DESIGN OF AGRICULTURAL EQUIPMENT FOR THE MARGINAL RICE FARMERS: A SOLUTION FOR TRANSPLANTING AND HARVESTING OF RICE

INDUSTRIAL DESIGN PROJECT III

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Design Project - III

Design of agricultural equipment for the marginal rice farmers: A solution for transplanting and harvesting of rice

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Approval Sheet

The project titled as "Design of agricultural equipment for the marginal rice farmers: A solution for transplanting and harvesting of rice" by Midhun K.M. is approved in partial fulfilment of the requirement for the degree of 'Master of Design' in Industrial Design.

Guide:

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Chairman:

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Declaration

I hereby declare that this written submission represents my idea in my own words and where others' ideas have been included; it has been adequately cited and referenced with the original source. I declare that I have adhered to all principles of academic honesty and integrity and have not fabricated or falsified any data/idea/facts/sources in my submission. I understand that any violation of the above entitles the institute to take disciplinary action against me to which I shall be answerable to.

Name	Midhun K. M.
Place	Mumbai
Date	31-05-2015

Signature

Acknowledgement

My thanks to my loving mother and my brother.

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Abstract

The current project is a continuation of the work carried out to identify the problems associated to marginal farming community of Kerala. In this part of the project, the focus is on providing solutions to the issues. The various design opportunities are studied from the needs of the user group and the need to sustain marginal rice farming community, by maximizing the profit, is taken forward. The solution proposes a conceptual machine which is economically viable to operate in marginal sized land holdings to carry out transplanting and harvesting of rice, which are the most intensive activities in rice farming. The solution also focuses on the various factors such as safety, comfort and efficiency for improving the productivity of the farm activities while addressing the need to sustain marginal rice farming. Along with the conceptual machine the project concludes with a note on the system level design based on the context of the user group for which the solution is designed for.

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1. Introduction

Motivated by the urge to meet the needs of the large unorganized work sector of India, a study conducted has taken its form to provide design solutions to the marginal farmers cultivating rice in the food production deficit state of Kerala in India based on a user research conducted

As mentioned above, the in depth user research is conducted in the previous project. This project is a continuation based on the inputs from the user research. The process adopted is a *user centered design* approach where the user, user's requirement and the context are given extensive attention.

1.1 Overview of the User Research

The user research was conducted with the marginal rice farming community of the state of Kerala by conducting interviews and thereafter interpreted the user needs by the analysis of data collected. The process involved the following major tasks:

- Secondary research on rice cultivation.
- Selection of appropriate users for interview.
- Choice of interview method and logistics.
- Preparation of questionnaire.
- Analysis of raw data and interpretation of user needs.

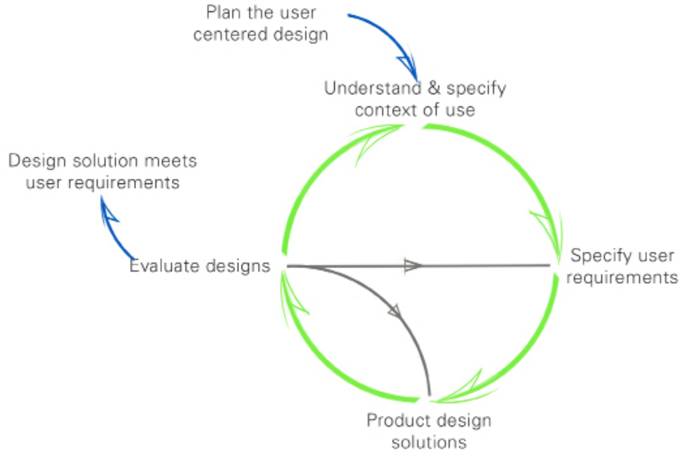


Figure 1-1 User centered design as per DIN EN ISO 9241-210[1]

