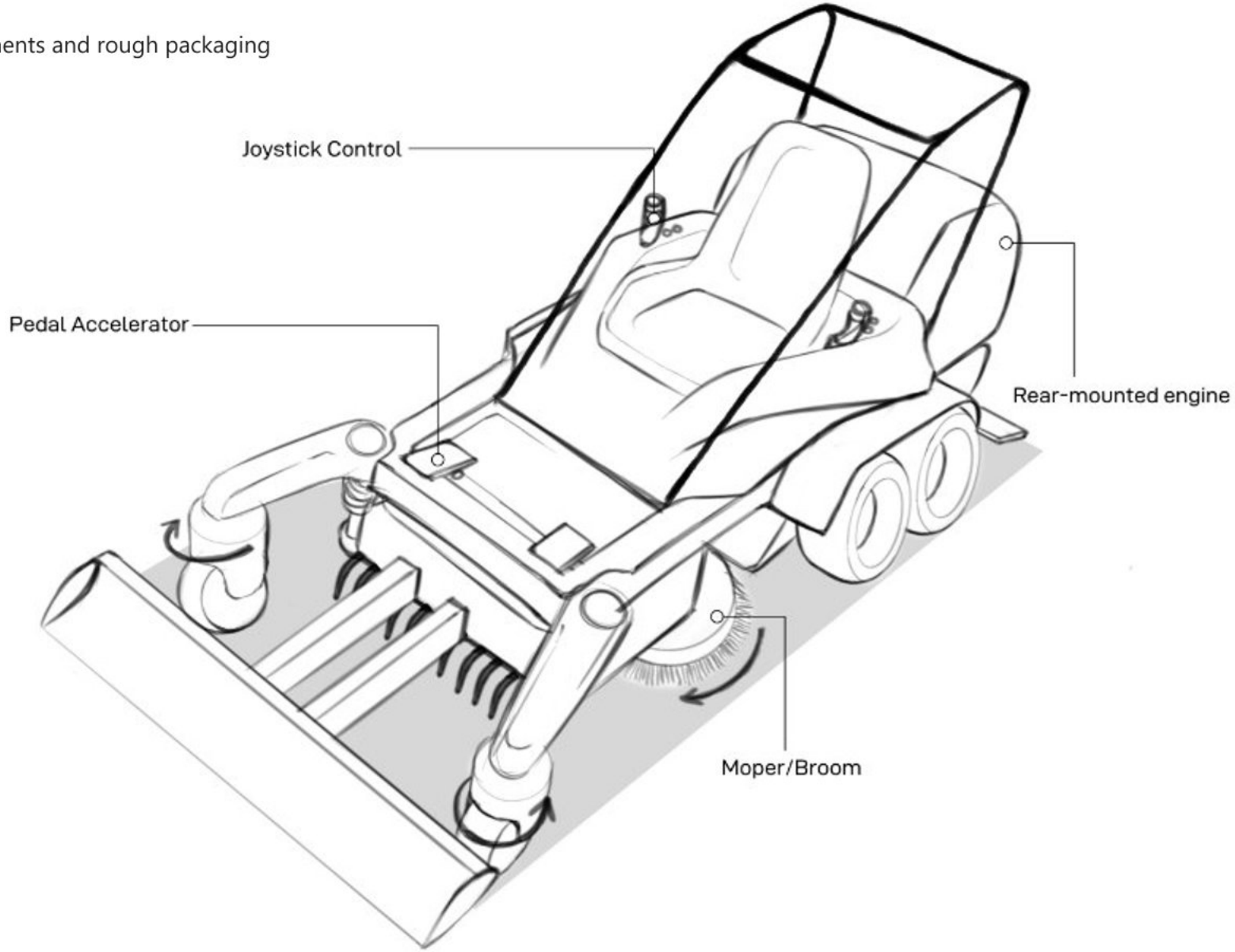

Roller drum for
washing trash
Trash and sand
mix on conveyor
Idea of a scraper and drum cleaner for
sand removal, and storage solution
Pressurized water storage
Exploring form for the
carriage
Conveyor feeding the mixed
waste material.
The drum rotates and
disperses water and
sand similar to a
washing machine

A low footprint ride-on waste collector that has several systems and filters in the base, allowing it to carefully collect the waste.

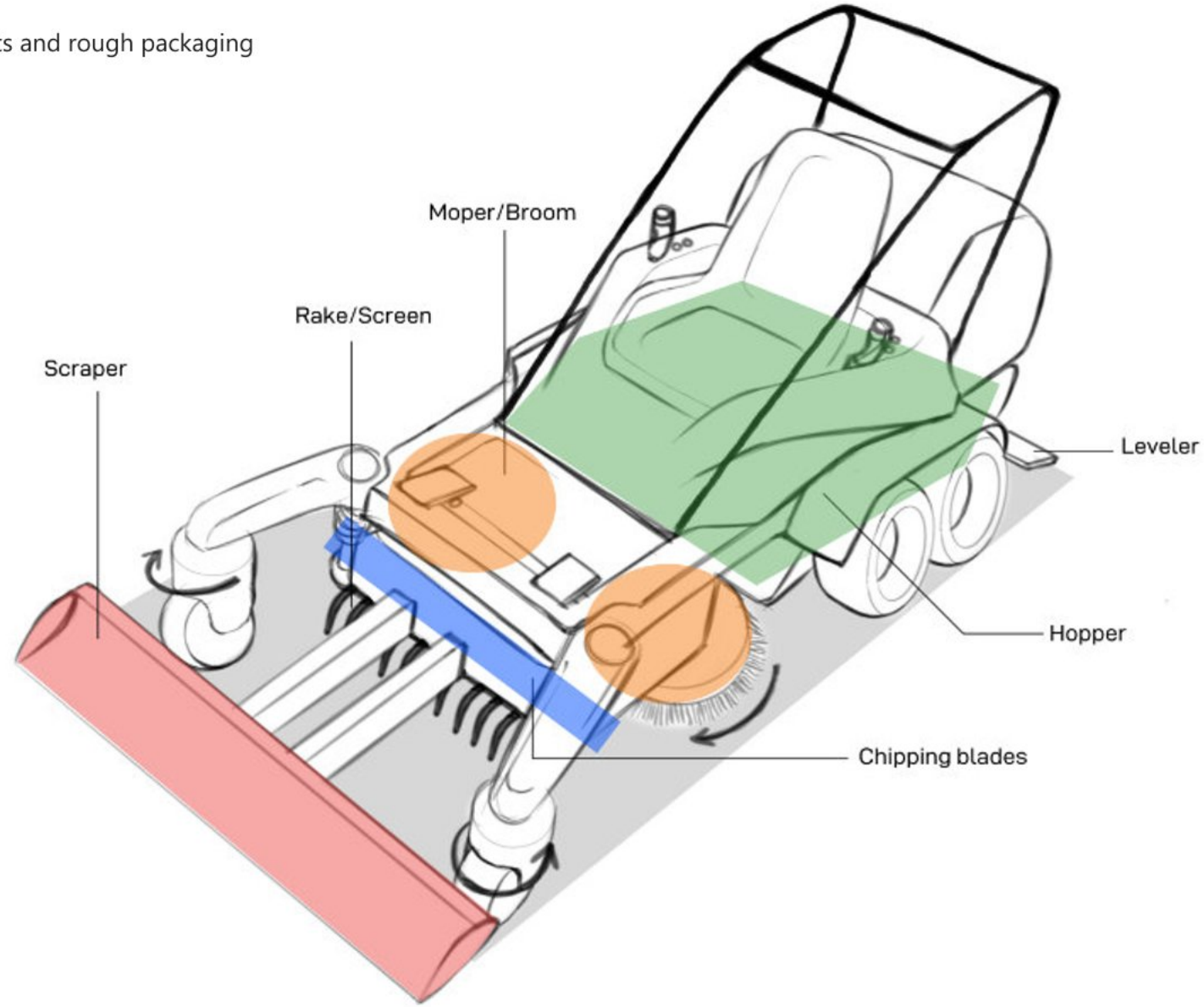


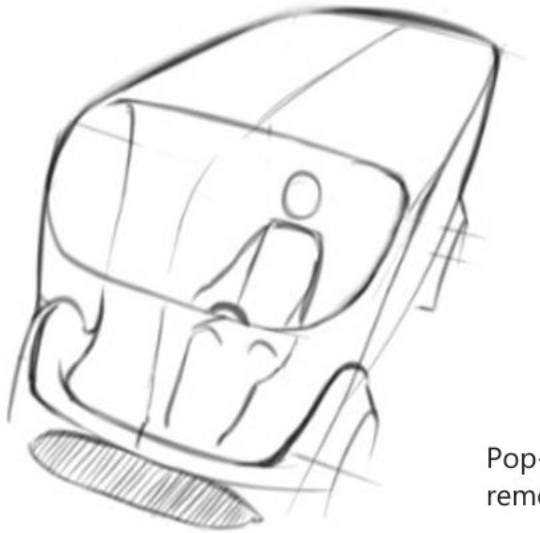

Disk brushes hauling waste into hopper after screening
Steel flat blades for cutting the top surface and trapped trash
Scraper
Front wheels
Rake
Brush
Hopper
Rear wheels
Leveler

- Components and rough packaging

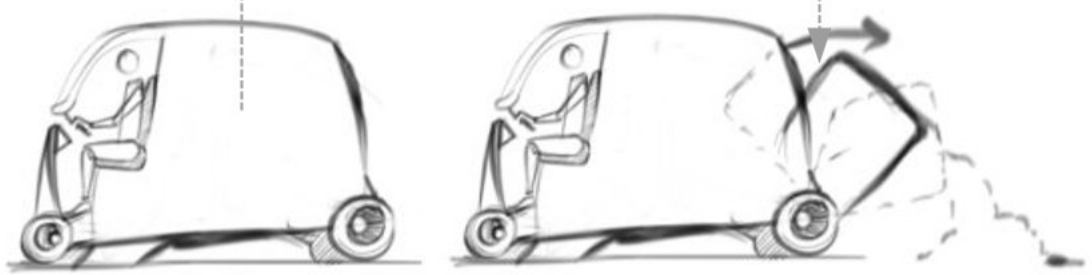


- Components and rough packaging

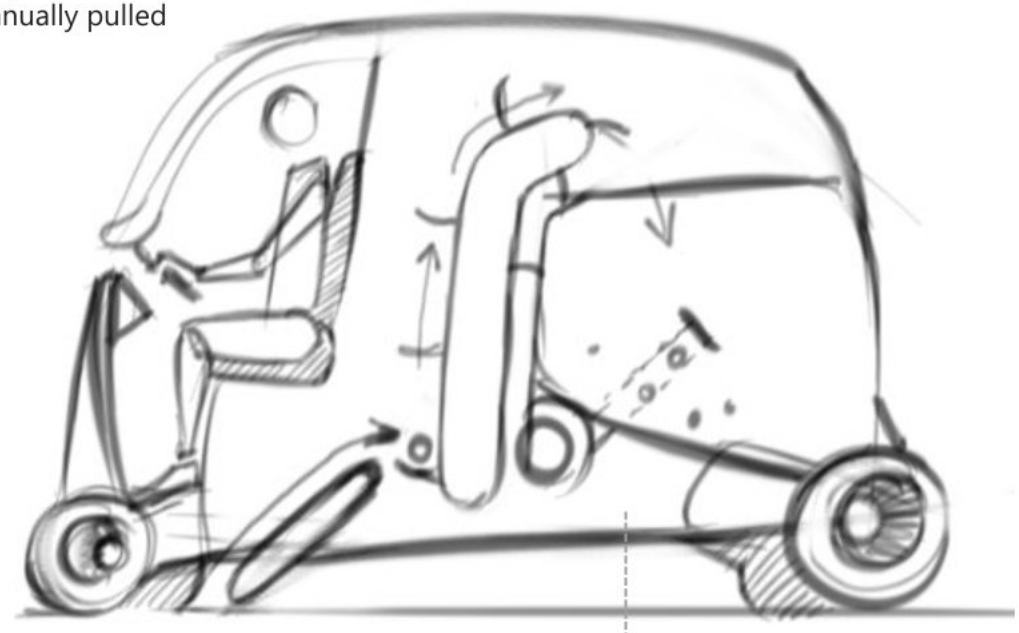


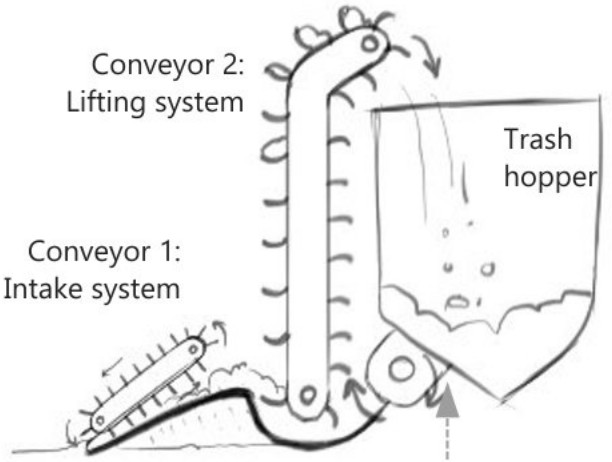


A compact and weatherproof trash collector for easy maneuverability in areas with scattered trash.