The users chosen were farmers, machine operators and solution providers for farm mechanization and were interviewed using the *general interview guide approach* method to ensure the same general information is collected from each user from a category with a degree of freedom and adaptability. The questionnaire was prepared for each category with open ended questions to extract the processes followed and the various problems faced by the users. The information collected from the secondary research also helped in ensuring the crucial topics are included in primary research as well as in analysing the data to interpret the user needs. The data collected from primary research was analysed in different stages where the raw data was mind mapped into categories based on the activities in rice cultivation and other factors by considering farmer as the centre point. This data was then analysed further and the problems arising was categorized into four groups each focusing on issues arising from machines, manpower, livelihood and problems from land and climate. This data was taken to the next step by retaining the same groups but projected the needs by interpreting the inputs. Finally the needs where also matched with the existing available solutions used in the current scenario to conclude the user research.

From the user research it was concluded that the major requirement of farmers are maximum profit from this seasonal crop since, in the current scenario due to the labour shortage and higher wages the profits are marginal. Looking at the specific purpose machines existing in the market and comparing it with the user needs and context, it proves that it is not economically viable for this user group due to two factors, the smaller size of land and the seasonal nature of deployment. This has resulted in farmers resorting to the traditional labour at a higher production cost or to quit rice farming. This is reflected clearly in the primary research conducted.

In addition to this, the primary research also pointed out other problems faced by the user group. The awkward work postures and the long work hours has resulted in a increasing occupational diseases due to the manual labour. The farmers engaged in cooperative farming were able to use some of the machines on rental basis but pointed out issues in manoeuvrability or accessibility of other machines to their fields. The farmers also face problems in the uncertainty or delays while depending on machines which negatively impact the yield. The problems were many and were an outcome of the transition from the old practices of farming and the changes in the society with the unresolved challenges in marginal farming due to the gap existing in the available solutions and the user needs. To start with the current project a detailed discussion on the design opportunities will be discussed in the subsequent chapter.

This chapter concludes here conveying that the present project is about designing solutions based on the user research conducted in the previous project. An overview of the process adopted in user research and some of the findings were also discussed for the reader to get more engaged and informative to start with the current project.

2. Design Opportunity

The user research discussed in the previous chapter has collected a substantial amount of data about the issues faced by the marginal rice farming community of Kerala. This chapter will discuss about the design opportunities that emanates from the user research conducted. Studying the user needs, the following are the design opportunities found out:

- Sustain marginal rice farming community by maximizing profit.
- Elimination of dependency on labourers through appropriate solutions.
- Redesign of existing specific purpose machines to suit the farmer's and operator's needs.
- Solutions for processing and safe storage of grains after harvest.
- Affordable solution for safe application of pesticides.
- Solution to rescue crop from flood and drought.

A discussion about the aforementioned points will help in getting a clear picture about the context of the proposal of those opportunities for intervention. Starting from the need for maximising profit to sustain marginal rice farming, an analysis of the current scenario depicts that the marginal farmers still do not have access to many of the existing machines and they depend on traditional labour for wages which are double the average Indian wage (Labour Bureau, Government of India, 2014). The point of maximizing profit is also linked to various other factors such as the unavailability of provisions to process and store grains to sell based on the time of peak prices and the need to educate the farmers about the shift from conventional farming is also crucial.

The elimination of dependency on labourers in addition to the reason suggested in the previous point is also a potential opportunity as the researches in autonomous farming machines are progressing.

The redesign of existing machines is another opportunity where the farmers and operators face issues such as the inaccessibility of machines to the fields due to the terrain and the limitations of village roads and the fields. The research also points out the various occupational diseases arising from the usage of machines due to the hand or whole body vibrations of operator.

Another opportunity is the need for processing and storage of grains after harvesting. The traditional process of partially boiling the rice and drying is not feasible in the current scenario as it requires a large amount of resources. The need to rescue the crops from flood and drought is very much crucial as this is the major risk associated to any farming.

Analysing the design opportunities and the context, the next phase is to choose the most appropriate challenge and it seems that maximising profit for marginal farmers needs to be focused. Now breaking down the activities in rice farming, the user research suggests that the land preparation, transplanting and harvesting is the most intensive. Considering the fact that the land preparation is affectively carried out by the tractors or power tillers which are widely available and used for multi purposes, our focus will be on the latter two activities. The reason is that it requires a large number of labourers at a higher cost as seen with the case of marginal rice farmers.