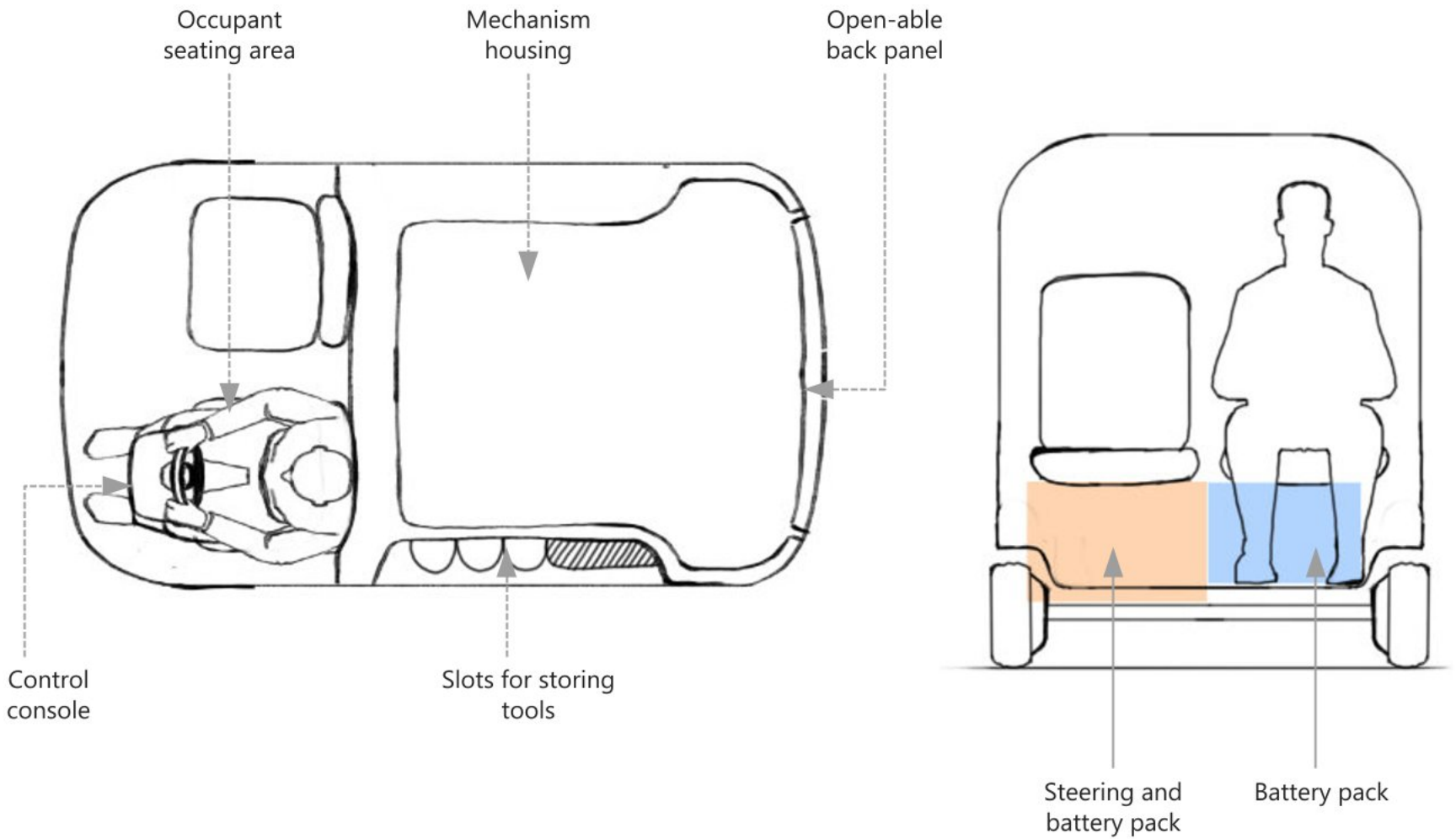


Pop-out hopper for trash removal: Manually pulled

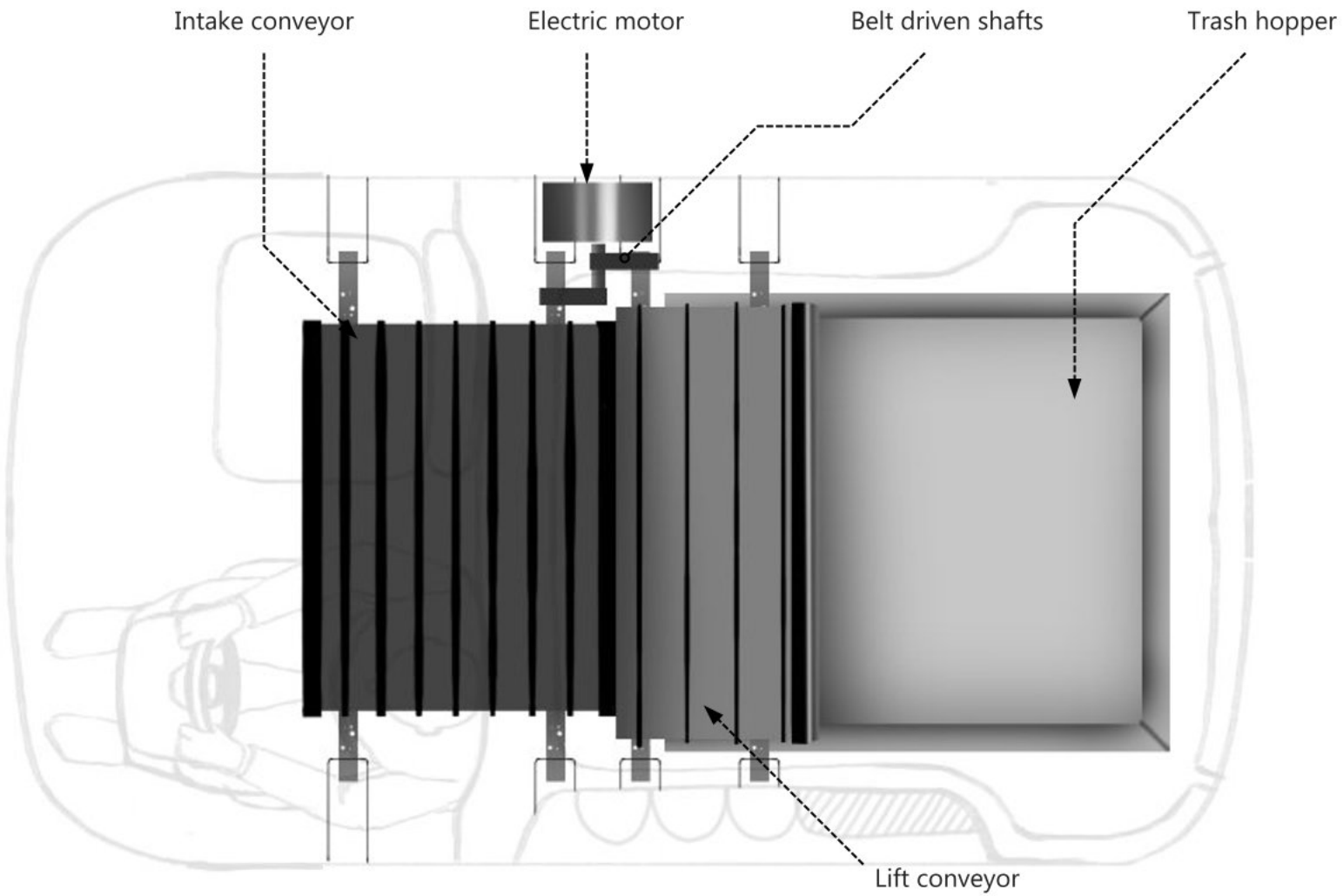


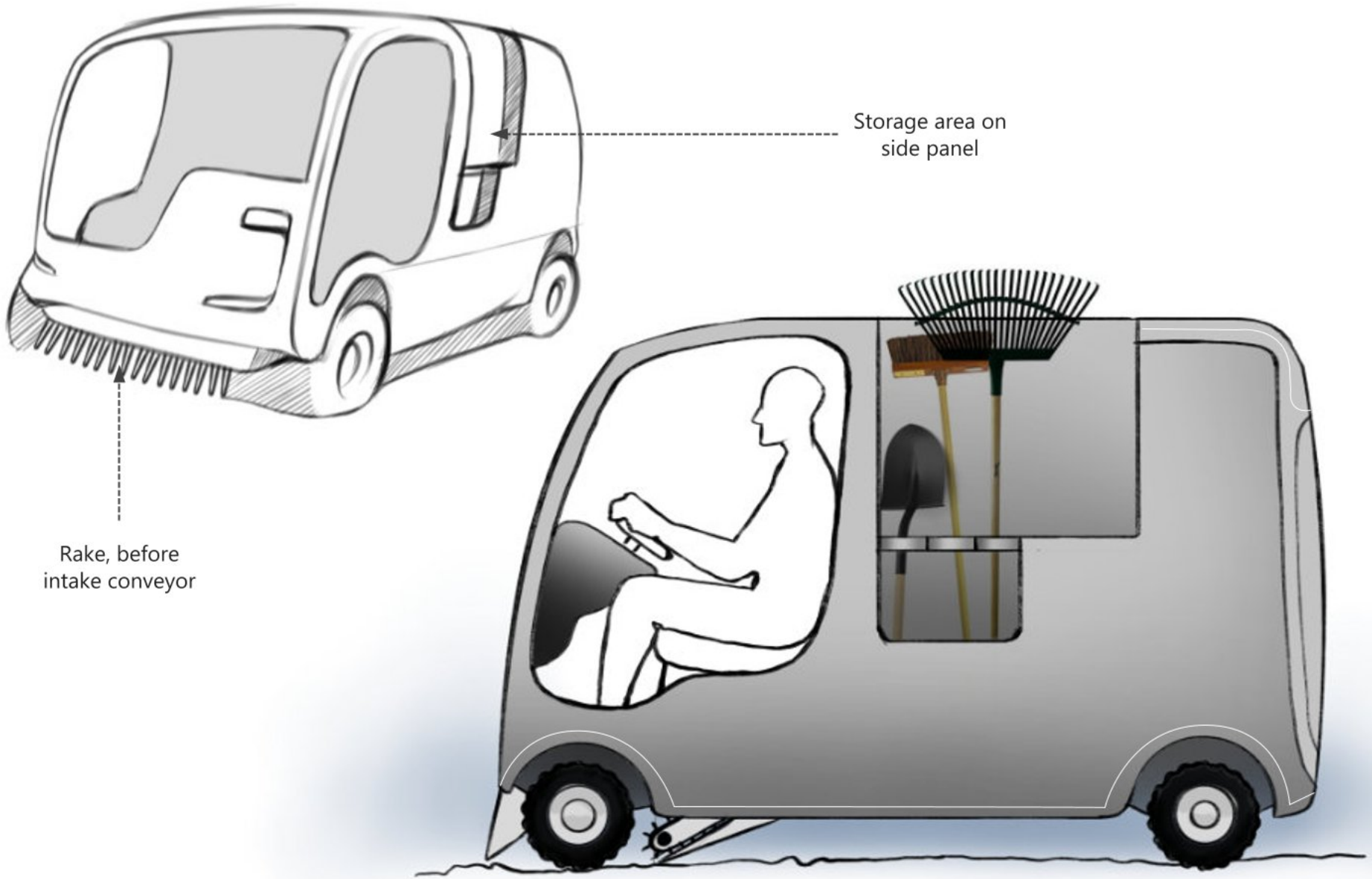


- Components and rough packaging

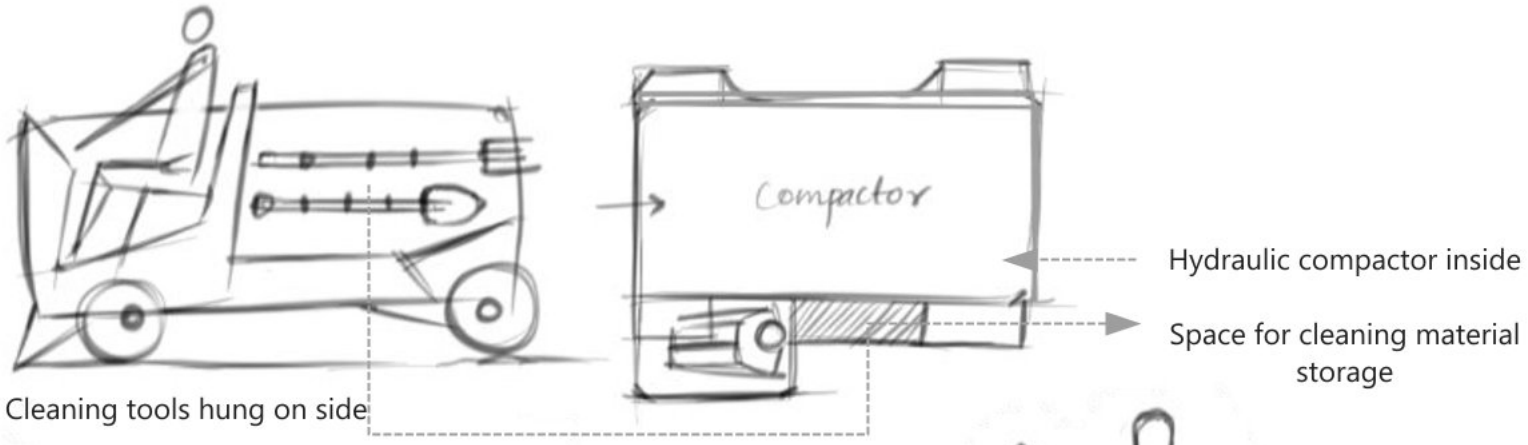


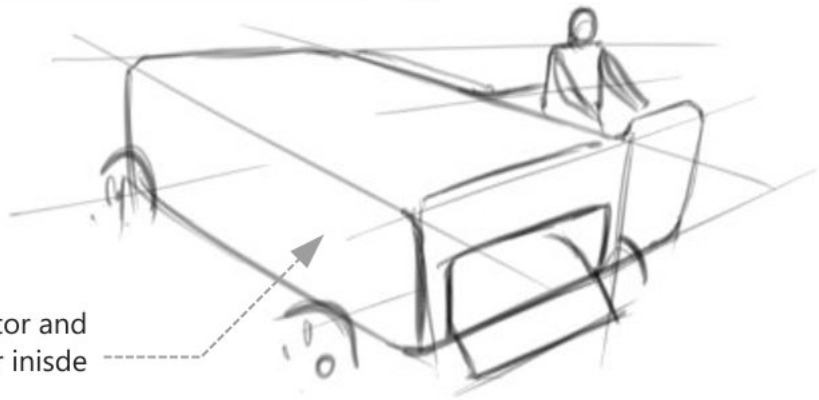
- Components and rough packaging



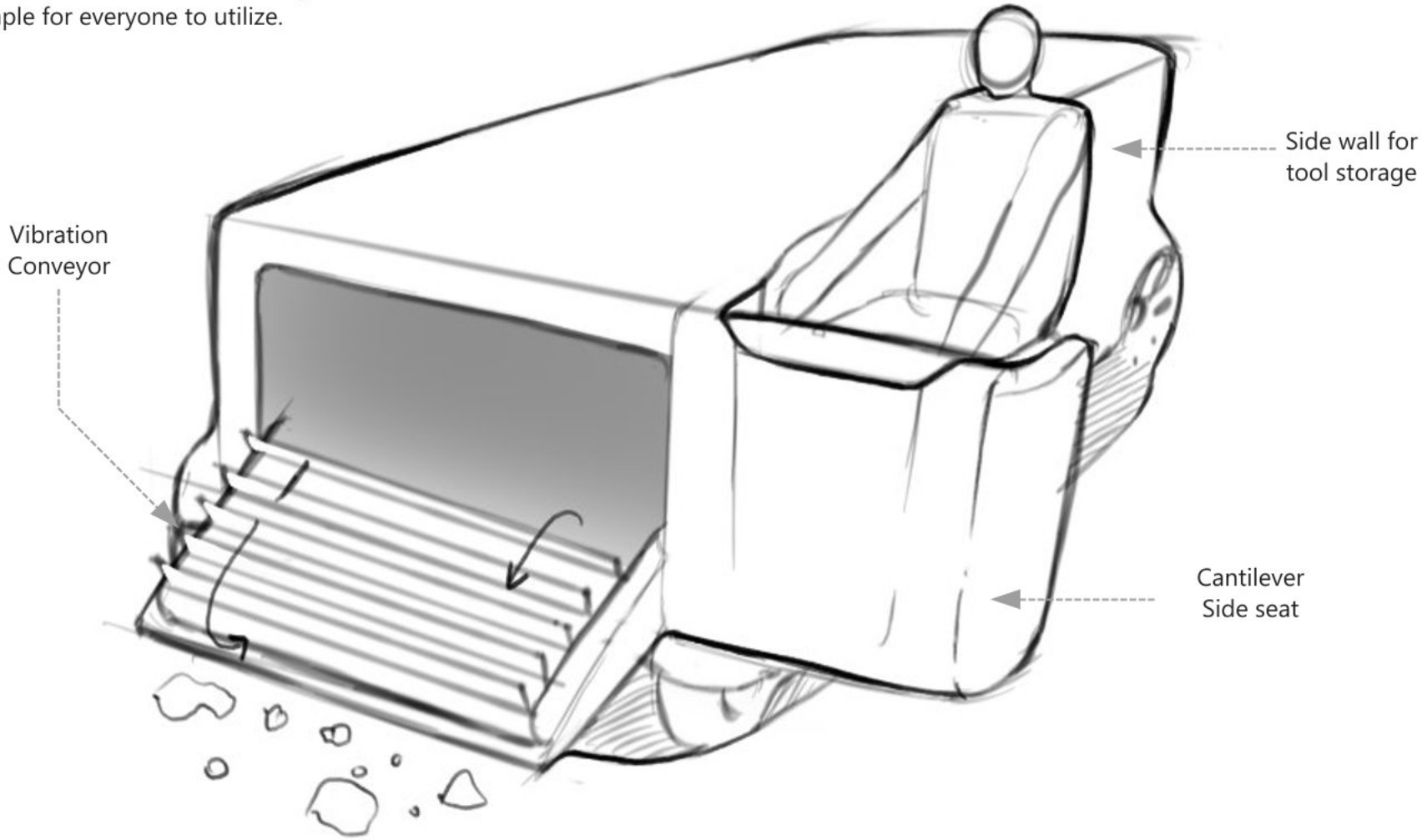

Storage area on
side panel
Rake, before
intake conveyor

Allowing man-machine synergy to contribute in the solution, adding more emphasis to manual assistance: raking and dragging of waste in standing posture and avoiding bending down and lifting heavy weight and storing the waste somewhere.

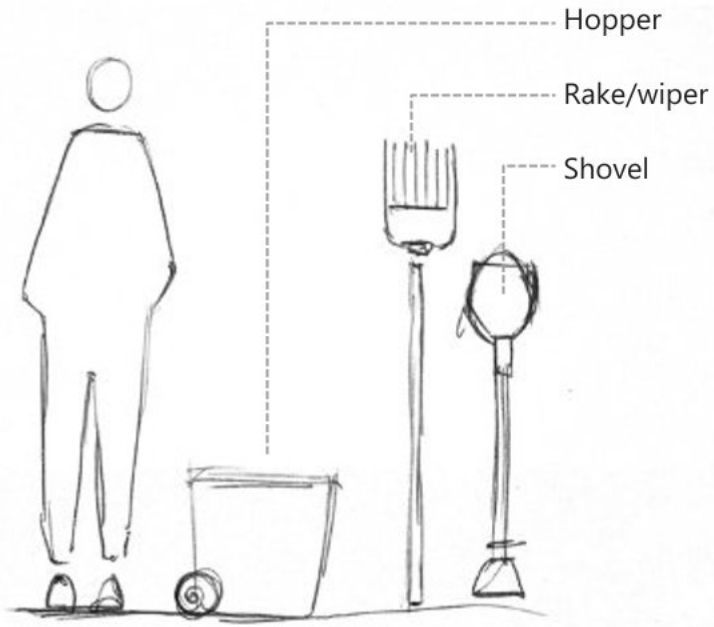




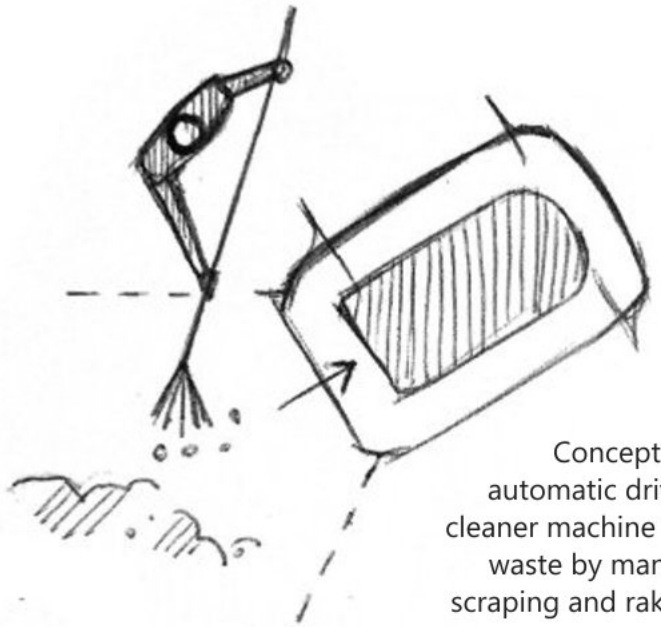
The usage of heavy machinery is not beneficial for universal scenario. The complexity and capability to operate such machines is not present with everyone. If we need constant cleaning of beaches we need to make the design simple for everyone to utilize.



Human Involvement Based

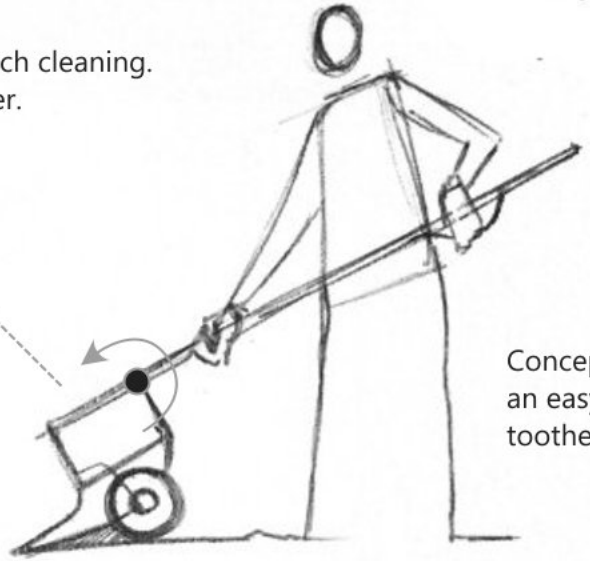


Basic requirements for beach cleaning.
Tools and storage container.

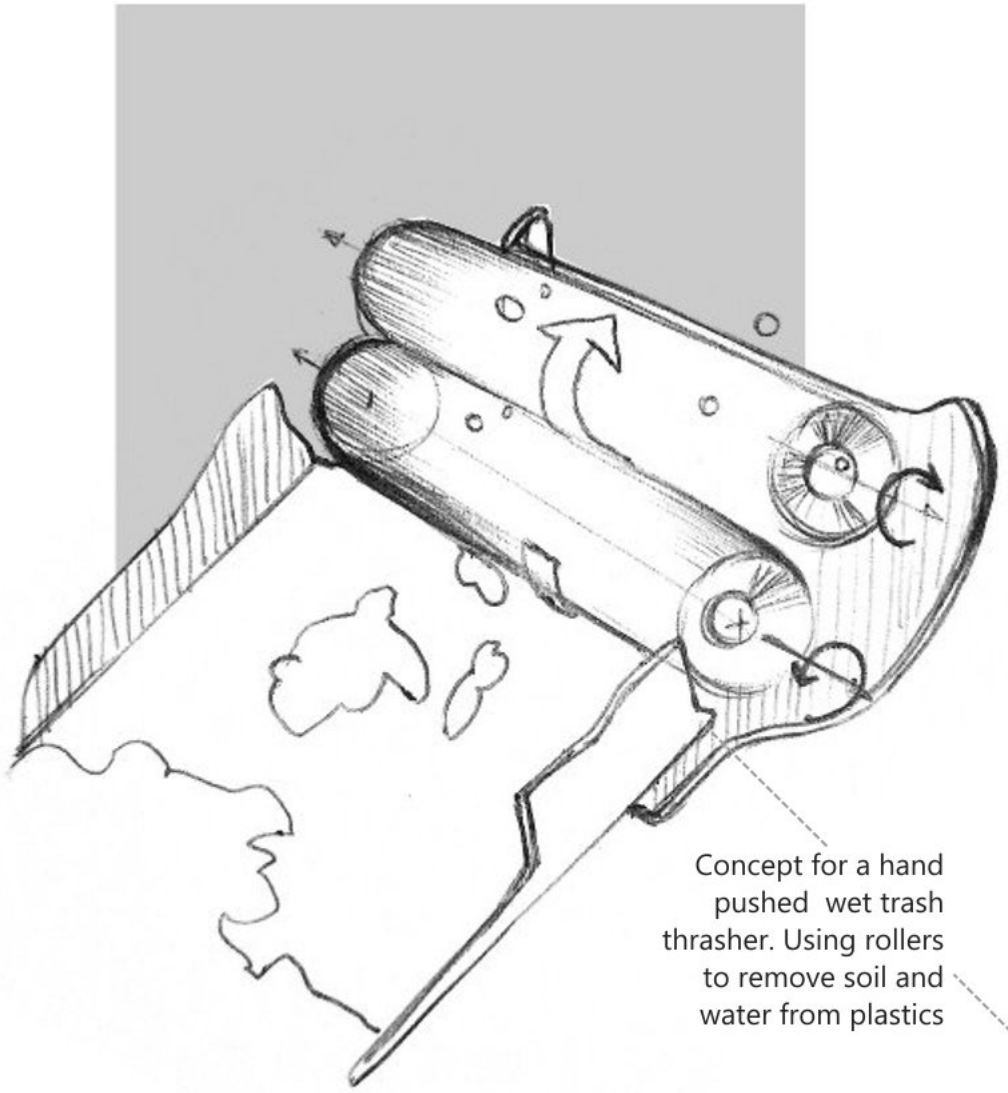


Concept for automatic driven cleaner machine fed waste by manual scraping and raking