This concludes the chapter with the information to propose the design objective in the next chapter

3. Design Objective

"To design an equipment to carry out transplanting and harvesting of rice for the marginal rice farming community of Kerala based on the needs and the context of the user group."

The design objective defined above is an outcome based on challenges existing in the mechanization for marginal farming and the needs of the rice farming community of Kerala. The idea is to reduce the gap existing between mechanization and marginal farming and thereby reducing the production cost for farmers to sustain rice cultivation.

As found out in the user research, the seasonal nature of crop and the smaller size of land are the core reasons for the slow pace of mechanization in the current scenario. This can be tackled by maximizing the utility of machine for multiple activities and also by designing the machines which are economically viable to access and operate in marginal size land holding. The choice of transplanting and harvesting operation is because these activities are the most intensive as observed from the user research. In the current scenario, there exists no machines which can carry out both the tasks and available ones are single purpose machines.

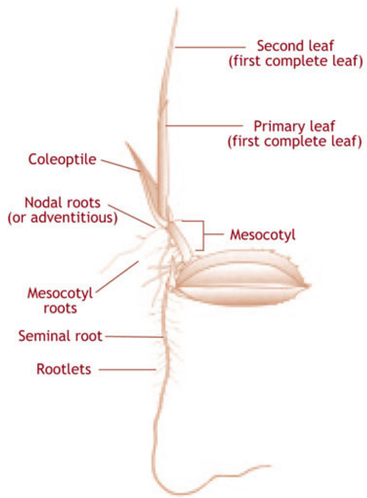


Figure 4-1. Parts of a rice seedling[2]

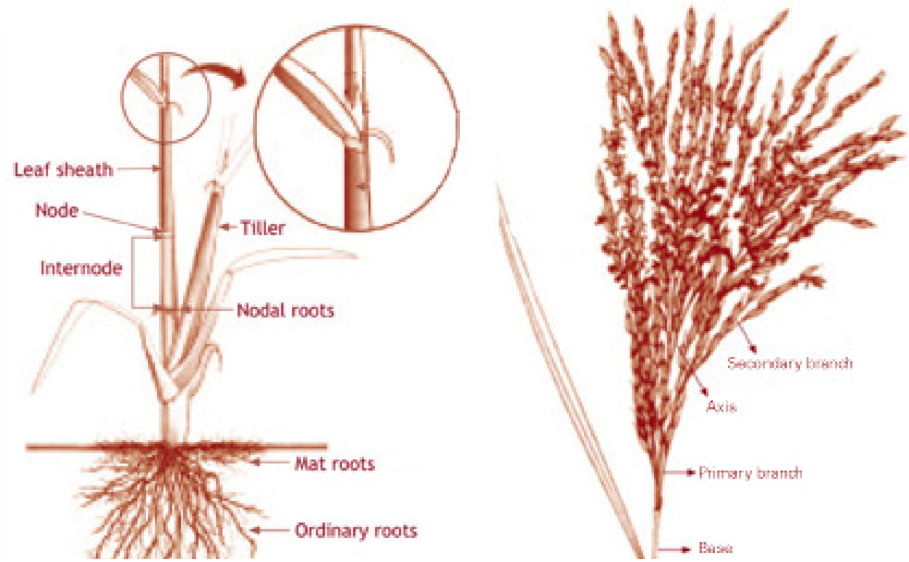


Figure 4-2. Parts of a rice seedling[2]

4. Activity Analysis

The previous chapter has clearly stated the design objective and now the focus of this chapter is to understand the various activities involved in transplanting and harvesting of rice. The data is collected in order to understand the various methods adopted and its implication on the yield of the crop. Before we discuss about the activities, a brief description about the seedling and matured plant is necessary

4.1 Understanding the Rice Seedling and the Plant

The rice seedling is the young plant from the germination of the rice seed. It consist of three main parts: the first root(radicle), first shoot (hypocotyl) and the first leaf (cotyledon) (Global Rice Science, 2013).