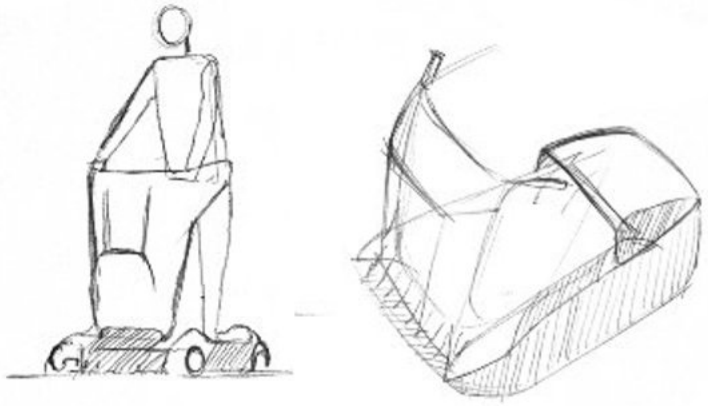
Handle can be rotated to pull and clean from the other side



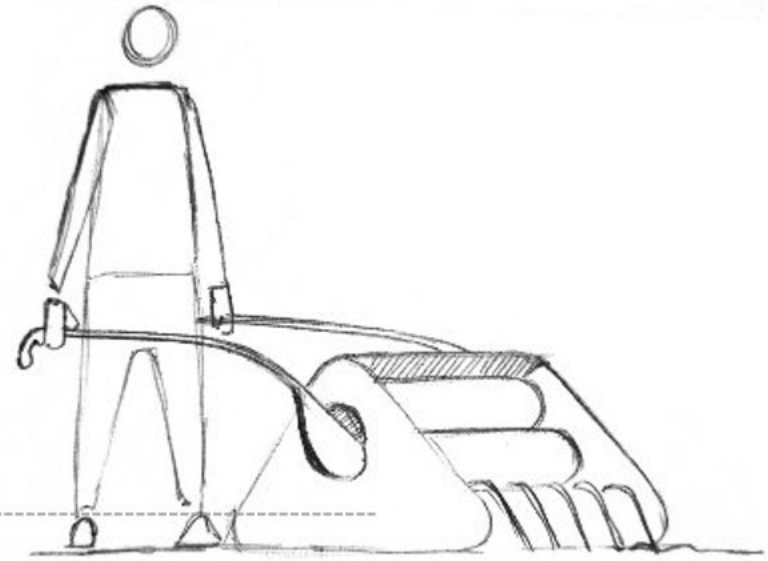
Concept for making an easy to move toothed hopper

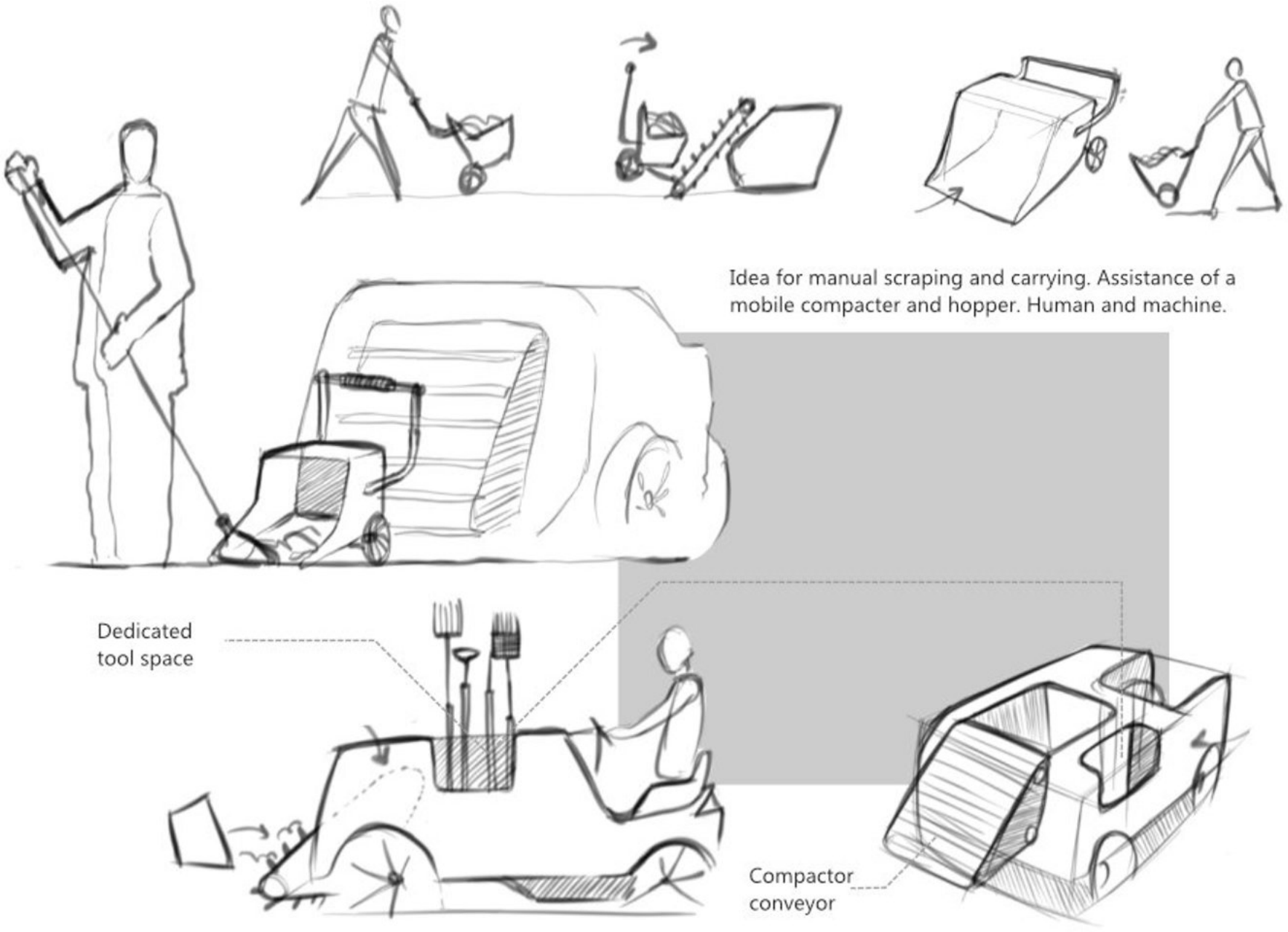


Concept for a hand pushed wet trash thrasher. Using rollers to remove soil and water from plastics

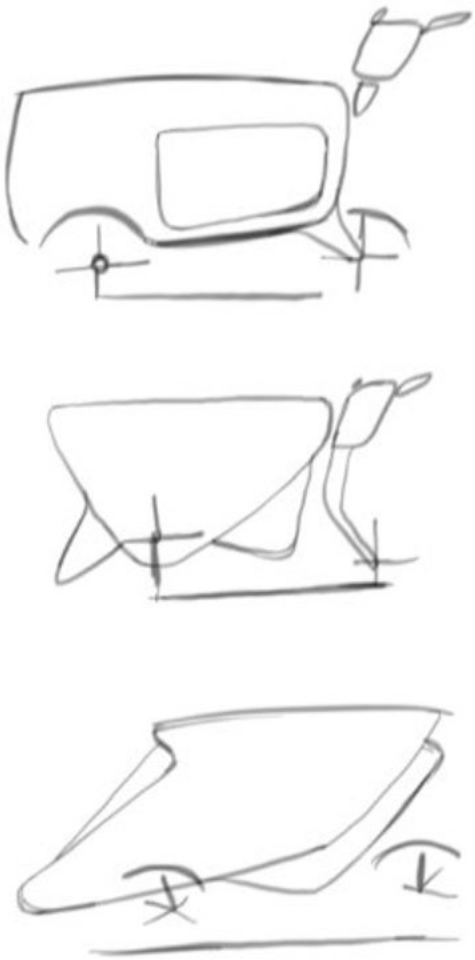


Idea for a stan-over mini cleaner that user body weight pressure and forward motion for turning the mechanism



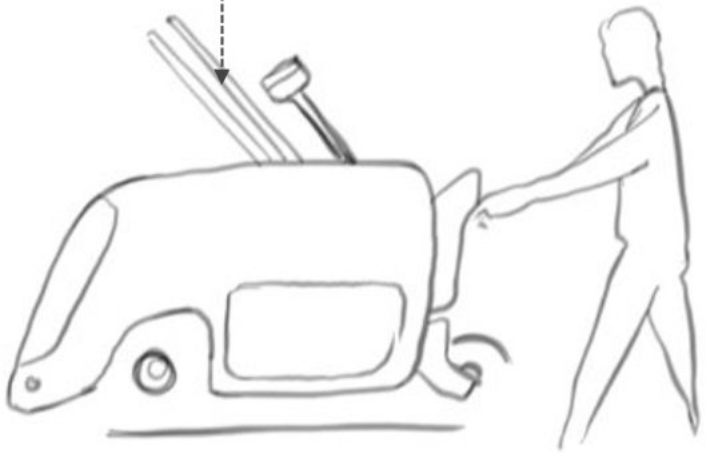

Idea for manual scraping and carrying. Assistance of a mobile compacter and hopper. Human and machine.
Dedicated tool space
Compactor conveyor

Exploratory doodles for walk-behind



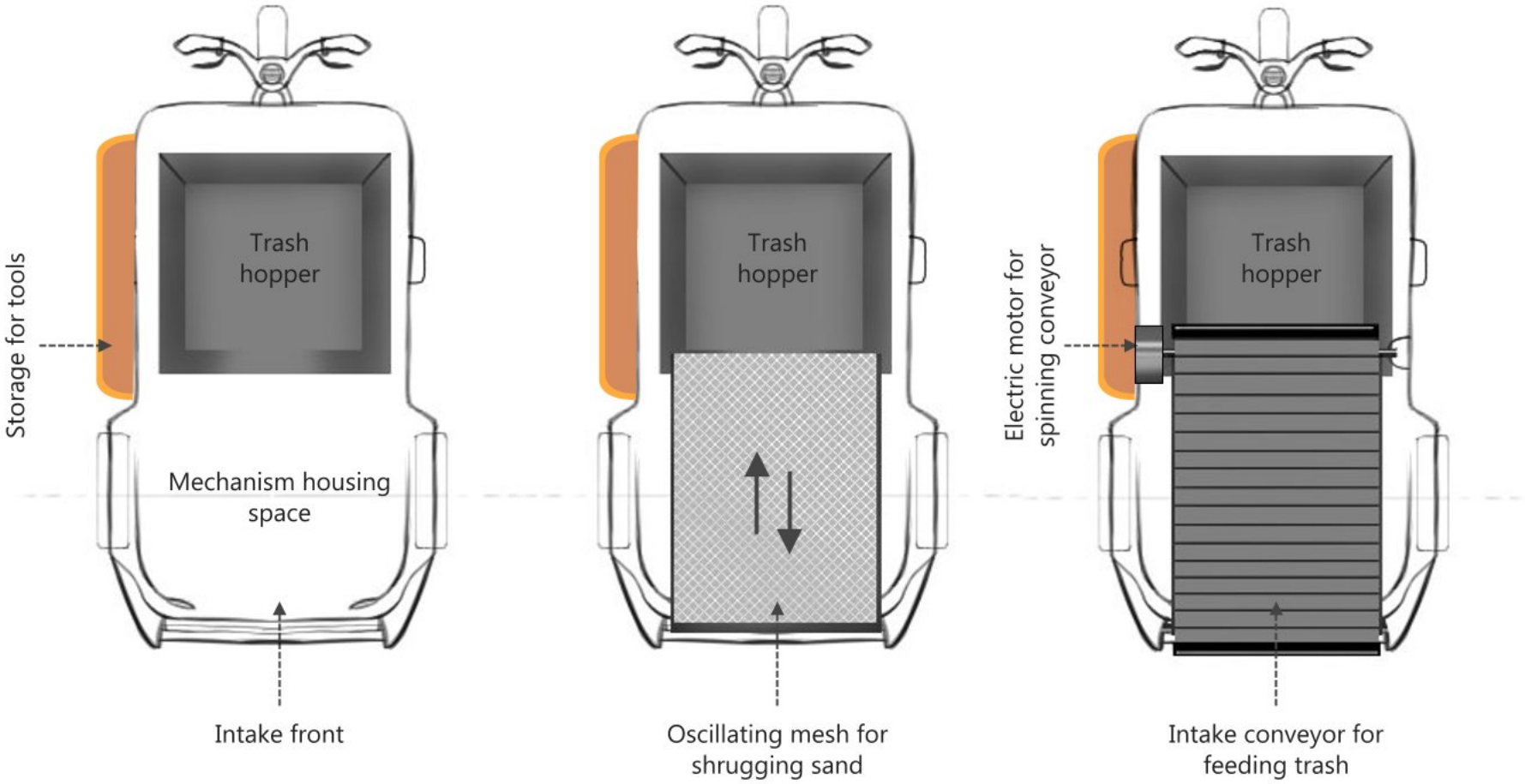
In this concept, exploring possibility of a 3 wheeler, walk behind human-powered trash collector and compactor. This will reduce the complexity of packaging engine/motors for drive. If required, a hub motor can be installed in the rear wheel for assistance.

Concept of removable trash collector from side to dispose quickly

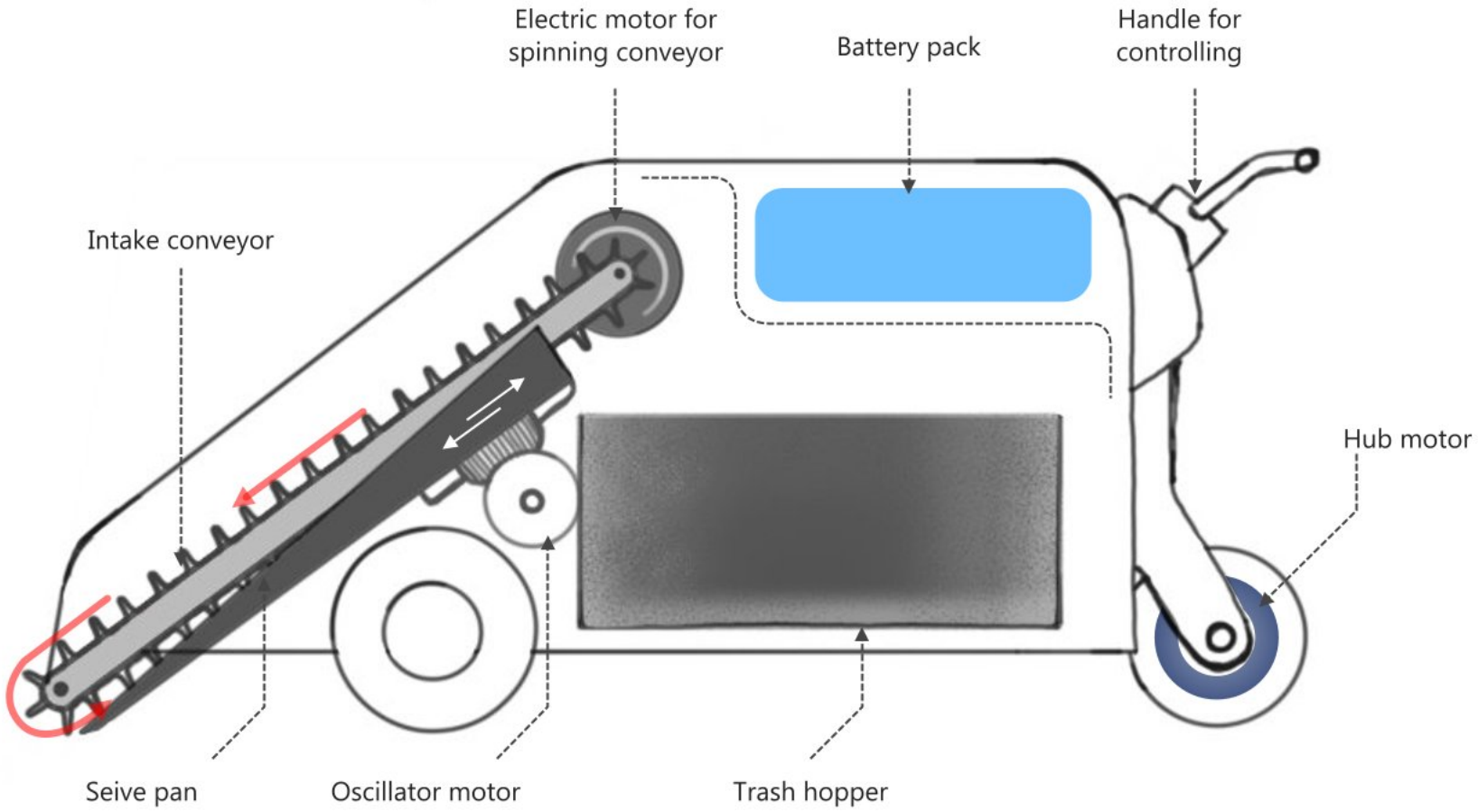


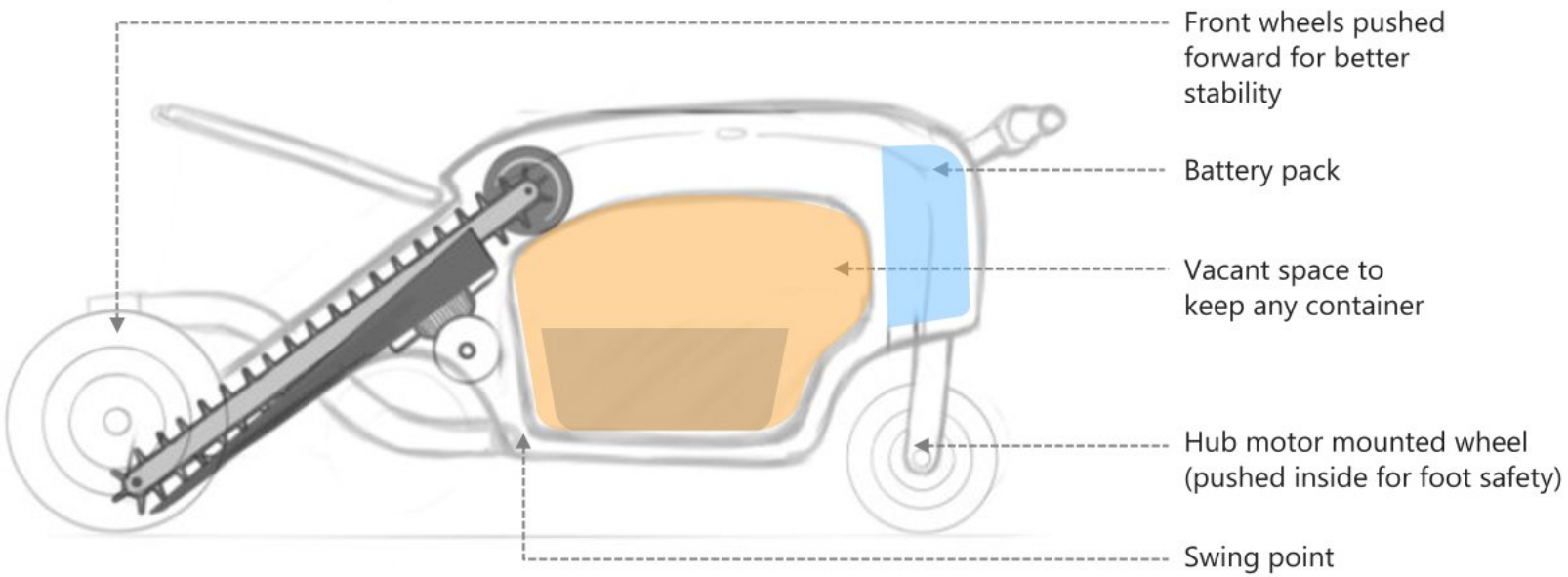
Space to keep cleaning tools for quickly scraping and feeding into the machine.

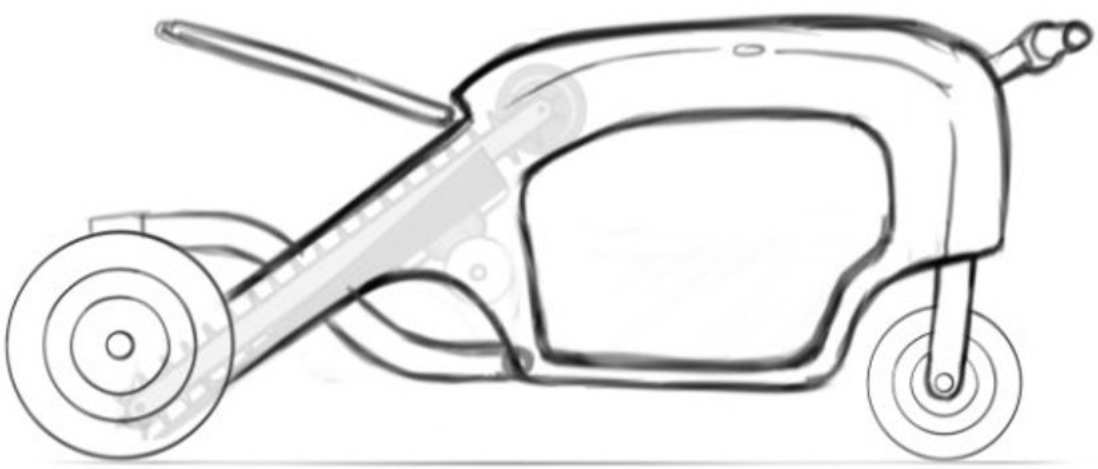
- Components and rough packaging (Top View)

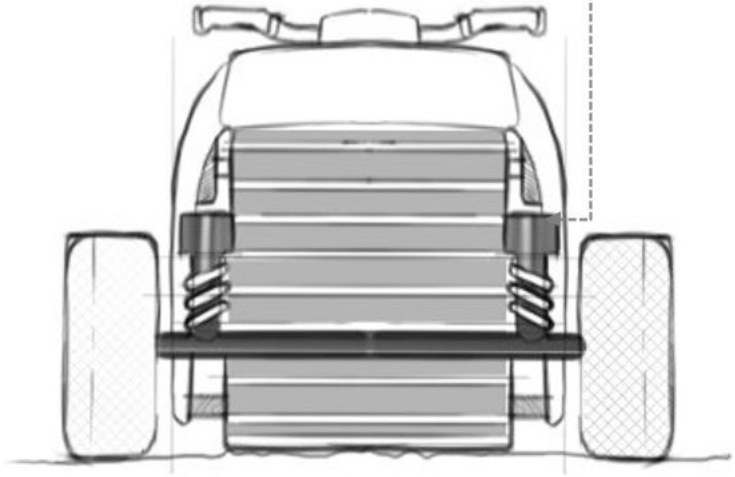


- Components and mechanism (Side View)

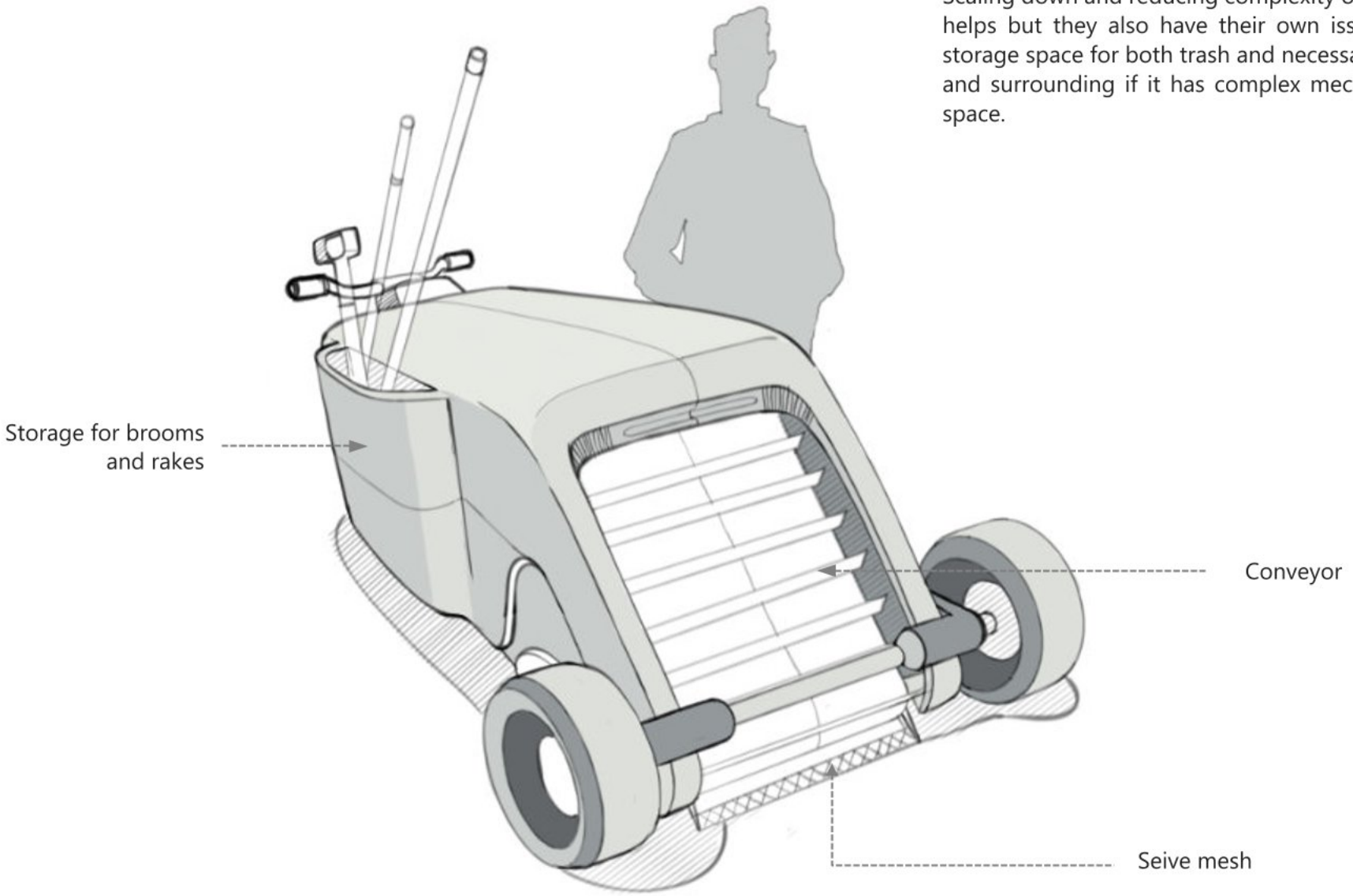


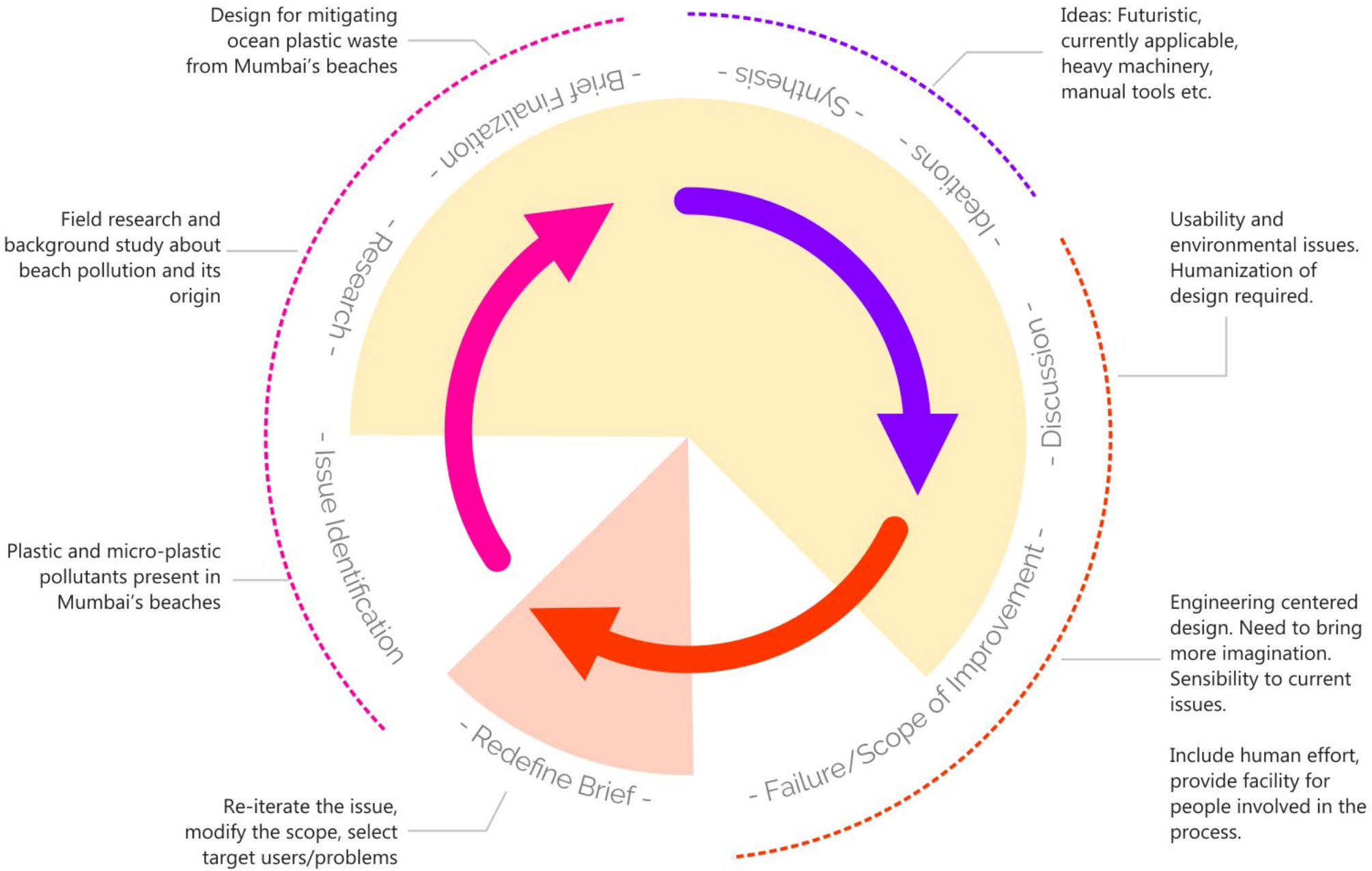

Front wheels pushed forward for better stability
Battery pack
Vacant space to keep any container
Hub motor mounted wheel (pushed inside for foot safety)
Swing point




Suspension

Scaling down and reducing complexity of tools and technologies helps but they also have their own issues: like compromising storage space for both trash and necessary items, safety of users and surrounding if it has complex mechanism packed in small space.




Design for mitigating ocean plastic waste from Mumbai's beaches
- Brief Finalization -
Field research and background study about beach pollution and its origin
- Research -
Plastic and micro-plastic pollutants present in Mumbai's beaches
- Issue Identification
Re-iterate the issue, modify the scope, select target users/problems
- Redefine Brief -
- Failure/Scope of Improvement -
Engineering centered design. Need to bring more imagination. Sensibility to current issues.
Include human effort, provide facility for people involved in the process.
- Discussion -
Usability and environmental issues. Humanization of design required.
- Ideations -
- Synthesis -
Ideas: Futuristic, currently applicable, heavy machinery, manual tools etc.

4.5 System Evaluation

Parameters	Mechanical systems	Manual Cleaning	Combined Effort
Versatility	Can pick up maximum amount of trash in shortest interval of time. Difficult in differentiating what to pick. Some waste material/ particles will be left behind.	Can pick nearly all kinds of waste in a larger interval of time. Micro plastics, however needs cleaning tools to segregate.	We can use the versatility of manual detection and ability to pick maximum amount of waste of different morphology.
Ease of operation	Often requires training and expertise in operating the machines.	Can be performed by any individual with no experience.	Can enhance the performance by using very easy to use machines.
Usability	Long operation hours, vibration causing body pain and locked posture.	Issues like painful posture, carrying, contamination, dehydration etc occurs.	Using manual tools, carrying necessary items for cleaning and safety.
User friendliness	Machines are often overwhelming and huge and they appear unsafe to be around.	Safest way to clean the beaches without disturbing/overwhelming the visitors.	Using a very simple machine/tool which facilitates a lot of options for cleaning, storage, transportation etc.
Maneuverability	Larger the size of the machines, lesser the maneuverability. Also requires a lot of situational awareness for safety of beach dwellers.	The most organic and flexible way to pick waste. People have maximum situational awareness and attention.	Can be of human scale and smaller footprint and lightweight for easy navigation on sand.
Environmental Impact	Can cause noise and emission of harmful gases if powered by fossil fuel. Disturbs the topology/ biodiversity of the beach.	It is quiet, peaceful and has no ill impacts on the beach surface. Minimum amount of digging and raking. Easiest way of segregation.	Removal of drive (making the system human powered) can reduce pollution. Cleaning by humans can ensure the beach surface is least impacted.
Cost of Operation	Usually very high and hence they are not mass deployed. Complexity in operation adds to this factor.	Lowest operation cost. Only requires safety gloves, sanitizers and some manual tools if required.	Can run on a low cost, investing mostly on the charging and cleaning mechanism.

4.6 System Selection

Sustainability of Heavy Machinery (Mechanical Systems)

Although everything can be achieved through technology and brute force of heavy machines, in terms of sustainability, we must address an integral approach that encompasses suitable measures that reflect economic, environment and social aspects (Singh et al., 2009). Prescott (1995) established a mechanism for integrating environmental and social elements of sustainable development. In this mechanism, he has emphasized that inclusion of ecosystem and human well-being is evenly required for achieving sustainable development.

The socioeconomic criteria for selection of an equipment can be governed by the following factors:

- Ownership cost
- Operational cost
- Availability of local skilled operator
- Operator health
- Operator view and comfort
- Safety features
- Operator proficiency
- Training needs for operator
- Relationship with dealer/supplier

There are numerous engineering criteria as well, which are difficult to manage while introducing a machinery for a specific function:

- Equipment age
- Equipment capacity
- Equipment reliability
- Equipment efficiency
- Equipment operating life
- Equipment productivity
- Fuel efficiency
- Implement system
- Traction system
- Structure and suspension system
- Power train system
- Control and information system
- Compliance with site operating conditions
- Meet job/operational requirements
- Meet haul road condition
- Versatility of equipment
- Easy repair and maintenance
- Machine/equipment standardization
- Spare parts availability

Finally the environmental aspects of selection can be:

- Greenhouse gas emissions
- Fossil fuel consumption
- Energy saving
- Noise control
- Vibration control
- Quantity of particulate
- Oil/lube leakage control
- Use of sustainable fuels
- Use of biodegradable lubricants and hydraulic oil
- Environmental statutory compliance

System Selection

It is evident that developing and instating a machine is a very complex and costly process and it may not be friendly to the socioeconomic conditions of a place to begin with. In Mumbai the sole stakeholder in the beach cleaning operation is the Municipal Corporation. However they have in various places given the contract to private engineering and technology groups such as **Spectron Engineers** (documented in research)**,** that procures machines from western countries.

The imported machines lacks on a variety of points mentioned in the socioeconomic, environmental and engineering criteria; found in the user research and observation. This is due to the complexity in the interaction of machinery and the actual ground condition that would take a very adaptable piece of technology, which can be very powerful, efficient and very costly if developed. As of now the Tractor-towed beach cleaners cost USD 10000 alone and they already lack the versitilty to work in extremely challenging waste clogged beaches like Versova and Juhu (documented in research).

Considering the current situation and socioeconomic context of India, manual intervention in beach cleaning is unavoidable. However a small step or addition in the facility available for manual cleaners and volunteers can go long way and can be developed into something powerful and cost efficient in the future. A time may come when a business model will be created around plastic economy and other engineering giants will invest into Research and Development of powerful, sophisticated and cheap machinery to curb this problem.

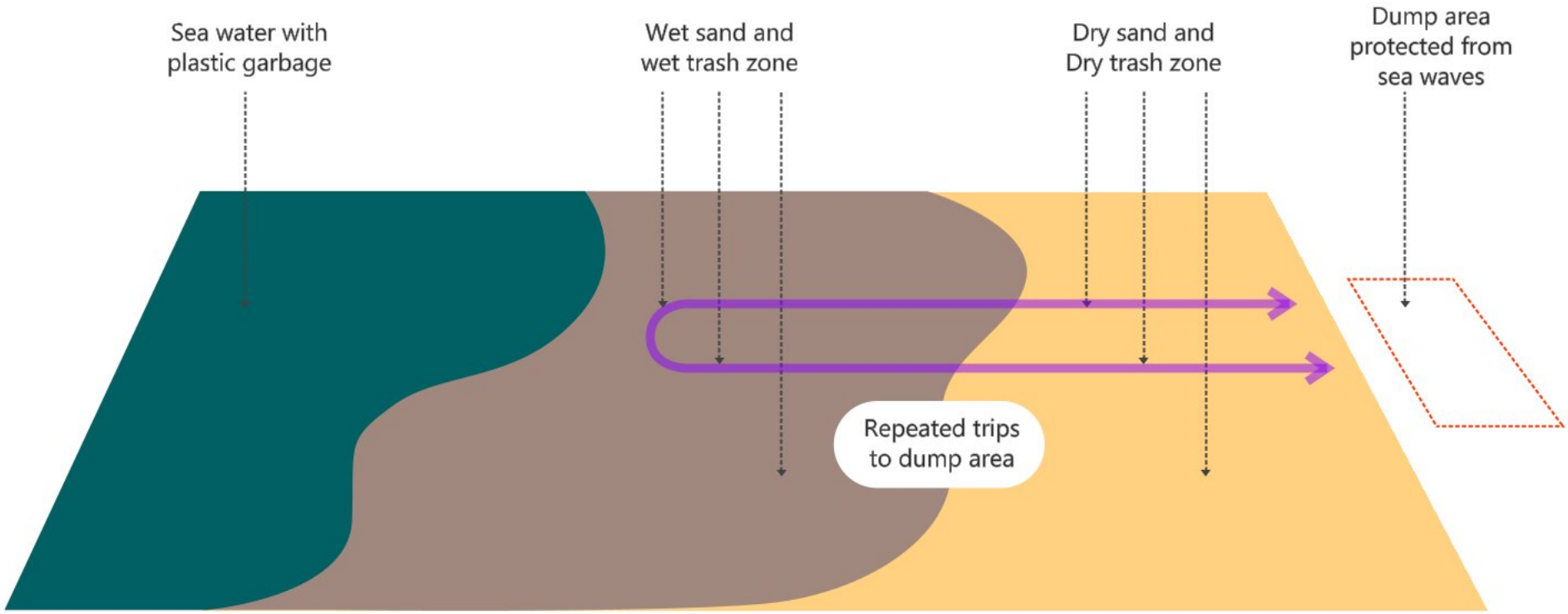
Image 49: Versova: Oct 2, 2019. Mechanical diggers can turn the soil and reveal the buried sand bags but they cannot efficiently seperate and pick them. A beach cleaning machine has to be extrememly powerful and technically sophisticated to adapt to this scenario.