As soon as the seedling is self-supporting, the plant develops tillers till the panicle initiation. The height of a rice plant ranges from 0.4 to 2m depending on the variety. The major parts of a panicle consist of a base, axis and primary and secondary branches. The axis extends from the base node to the apex and consists of nodes from which the primary branch rises. The secondary branch then extends from the primary branch (Global Rice Science, 2013).

4.2 Transplanting

Transplanting is the process of planting the rice seedling grown in a nursery in to the puddled field. The process is carried

Figure 4-3 Manual transplanting[3]

Figure 4-4 Mechanical transplanting[4]

out either at random or in straight rows. This process requires less seed when compared to broadcasting. It also helps in better weed control. The spacing of the plant is a crucial factor in this method as it dictates the yield of the crop (IRRI-Rice Knowledge Bank, 2014).

The major three types of transplanting are manual, mechanized and seedling broadcasting.

4.2.1. Manual Transplanting

This method involves a large group of workforce of upto 25 to 30 persons a day for 1 hectare of field. The labourers carefully pull two to three seedlings between the thumb and index finger by holding on close to the root from the nursery. This is then bundled and carried onto the puddled field. The carefully handled seedlings are then transplanted in the field at a shallow depth with 2-3 seedlings per hill (IRRI-Rice Knowledge Bank, 2014).

4.2.2. Machine transplanting

The machine transplanting uses a machine to plant the young seedling into the puddled field. This method is fast and efficient and uses less labour. This process ensures uniform spacing and plant density.

The method demands for a well irrigated area with special nursery management. The nursery grows the seedling as mats or in seedling trays. The land should also be prepared and levelled for efficient planting.

4.2.3. Seedling Broadcasting

In this method of transplanting the seedlings are grown in special bubble tray nursery to develop seedlings with root balls. The seedlings raised on these trays experience less transplanting shock. These seedlings are then thrown or broadcasted into the puddled

Figure 4-5 Seedling broadcasting[5]

Figure 4-6 Manual harvesting[6]

field. 1 hectare of land requires 750 trays for nursery (IRRI-Rice Knowledge Bank, 2014). The cost of a single tray is within the price range ₹10-15 (Paddy Transplant Rice Seedling Tray AM-P01, 2015).

In addition to the conventional transplanting processes, the System of Rice Intensification (SRI) is a method which has proven higher yield of 20-100% using 90% less seed for nursery. It also ensures upto 50% water saving (The System of Rice Intensification, 2015). In this method, 1 seedling per hill is transplanted at an equal spacing of 25cm between each planted seedling. The activity should be carried out with care to minimize any root trauma as the seedling is only 8-12 days old (System of Rice Intensification - Principles and methods).

4.3 Harvesting

Harvesting involves collecting the crop from the plant when it is matured. The various activities associated to harvesting are cutting, handling, threshing and cleaning of grain. These can be done manually or using combine rice harvesters (IRRI-Rice Knowledge Bank, 2014).

4.3.1. Manual Harvesting and threshing

In this process labourers cut the stem of the plant just above the ground using hand tools like sickle. These are then collected for threshing. Manual threshing involves separating the grain from plant by impact. This can be done in various ways such as hand beating, trampling or using a pedal thresher. In hand beating the crop is beaten against a hard surface and in trampling animals or humans trample on the ground laid with cut plant. Later the straw is removed and grain collected. Pedal thresher is recommended to be the best option for manual threshing. It uses a pedal operated rotating drum with spikes which separates the grain when the panicles are held close to it. The threshed grain is then cleaned by siev-

Figure 4-7 Mechanical reaping[7]

Figure 4-8 Combine harvesting[8]

ing and winnowing (IRRI-Rice Knowledge Bank, 2014).

4.3.2. Manual harvesting and mechanical threshing

In this method the manually harvested crop is threshed in a mechanical thresher. Based on the feeding type, crop flow and threshing mechanism used, the threshers differ (IRRI-Rice Knowledge Bank, 2014).