DESIGN DEVELOPMENT

5.1 Focus Area

According to the study and explorations and discussions based on same, the final solution is focused on combined effort of human and machine. The focus is on delivering better user experience to the users that work on ground and does not have advanced machinery.

Intervening in this area is more appropriate as a mass of people are aware about this issue and are motivated to act in the present moment. Designing a solution for them can increase their productivity and satisfaction and participation of people.



5.2 Designing a system

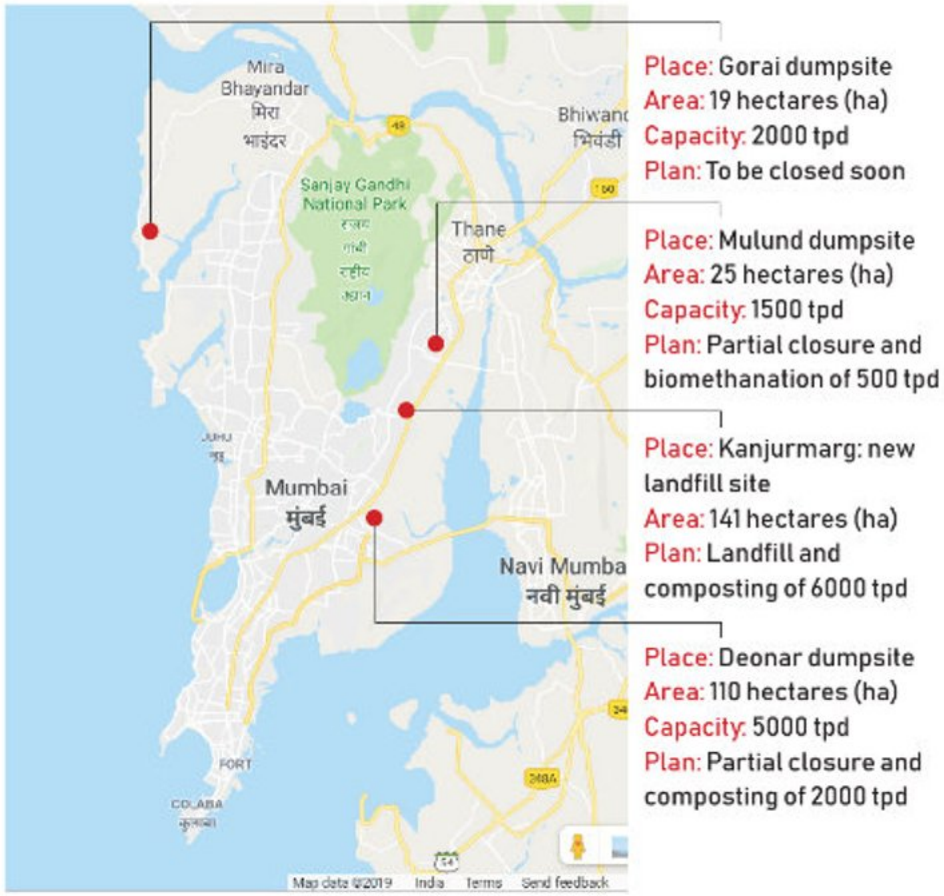
Plastic removal alone does not solve the whole issue. The following challenges need to be met in the whole process that is involved:

- Collection of beach trash
- Storage and protection of beach trash
- Transportation of the trash to a larger hub
- Transportation from hub to segregation centers/ recycling centers or landfills.

Currently processing and segregation systems are not deployed on the beach itself. All the sand infested waste is carried to various landfill sites all over Mumbai. These wastes are not washed and compacted. Due to which, the transportation becomes inefficient. As previously discussed the dumpsites closest to the sea-face on the west coast of Mumbai have exhausted their capacity to contain any more waste. The larger landfills are located in the heart of the city. There are no dumpsites in the South Mumbai area.

To improve the transportation a network of simple mechanisms can be implemented:

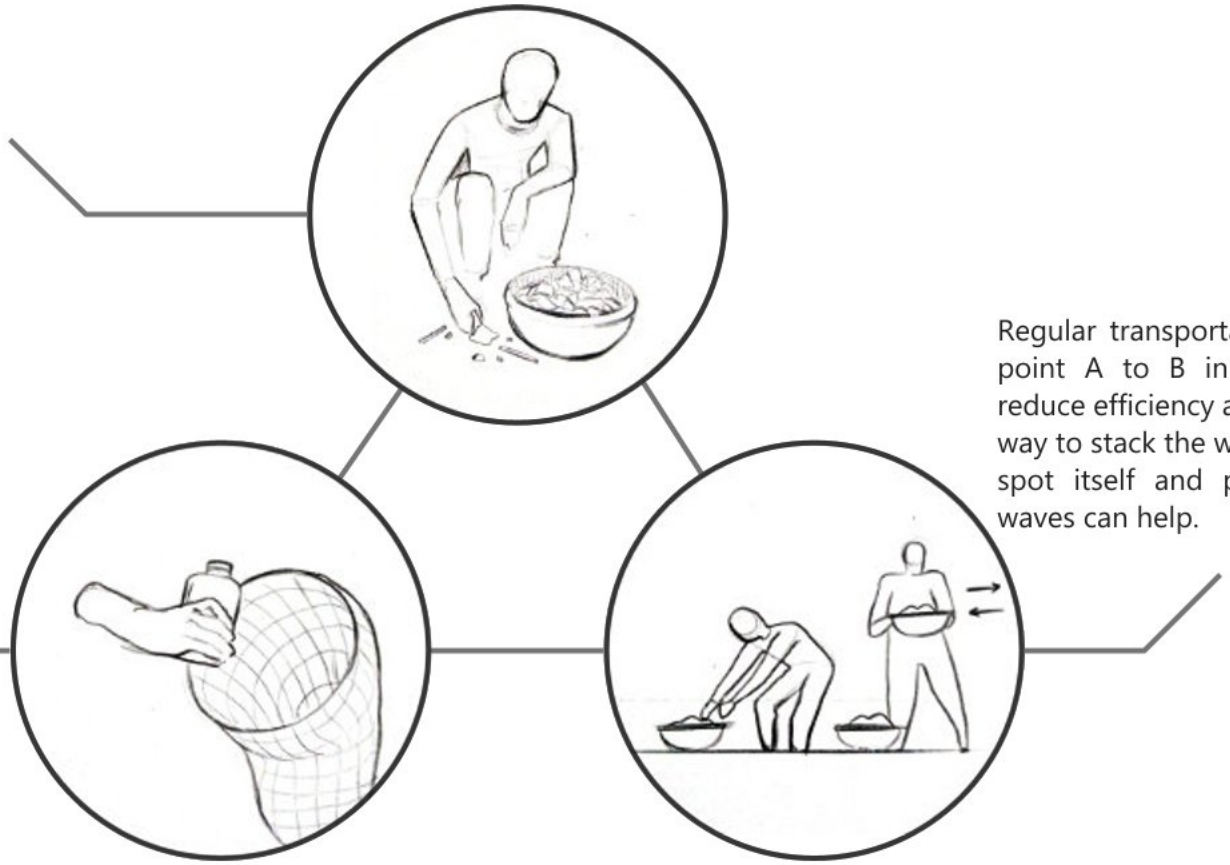
- On site waste collection; easy and efficient from user's point of view.
- Protected storage and easy transportation to a trash hub.
- Mechanism to wash and segregate plastics using some mechanism.
- Drying and transportation to landfills/recycle centers.



5.3 System framework

5.4 Final Ideas

Designing a way such that leaning or sitting is not required, will reduce the discomfort from the posture related issues



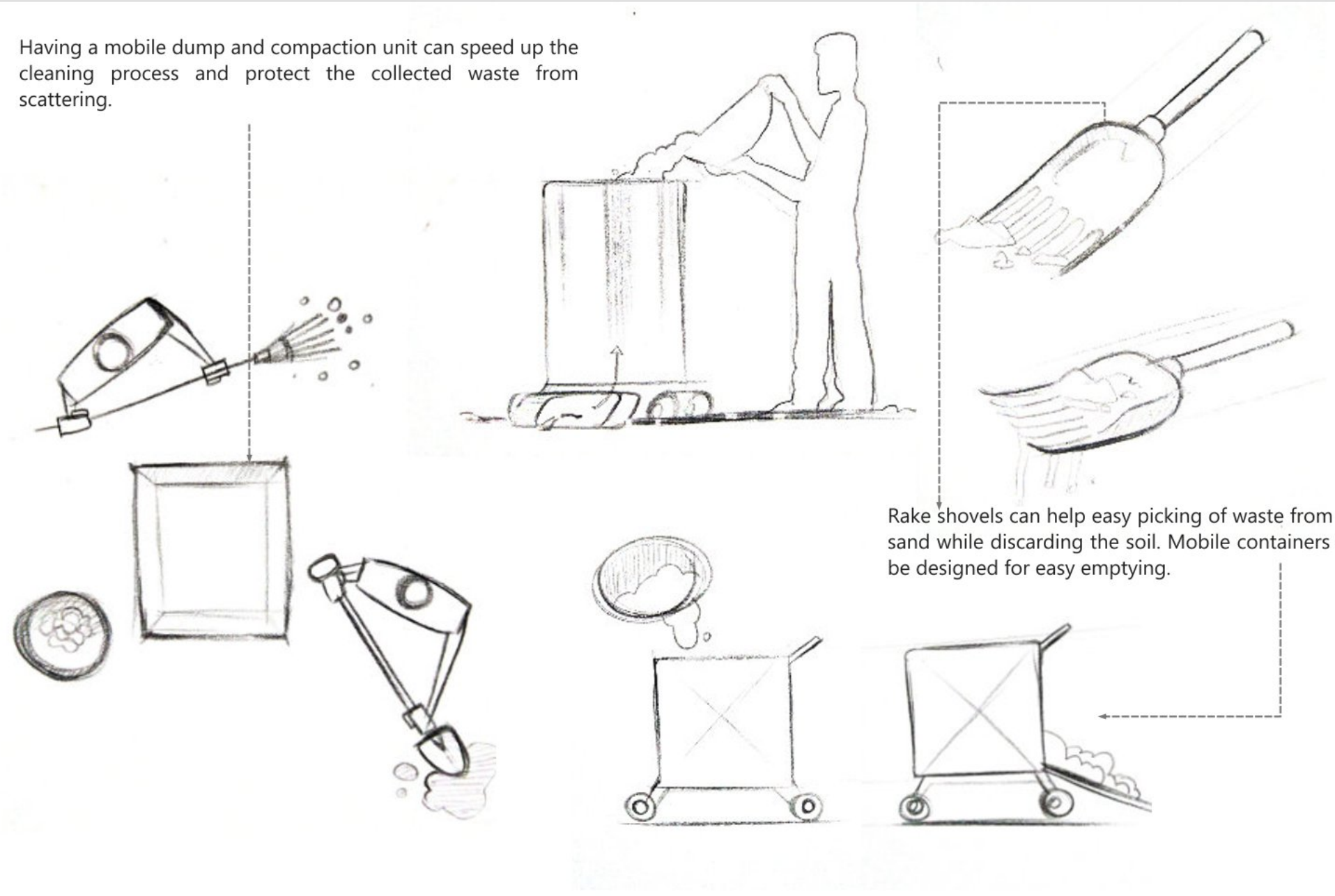
Regular transportation of waste from point A to B in small potions can reduce efficiency and increase effort. A way to stack the waste on the cleaning spot itself and protect it from the waves can help.

Much of the loose trash can be picked up by simple tools like rake shovels/ trash pickers instead of doing it by hand. Designing a way to keep the tools around shall help

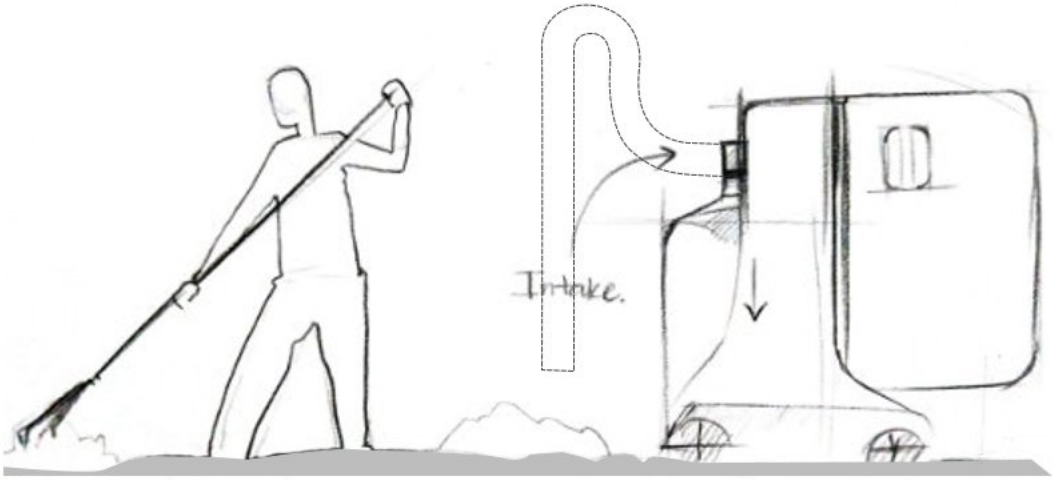
Currently the volunteers need to manually sit down/lean/bend to pick up waste from the beach precisely. From micro level waste to big chunks they have to pick it by hand and store them into baskets. They make multiple trips carrying the heavy basket to drop the trash at the dump spot.

Complicated mechanical and moving parts can get expensive and difficult to operate. The same power can be utilized in vacuum to obtain better results. The users also need some on-ground facilities like drinking water, disinfectant, first-aid, which they aren't able to carry.

Having a mobile dump and compaction unit can speed up the cleaning process and protect the collected waste from scattering.



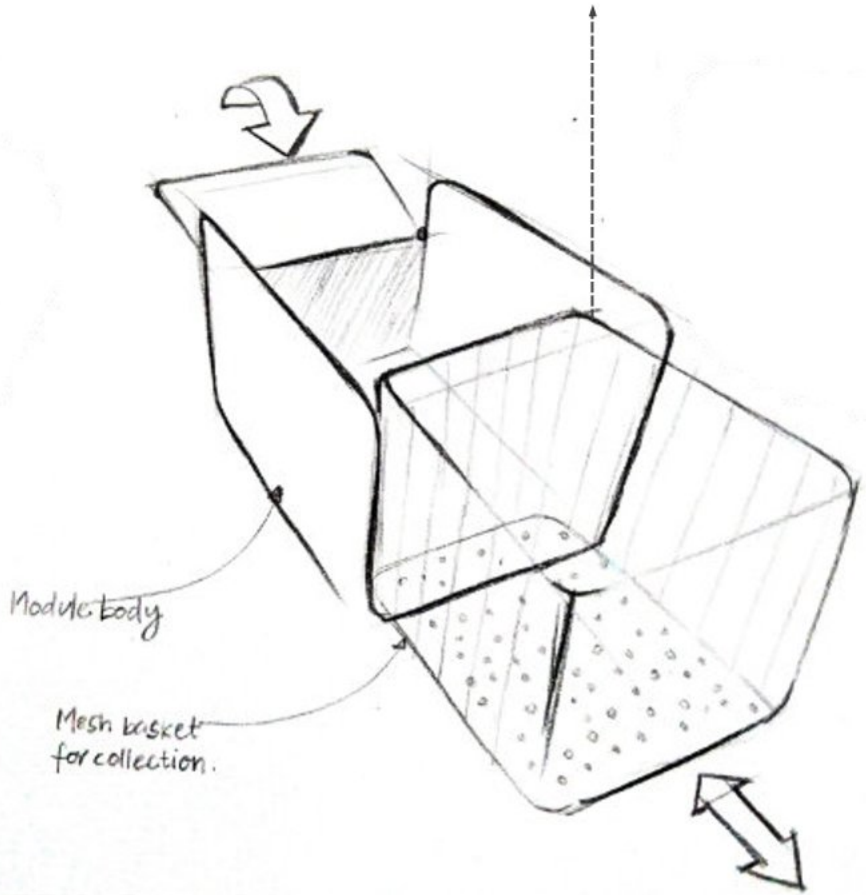
Rake shovels can help easy picking of waste from the sand while discarding the soil. Mobile containers can be designed for easy emptying.

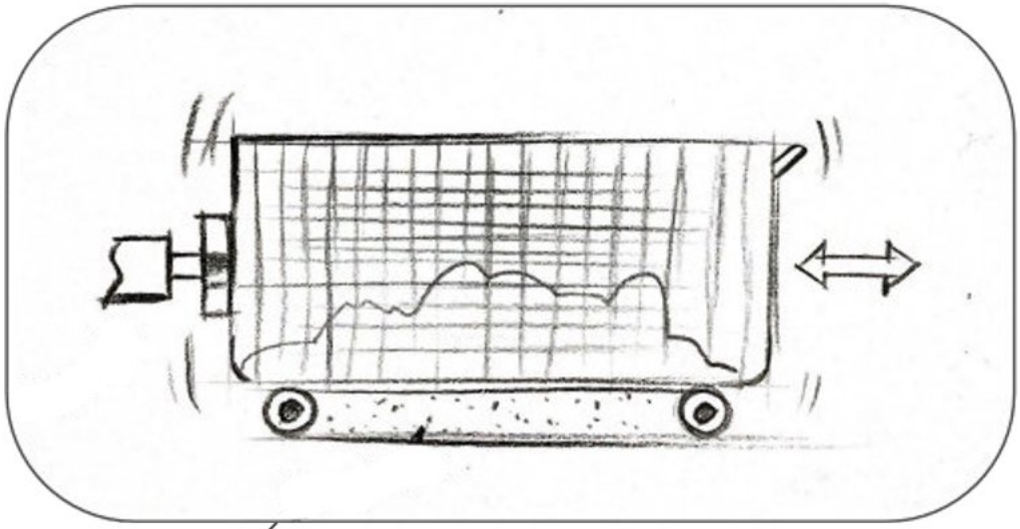


Vacuum based intake system for least interaction of mechanism and waste

Pulling out the waste collector from the cart

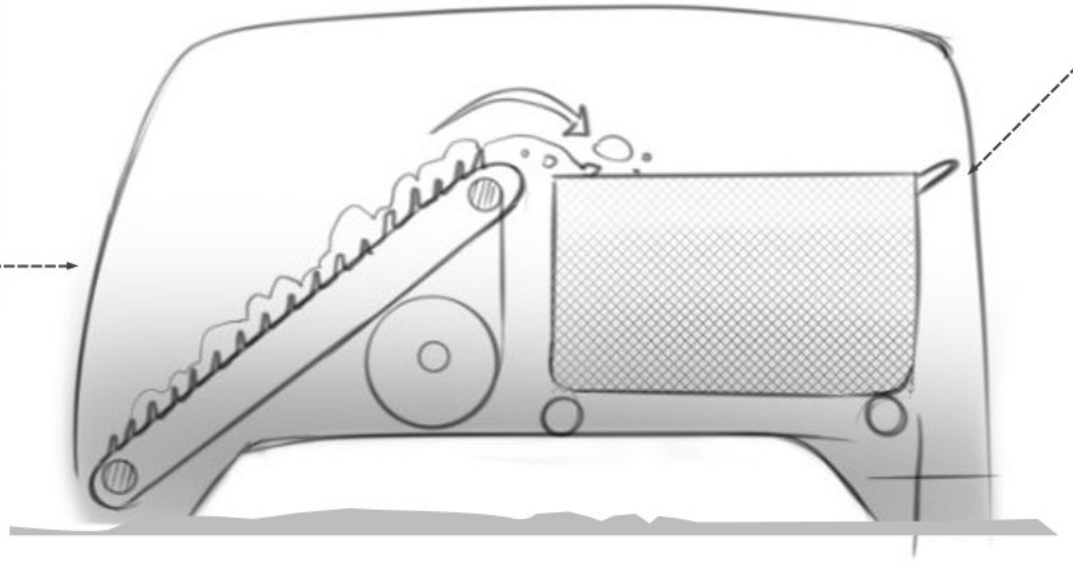
A mesh basket inside the main body can collect all the waste while discarding the sand using vibration mechanism.



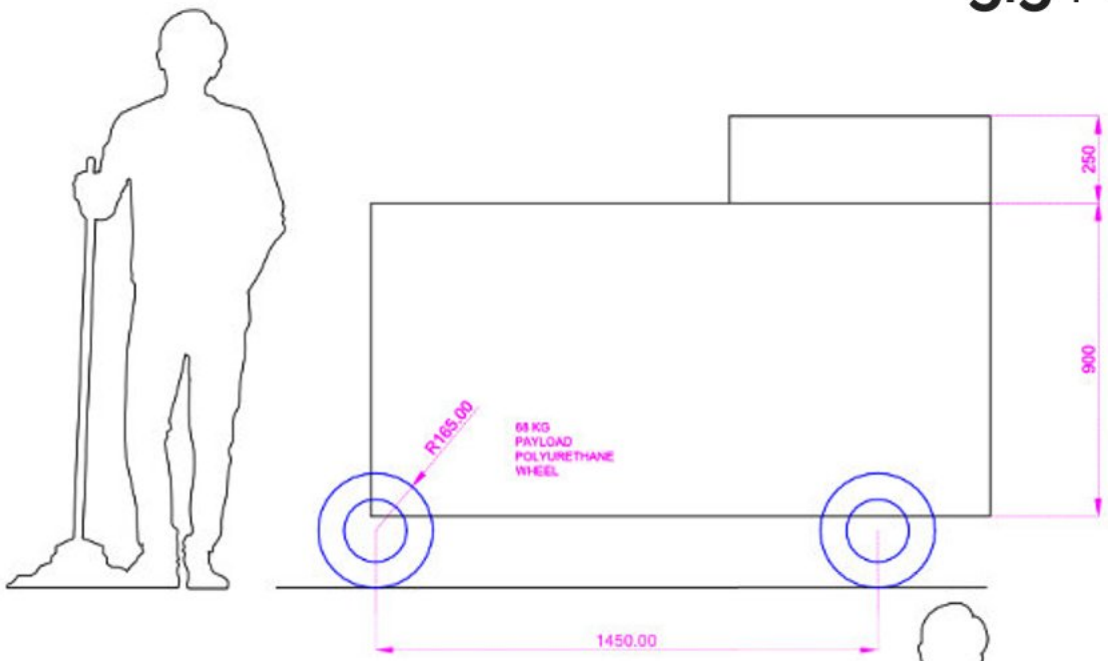


A waste picker with mesh basket and conveyor. Powered by electric motor and human pulled.

Vibration mechanism used to shake off the sand from the waste collected. Inside the body which can be removed later.

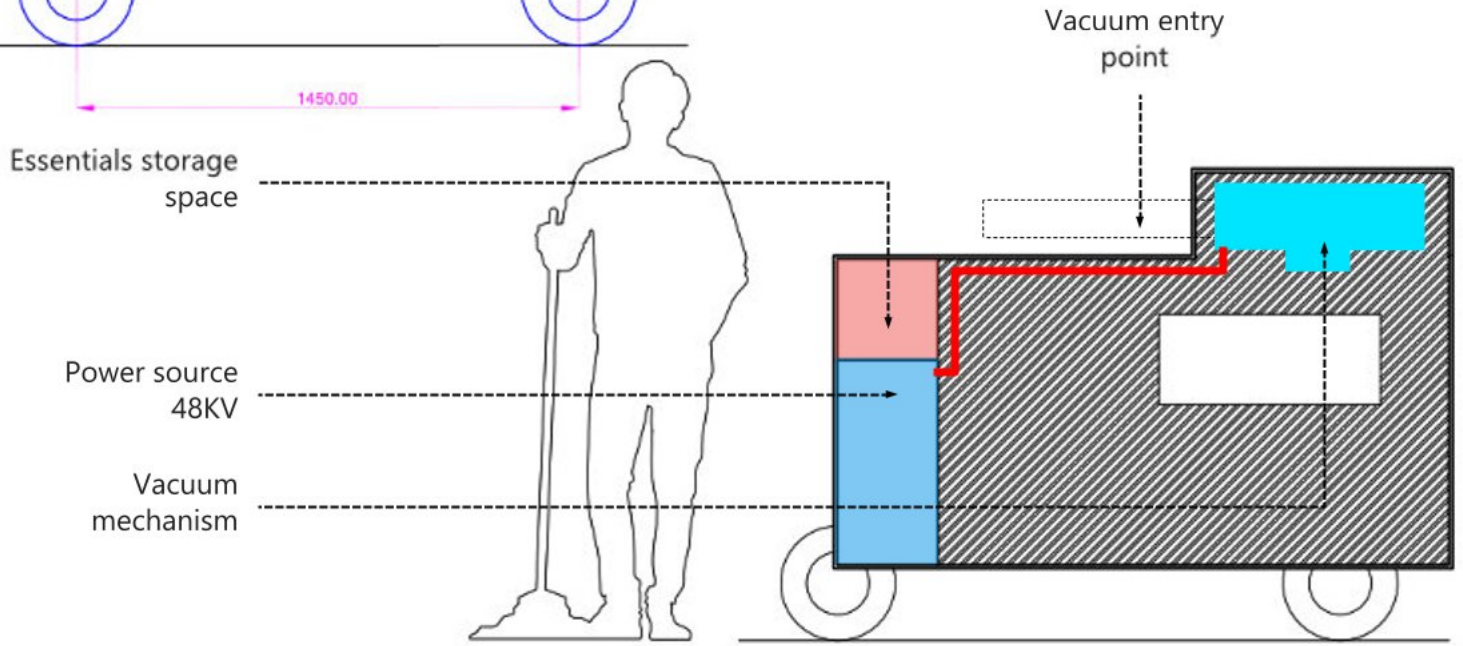


5.5 Packaging and dimensions

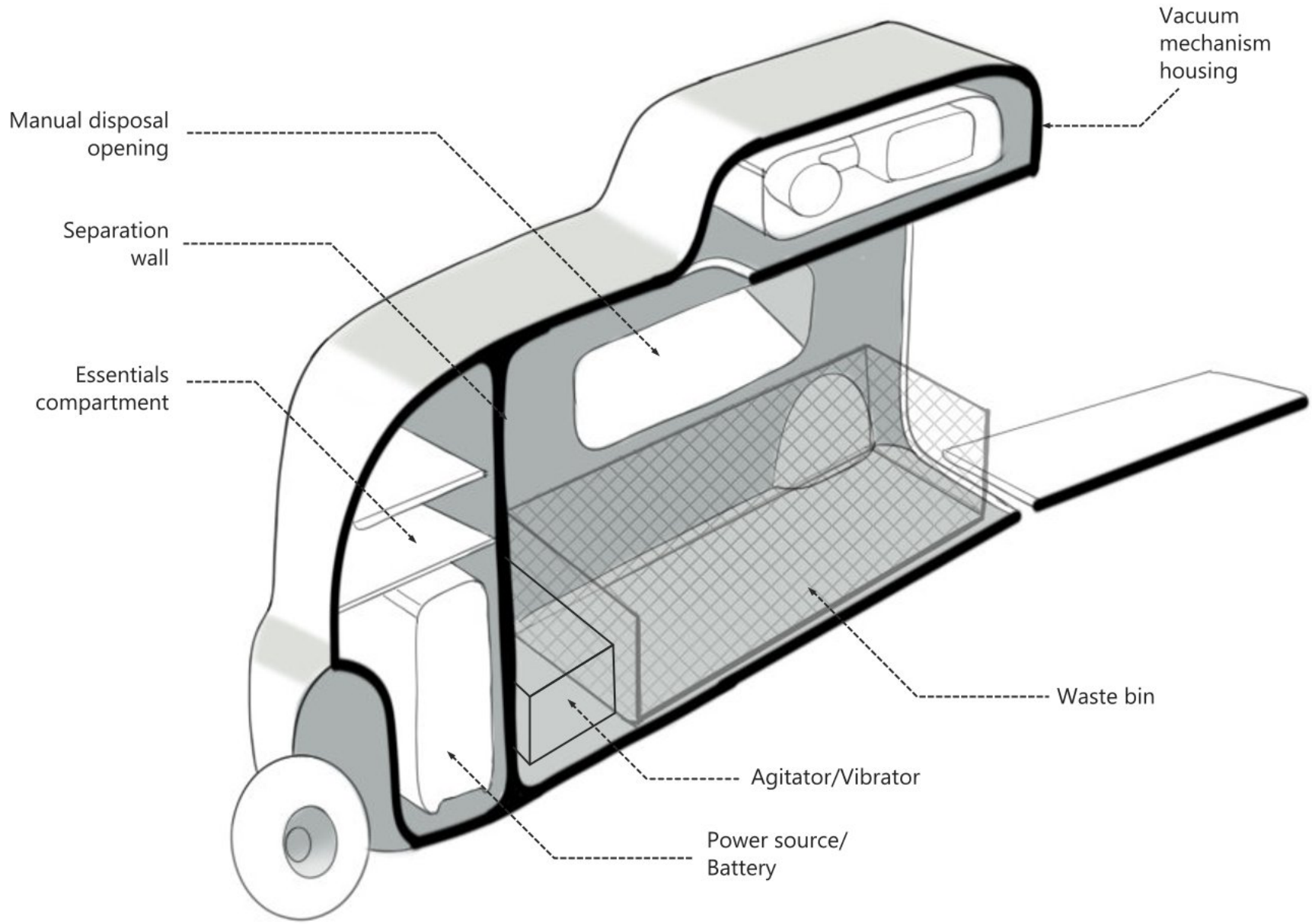


The overall size and footprint of the product is quite small and in human scale for easy and safe interactions. The majority of the space is utilized for storage of waste. Drive has been removed to increase efficiency and reduce weight.

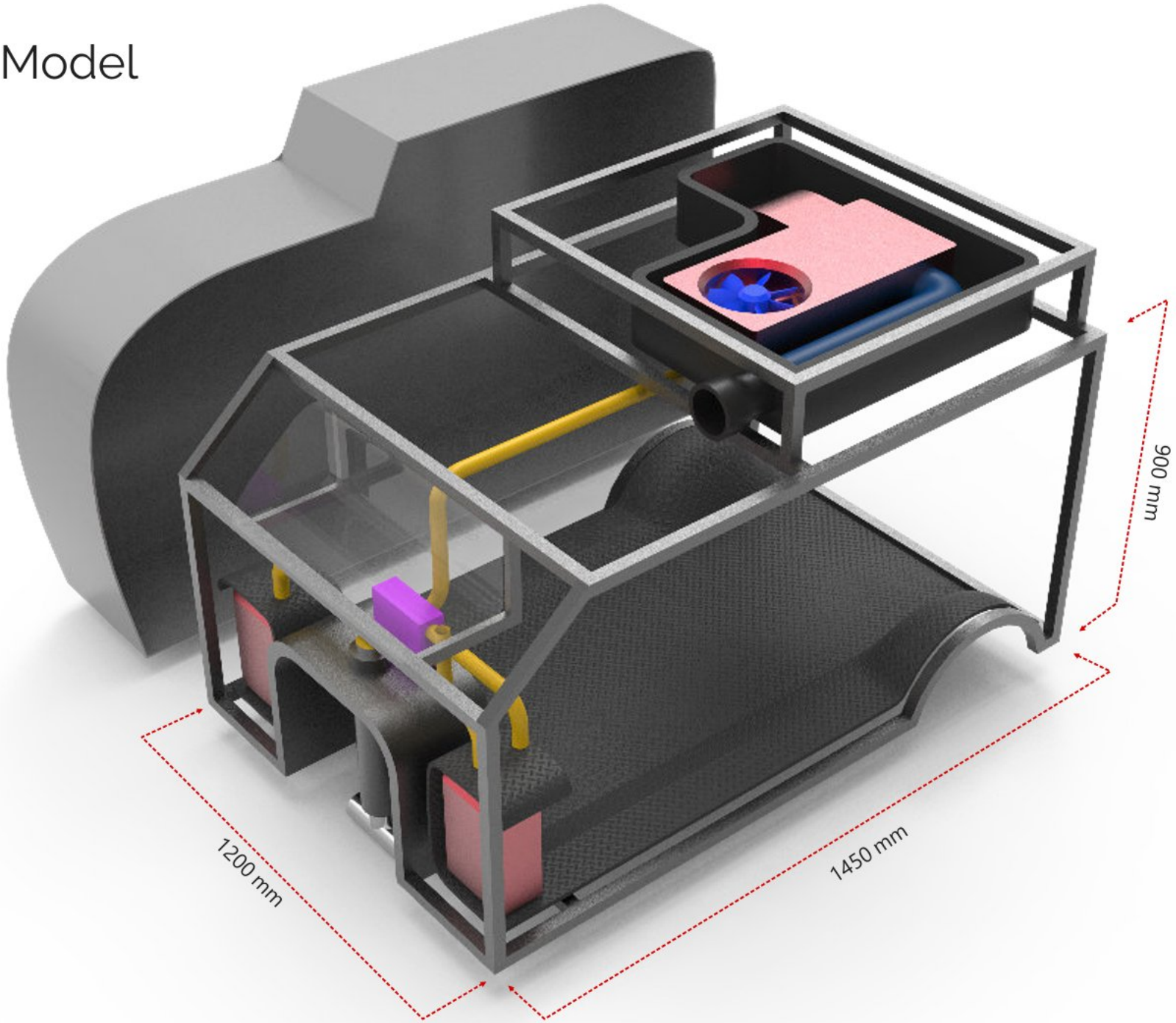
Body material: Fiber Reinforced Plastic
Frame: Stainless steel (anti-rust)
Wheels: Polyurethane
Waste capacity: 400 L