4.3.3. Mechanical reaping and threshing

The reaping of the plant is carried out by mechanical reapers and this is then collected manually and taken for threshing. The mechanisation of the reaping reduces the time and cost (IRRI-Rice Knowledge Bank, 2014).

4.3.4. Combine harvesting

This is the most acclaimed method of harvesting as the process combines reaping, threshing, separating and cleaning of grain from plant (IRRI-Rice Knowledge Bank, 2014). A detailed discussion on the various modes of harvesting is discussed in the next chapter.

5. Market Study

The activities involved in various stages of transplanting of rice seedling and the harvesting of the grain is discussed in the previous chapter. This chapter focus on understanding the various types of products available in the market to carry out these activities.

5.1 Transplanting Machines

A transplanting machine is used to plant young seedlings into the puddled soil by using appropriate mechanisms (Machine transplanting - IRRI Rice Knowledge Bank, 2014). A study of the available machines and mechanisms in the market will give an insight in to the process of transplanting and a database for the development of possible new concepts. In the current study, both, human powered and mechanized devices are studied.

5.1.1. Mechanical Transplanters

The mechanical transplanters have a wide range of benefits and can complete the task with less labour and time when compared to the manual transplanting (Machine transplanting - IRRI Rice Knowledge Bank, 2014). The two major types of the harvesters used are the walk behind and the ride-on models. In the ride-on models there are again two types with the three wheel and four wheel options (PNS/PAES 151 : Agricultural machinery - Mechanical Rice Transplanter -Specification, 2010).

Figure 5-1. Mechanical transplanter[9]

Figure 5-2. Manual transplanting machine[10]

Parts of a transplanter

The basic or the essential parts of a transplanter are the engine, the grasping fork on the transplanting arm, the paddle wheel, the seedling tray and the driving controls. The grasping fork is the device which picks the seedling and is connected to the transplanting arm which actuates the motion of picking and transplanting the seedling into the puddled field. This is provided with a clutch mechanism to avoid any damages arising from hitting on stones or hard surface during transplanting. The paddle wheel is a modified wheel which facilitates the movement in the puddled field. The seedling tray is where the seedlings are placed Based on the type of machine, the driving controls can be a handle or a steering type (PNS/PAES 151 : Agricultural machinery - Mechanical Rice Transplanter -Specification, 2010).

Principle of operation

This machine is capable of carrying out its intended function of transplanting the seedling by satisfying a wide range of parameters which are crucial for the activity. The basic principle of operation is:

1. Place the seedlings on the seedling tray.

2. As the machine moves forward, the grasping fork plucks the preset number of seedlings from the tray.

3. The transplanting arm is then actuated by a cam assembly which pushes the seedling into the puddled soil.

4. After this, the arm reset back to its original position for the next cycle (PNS/PAES 151 : Agricultural machinery - Mechanical Rice Transplanter -Specification, 2010).

The machine is supposed to plant the seedling at spacing as per the desired setting. The grasping fork should pick the seedlings uniformly and plant it at the desired uniform depth as per the settings. It should also be ensured that the missing of hills and damaged hills during transplanting should be less than 10% (PNS/ PAES 151 : Agricultural machinery - Mechanical Rice Transplanter -Specification, 2010).

Apart from these bare minimum requirements, the machine is also enhanced with high fuel efficient, low noise and low vibration engines. Efforts are made to provide comfort to the operator for ease of manoeuvring and also for his safety. There are also innovations in the grasping arm which can pluck the desired number of seedlings. The machines are also equipped with self-adjusting mechanisms to control tilt due to the variations in the height of the hard pan of the field (NSD-8, Rice Transplanter, 2014).

National Agricultural Research Centre in Japan has developed an autonomous rice transplanter which works with help of a combination of GPS and on-board positioning sensor. The machine requires the location and shape of the field which is fed into the computer by the operator by providing the location of four corners. To avoid the frequent feeding of the machine with seedling, the research team also developed long-mat seedlings of length 6m. This is made on unwoven cloth and loaded on to the machine as rolls (Making Farmwork Easier, 2013).

The cost of a mechanical transplanter used in India in the current scenario ranges from ₹200,000 to 800,000 depending on the performance and the specifications. The expensive models are capable of completing 3.2ha/day while the cheaper ones can transplant 1.4ha/day (Imported Machineries, 2014)

5.1.2. Manual Rice Transplanter

Manual rice transplanters are human powered and it was

Figure 5-3. John Deere combine harvester[11]

Figure 5-4. Head feed combine harvester[12]

developed in the fifties in China. The major advantage of this device is its low cost and also avoids labour displacement in labour surplus regions. The device also reduces the planting time when compared to the fully manual mode of transplanting (G. Singh, 1985).

The machine consists of wooden skids, main frame assembly that supports the seedling trays and the mechanism for the actuation of task. The mechanism is actuated by the movement of the handle. When the handles are pushed down the picker cuts a chunk out of the mat and pushes into the puddled soil. The cycle is completed when the handles is pulled back to the initial position by the operator (G. Singh, 1985).The other model of the manual transplanter is the hand cranked model. The device is a backward walking type machine and can plant upto two rows simultaneously (rajkumar agromachines, 2015).

5.2 Combine Rice Harvester

A combine harvester is a machine which is capable of processing operations such as harvesting, threshing, separating and cleaning of various crops (IS 15806: Combine-harvester-thresher , 2008). Reports suggest that the usage of combine harvesters has increased in India due to the severe shortage of labourers and the higher harvesting costs (IRRI-Rice Knowledge Bank, 2014).

The machine comes in different sizes. The bigger machines are equipped with tracks for better mobility and the smaller or mini combines have wheels. The other differences among the machines are in the processing techniques. The various categories in this aspect are:

5.2.1. Standard combine harvester

The machine carries out the harvesting, threshing and cleaning of crop mechanically. The cutter bar in the front cuts the

Figure 5-5. Stripper header combine harvester[13]

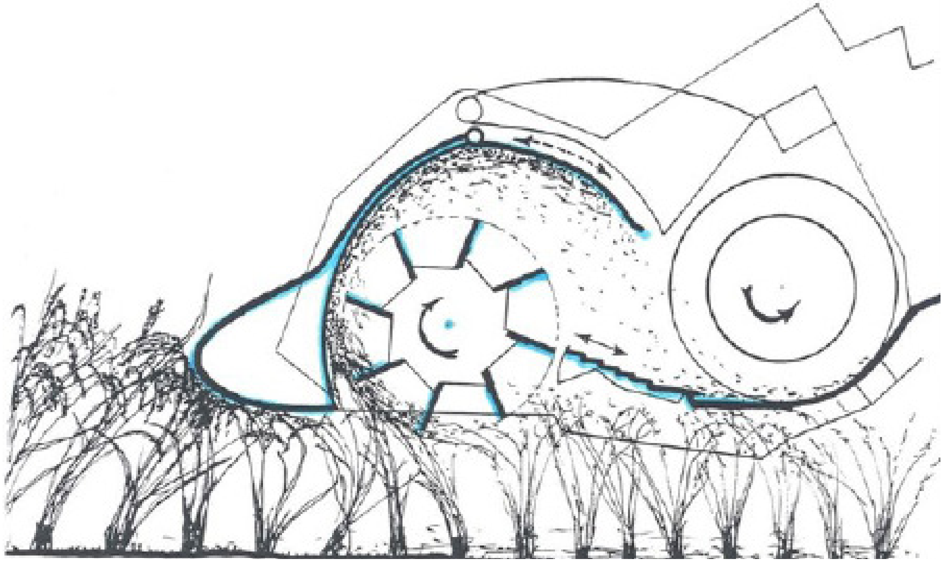


Figure 5-6. Schematic of stripper header[14]

crop and conveyed to the threshing and cleaning system through the conveyor. The threshing drum tip operates at a speed ranging from 20 to 25m/s. The machine produces clean grain and spread the straw back into the field. It can also be used for a wide variety of crops. The higher cost and less efficiency in handling the partially lodged crop is a disadvantage (IRRI-Rice Knowledge Bank, 2014).