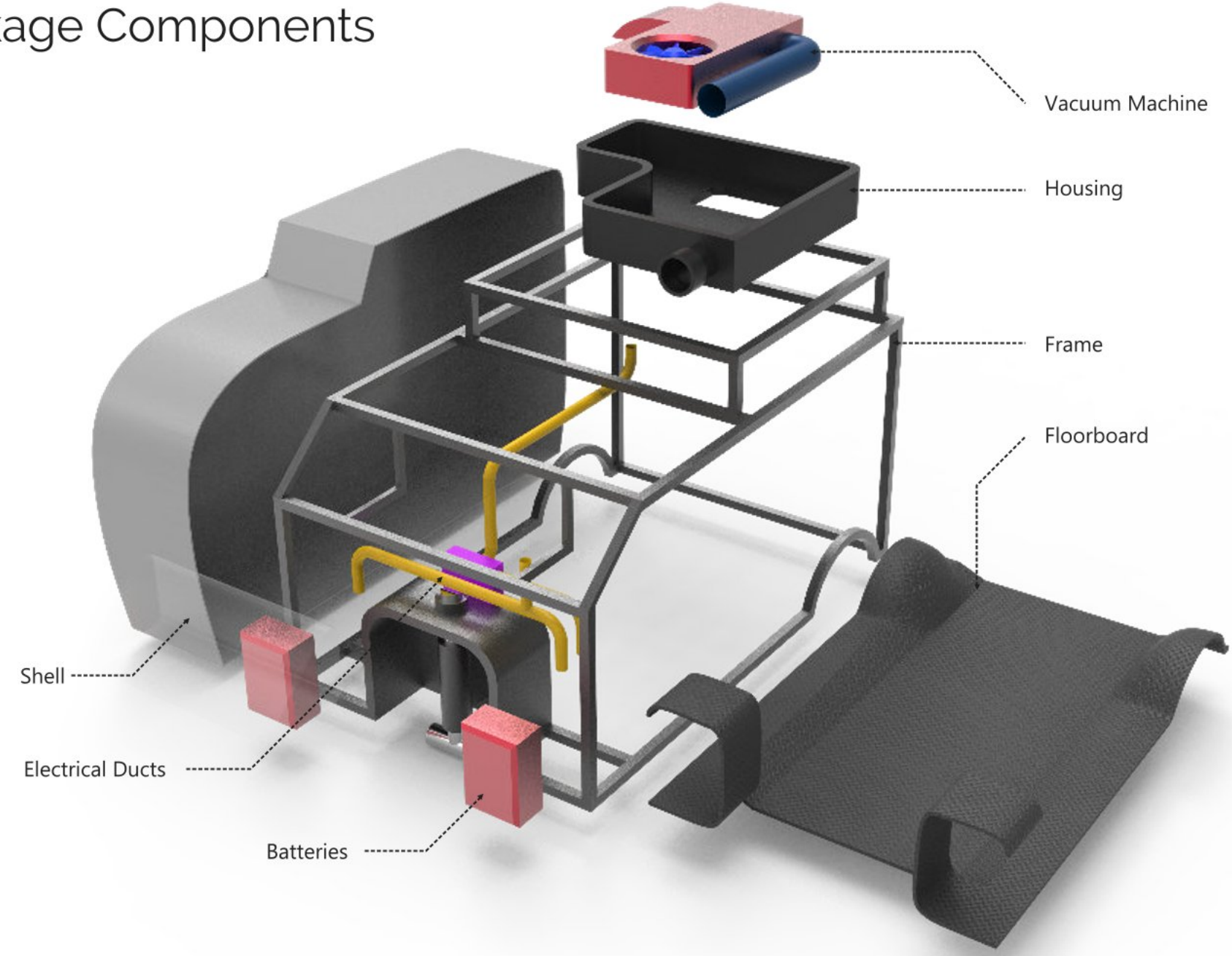
Section sketch

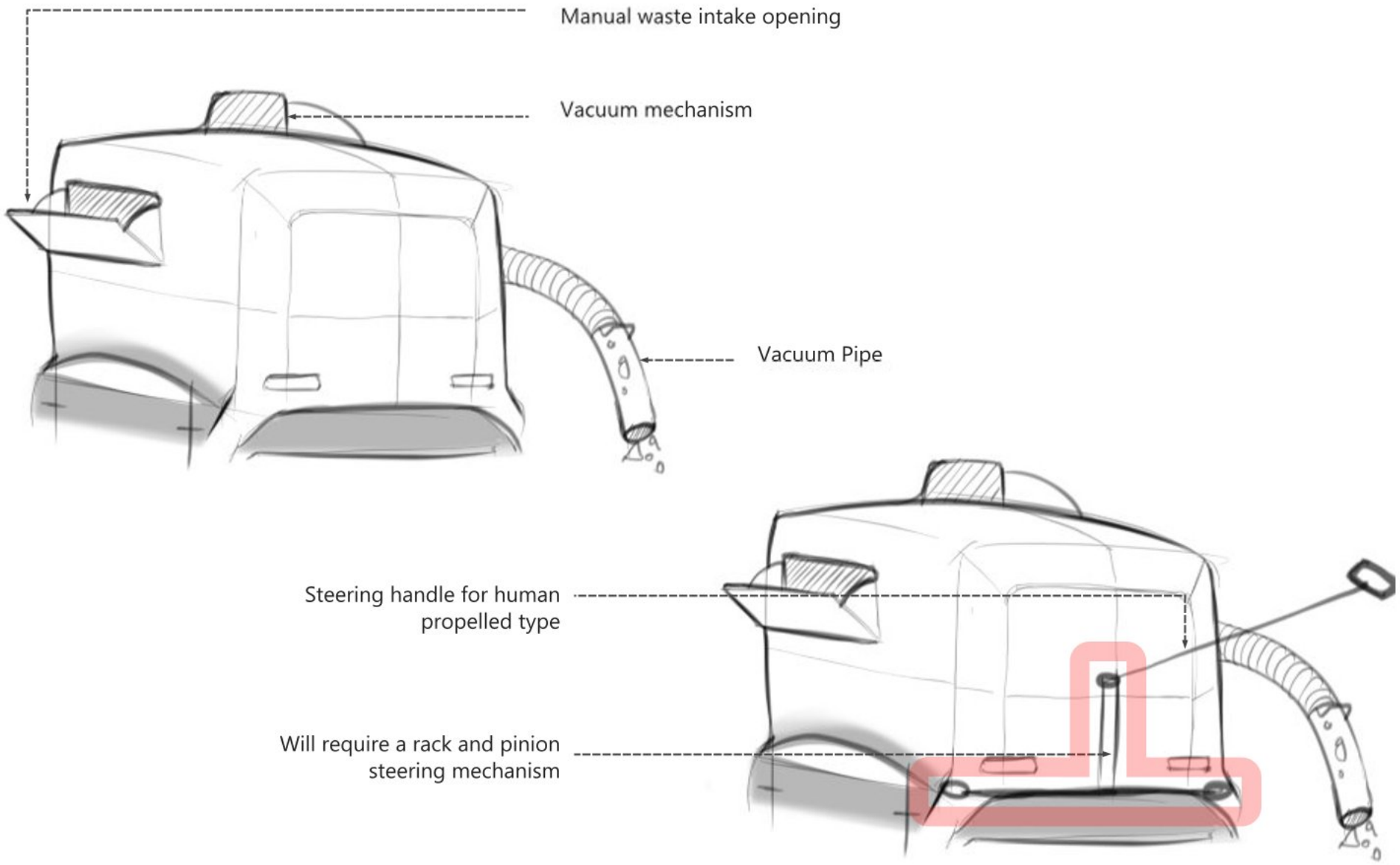


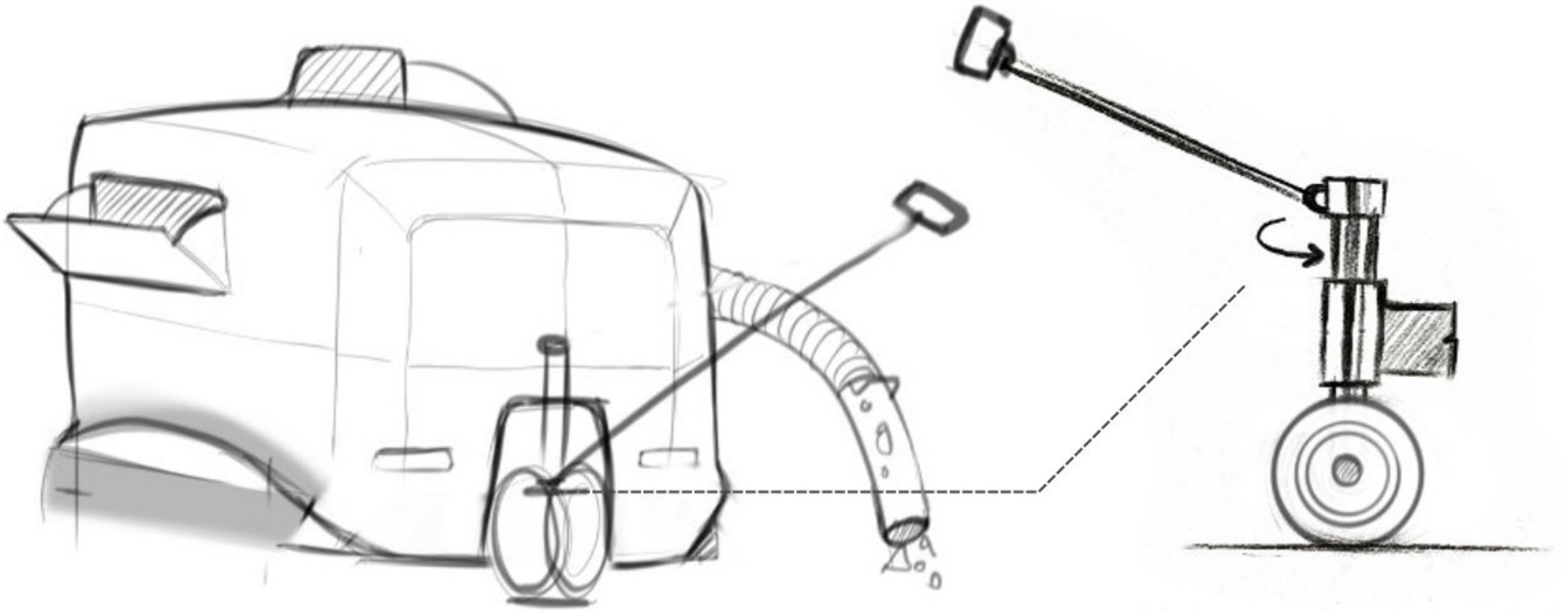
Package Model



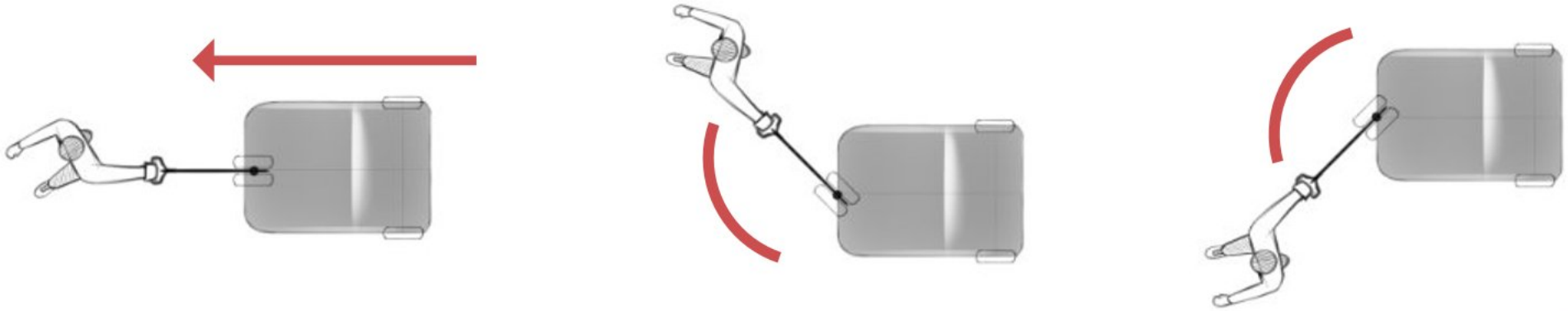
Package Components

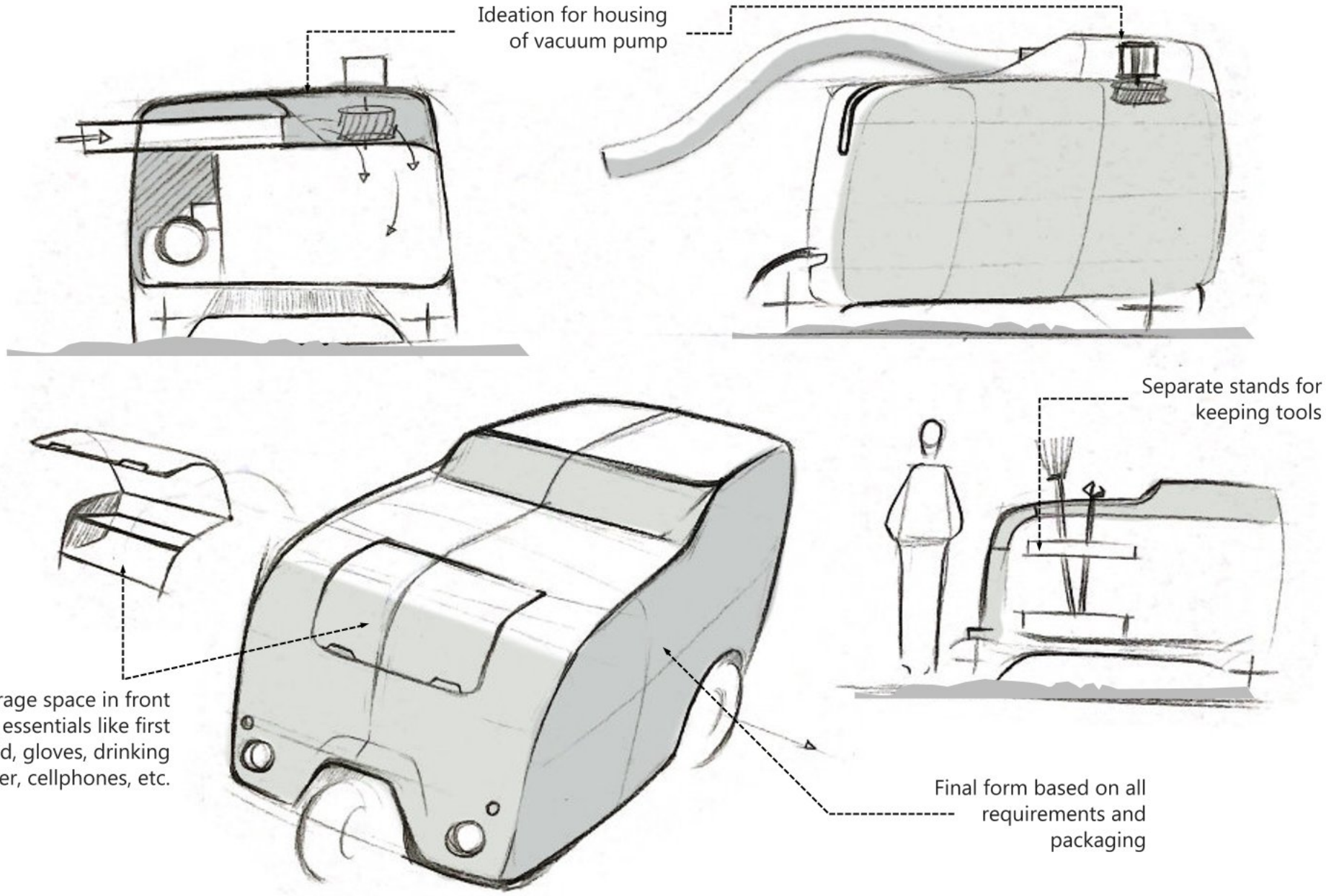



Manual waste intake opening
Vacuum mechanism
Vacuum Pipe
Steering handle for human propelled type
Will require a rack and pinion steering mechanism

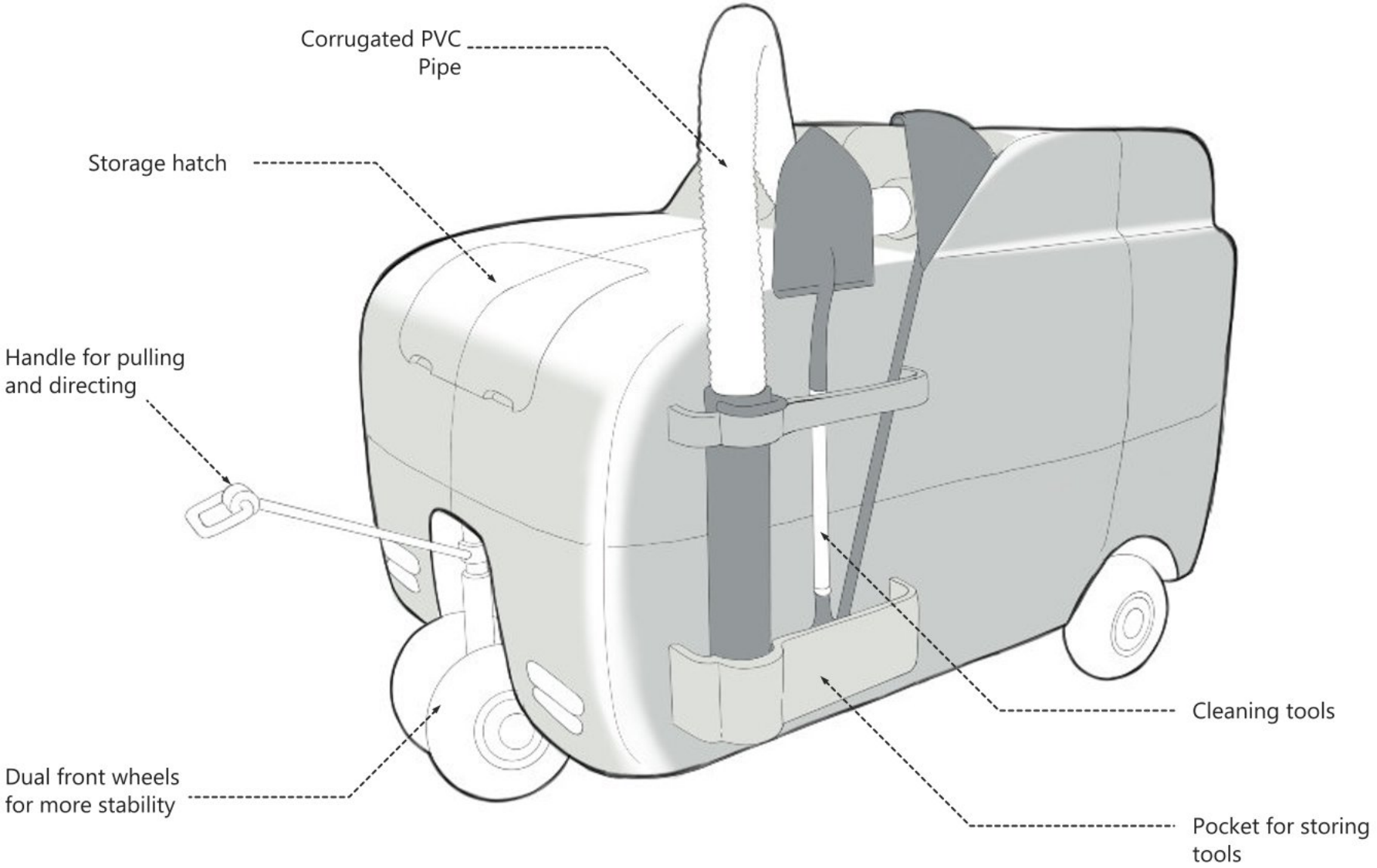


Simplified steering through three wheeler type configuration, the shaft directly turns towards the direction in which the handle is pulled.

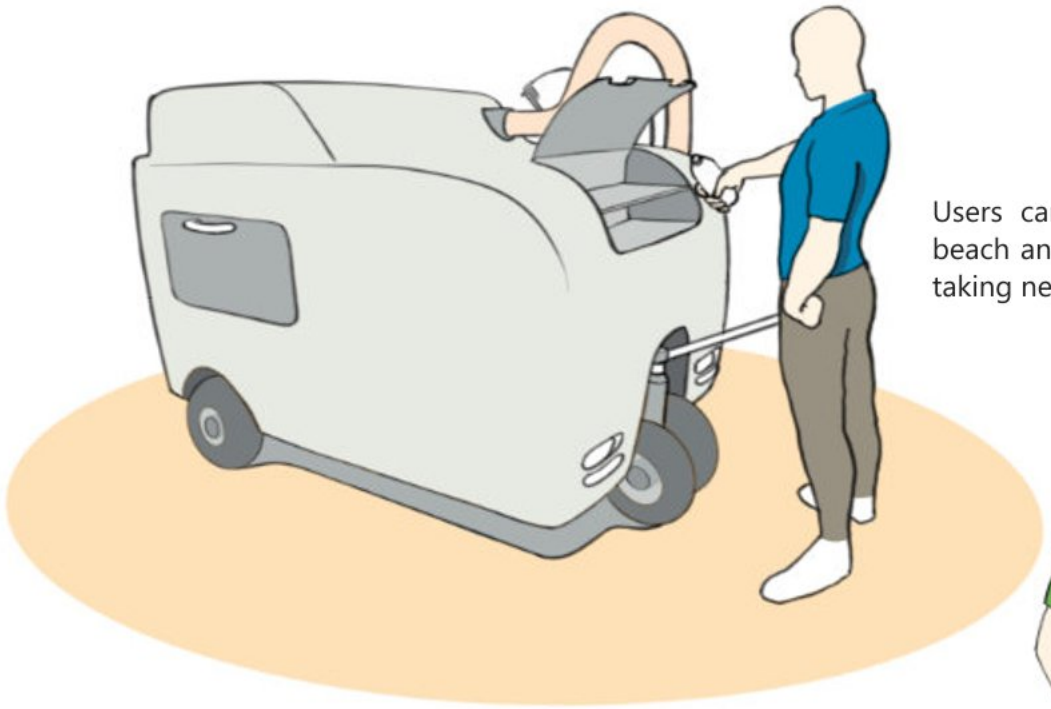



Ideation for housing of vacuum pump
Separate stands for keeping tools
Storage space in front for essentials like first aid, gloves, drinking water, cellphones, etc.
Final form based on all requirements and packaging