5.2.2. Stripper header combines

The stripper header carries out the same functions of a standard combine but uses a stripper header instead of the cutter-bar. The header strips the grain from the plant. The advantage is the easier cleaning and less power for threshing. (IRRI-Rice Knowledge Bank, 2014).

5.2.3. Head feed Combines

This machine has the cutter bar and the conveying system holds the straw and feeds only the panicles into the thresher. The threshing drum tips is around 15m/s. The major advantage is that it can operate in small fields and requires less power for threshing and cleaning. The disadvantages are the low throughput and the complexity in the machine along with the higher cost. It is also not suitable for high shattering variety of crops (IRRI-Rice Knowledge Bank, 2014).

5.2.4. Axial flow combines

This machine is similar to the conventional harvesters, but uses an axial flow type thresher. The axial flow system provides high throughput and the machine is cheaper than the conventional combine harvester (IRRI-Rice Knowledge Bank, 2014).

This concludes the discussion with an overview about the existing products and the technology used in the current market. With the general information about the activities in rice cultivation

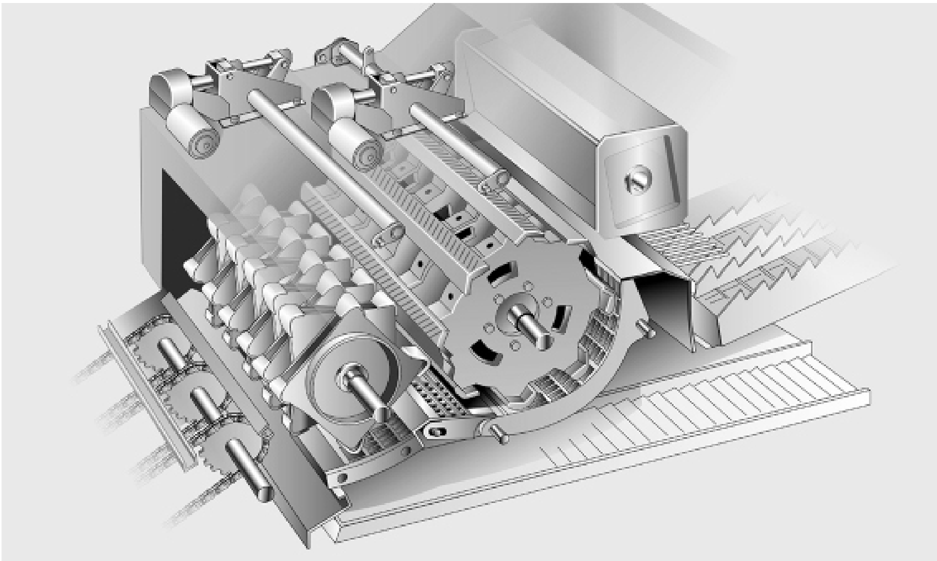


Figure 5-7. Schematic of standard combine threshing unit[15]