Final sketch

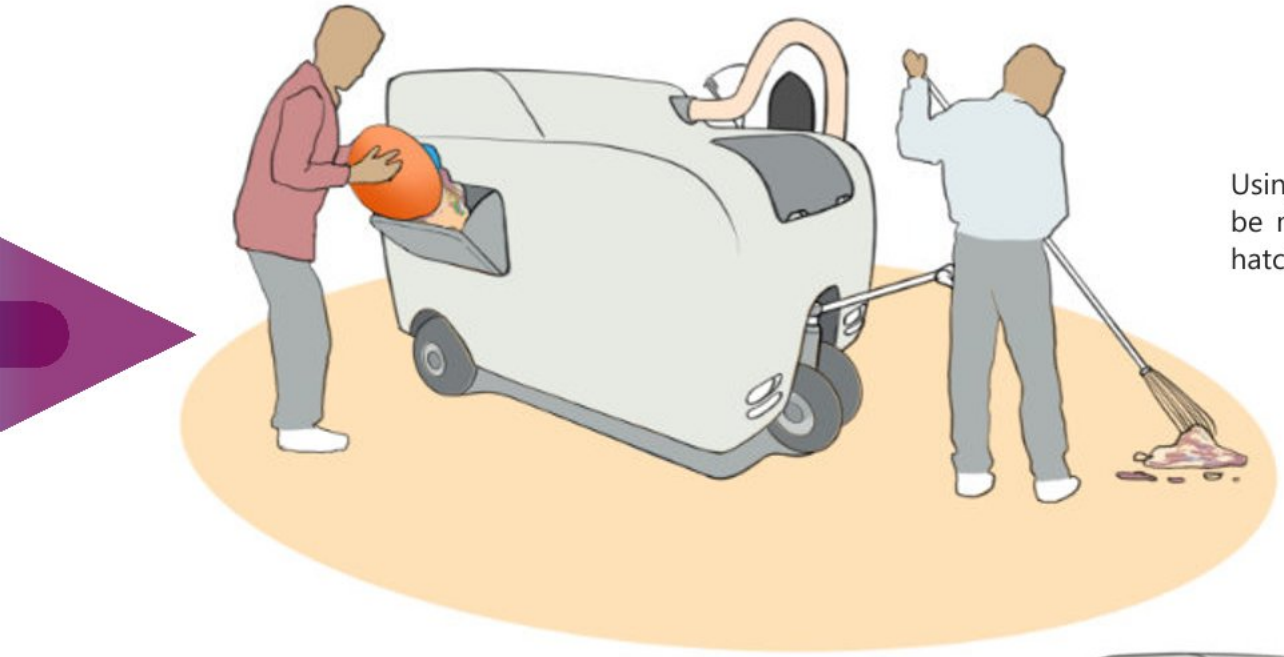


Scenario Sketches

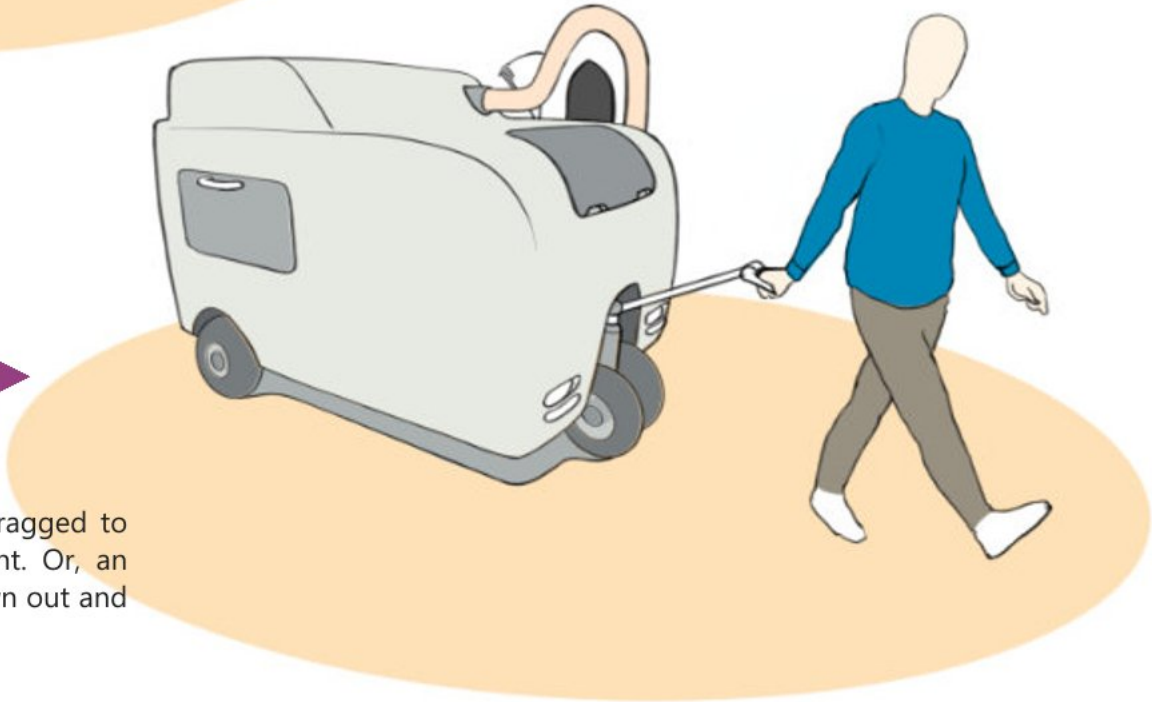


Users can get started by reaching the beach and turning on a unit, storing and taking necessary items.

Using various tools and the in-built vacuum mechanism cleaning can be done.. Users can keep trash pickers, rakes, brooms etc. in the side storage.

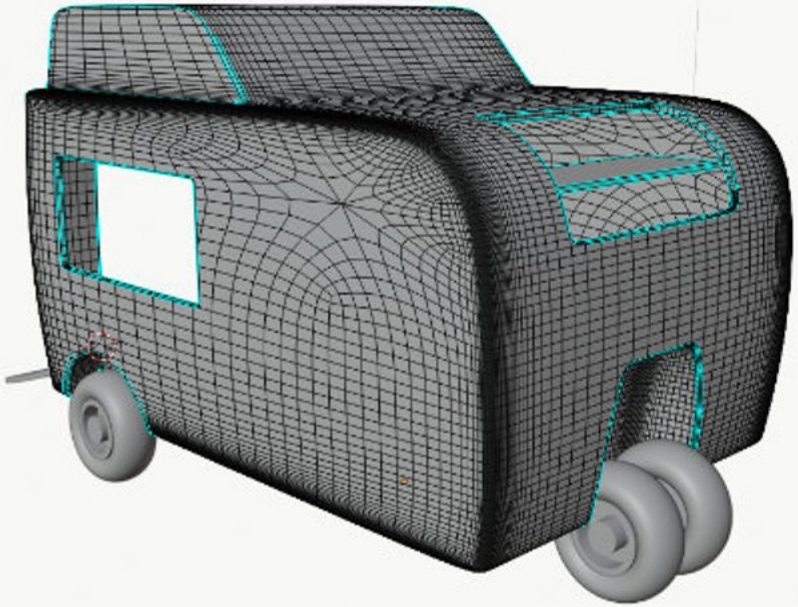


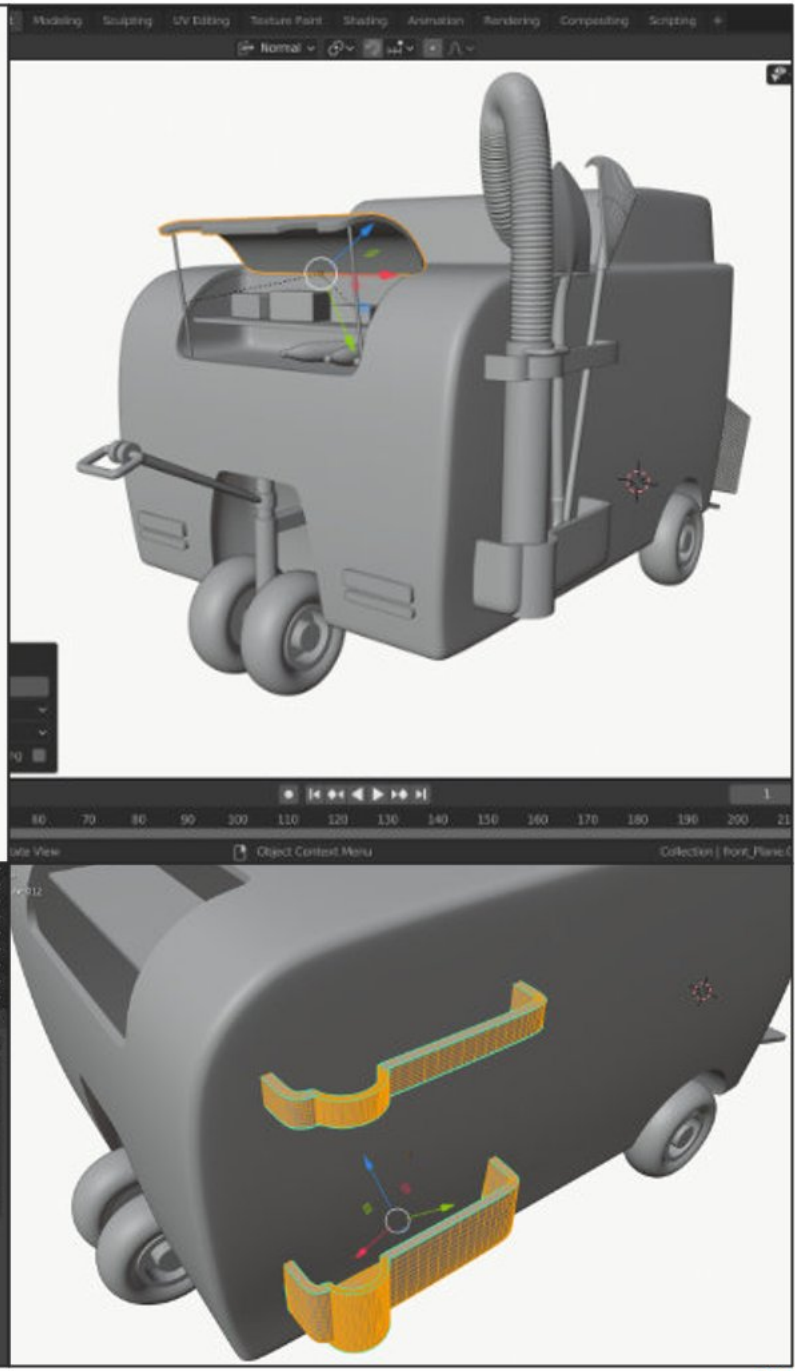
Using Shovel and rake, the trash can also be manually picked and dropped into a hatch on the side of the unit.

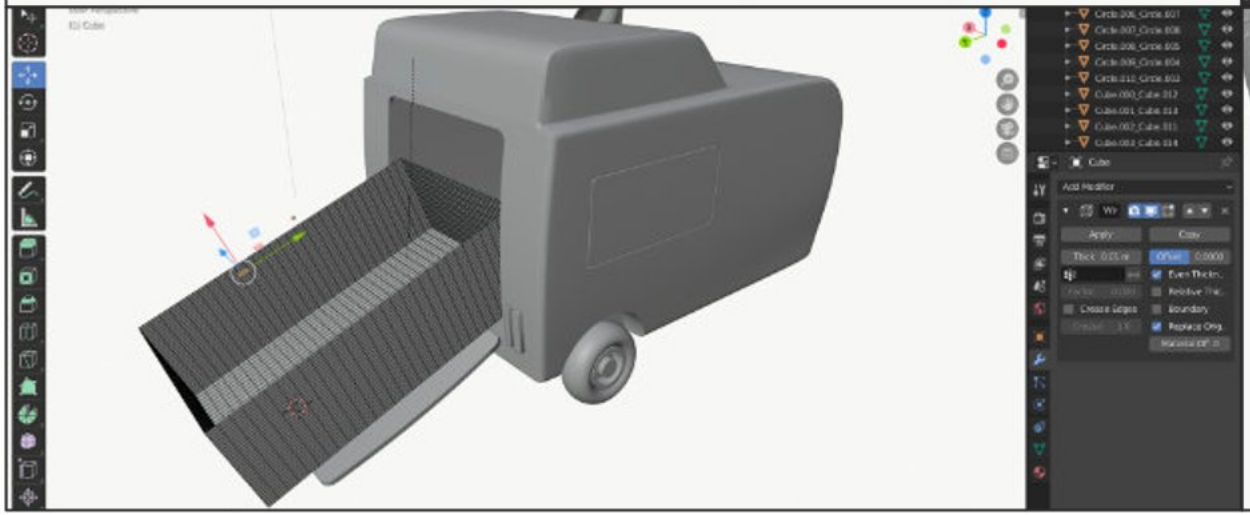


Once Filled, the unit can be dragged to the on site sedimentation plant. Or, an inbuilt trash carrier can be drawn out and taken instead.

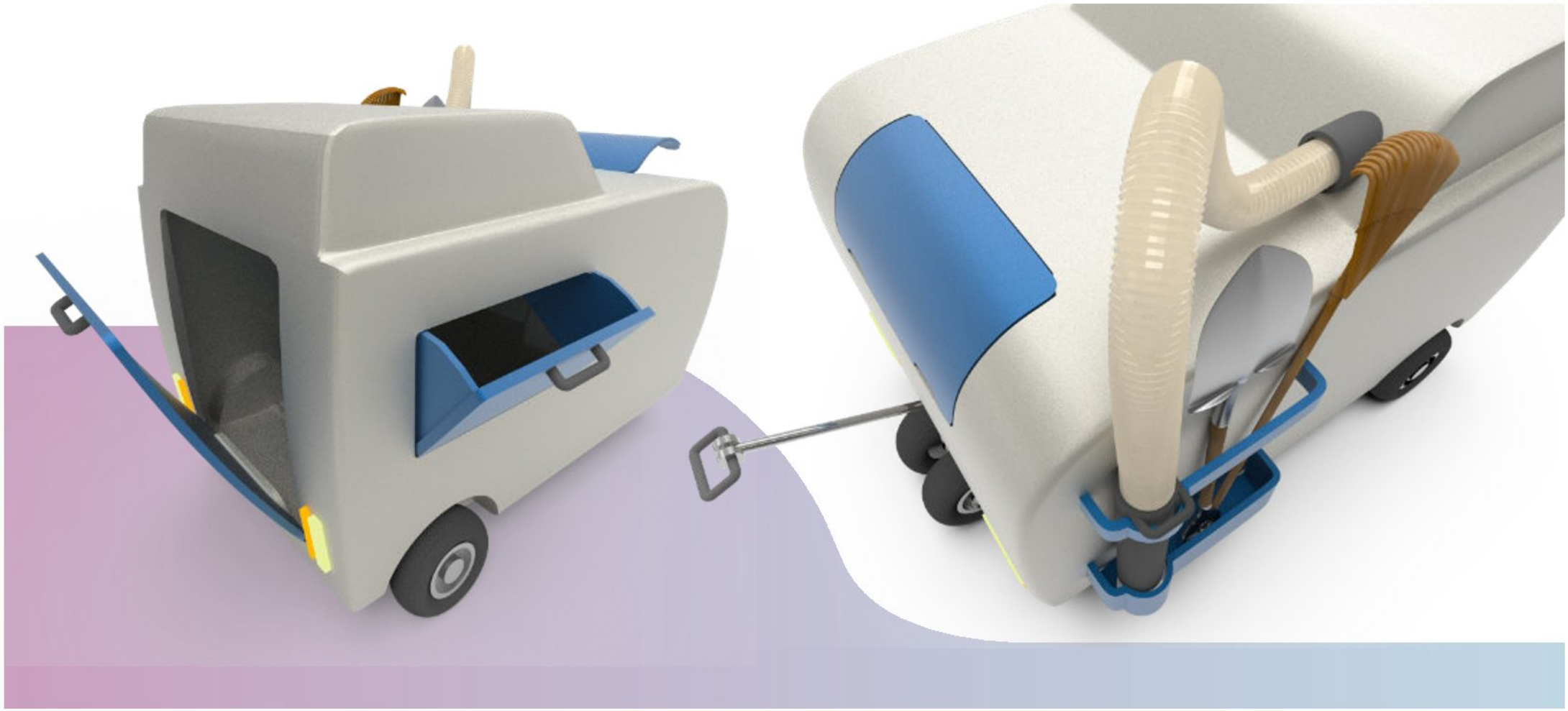
5.6 CAD Modeling

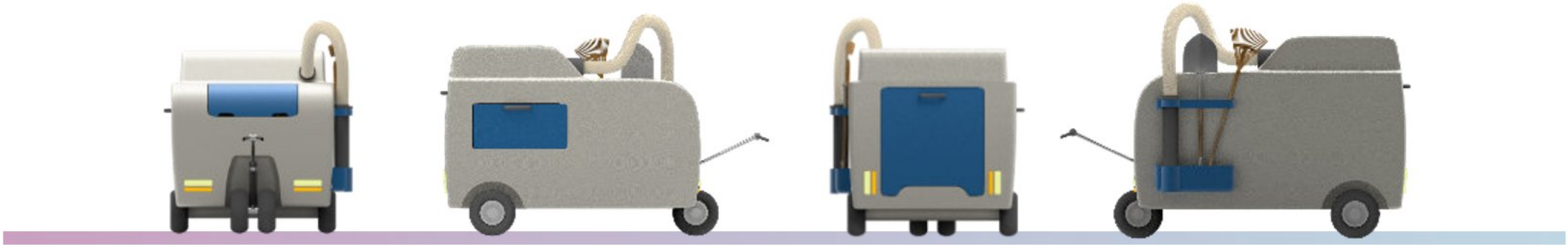


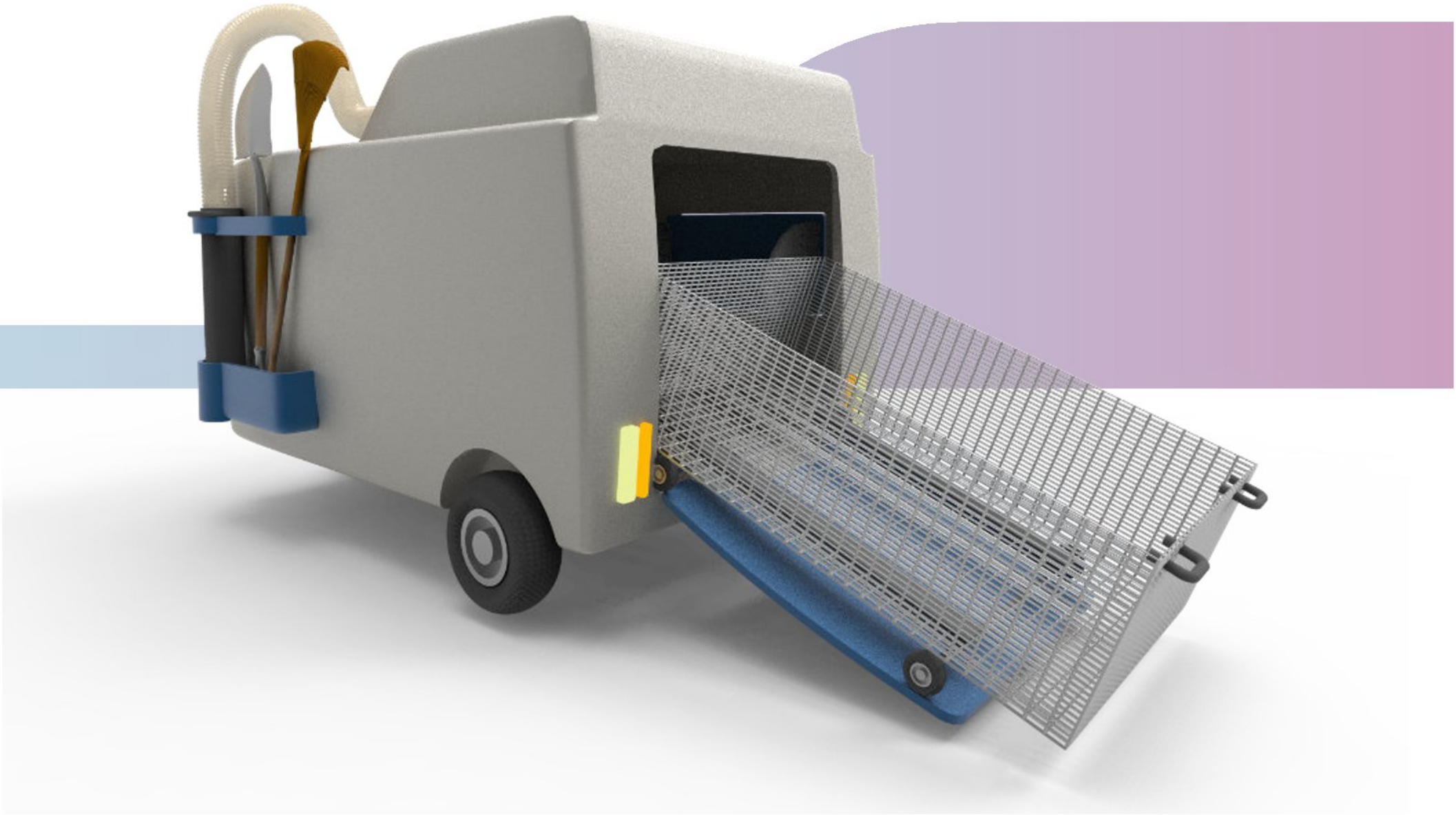




5.7 Renders







ANNEXURE

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