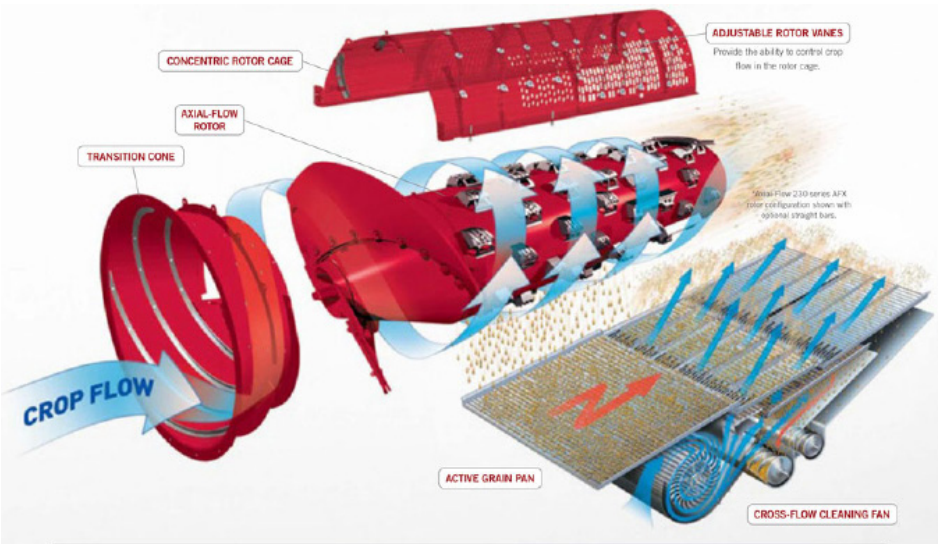


Figure 5-8. Schematic of axial flow threshing unit[16]

discussed in chapter 4 and this chapter, we now focus on our user group and context in the next chapter.

6. User and Context

As suggested, the current chapter will focus on specifying the user group and the context for which the solution will be designed for. The context will discuss about the physical environment and the proposed usage scenario.

6.1 Primary User

The primary user is the rice farmer who cultivates rice in a field which is lesser than 1 hectare. In this context, rice is not the primary source of income and grows maximum 2 crops a year. The user is primarily employed in unorganized work sector and has flexible job opportunity. In the existing scenario, this group of users are unable to access any of the machines due to the smaller land size and also due to the freedom they enjoy in deciding when to plant the crop and also in deciding the variety of the seed. They also continue rice cultivation since the total time for yielding the benefit is short when compared to other cash crops.

Figure 6-1. A marginal farmer and the divided field[17]

6.2 Secondary User

The secondary users are the machine operators. This can be a farmer by himself or a dedicated operator. This group of users are focused on making profit by maximising the usage of machine from a seasonal crop like rice or to hire machines to maximise profit by becoming independent of labourers. This group faces problems with the correlation of yield of crop with the expertise in using the machine.

Figure 6-2. The bunds separating the field can be high upto 1m [18]

Figure 6-3. The dry field after the summer harvest[19]

6.3 Tertiary Users

This consists of the service and repairs personnel and the owner of the machine. The challenges faced by the repairing personnel are the availability of spare parts and the resources for servicing. The machine owner expects to make profit by maximizing the usage of machine in this challenging environment of small land size and the seasonal usage.

6.4 Context

The machine or the solution is expected to be used on a rental or contract scheme where the famer hire a machine or sign a contract with a firm to complete his tasks of transplanting and harvesting. As per the information obtained through RTI act 2005, there are custom hiring centres to popularize high value and high productive machineries and to have easy access for small and marginal farmers without any significant capital investment (Appendix 1).

This concludes chapter 6 and in the next chapter a detailed description on other scenarios will be discussed along with the design brief.

7. Design Brief

The current chapter focus on listing out the design brief to achieve the solution for the objective set for the design. The inputs collected so far are effectively utilized for this purpose. Before we start the discussion, we ensure that the user group and context discussed in the previous chapter are kept in mind. Now, the categorized design brief is discussed below.

7.1 Functionality

The product should be able to carry out the transplanting and the harvesting activities in a land size which is lower than 1 hectare and at the same time economically viable to reach the field and complete the tasks.

The device should be able to control the depth and spacing between the seedlings during transplanting. It should also ensure there is sufficient space for storage of seedlings. The sensitivity to handle the seedling and the height of the matured plant are the factors to be considered.

For the harvesting of the crop, the device should ensure the grains are separated from plant and stored for easy transfer. It should also be ensured that the partially lodged crops also need to be handled during the operation. The cleaning of crop and bundling of straws as per the traditional market are other requirements to be satisfied.

7.2 Performance

The device should be able to easily manoeuvre in the muddy and dry paddy fields and cross bunds. The corners and the irregular shape of the plots are also to be considered while manoeuvring. It should also be accessible for the machine to travel through the narrow village roads to perform the required functions. The transplanting and the harvesting capacity should be atleast 1 Ha per day.

7.3 Maintenance

The machine should be easily repairable by the local mechanics with limited technical knowhow. The spare parts needs to be of Indian standards and affordable.

7.4 Assistance

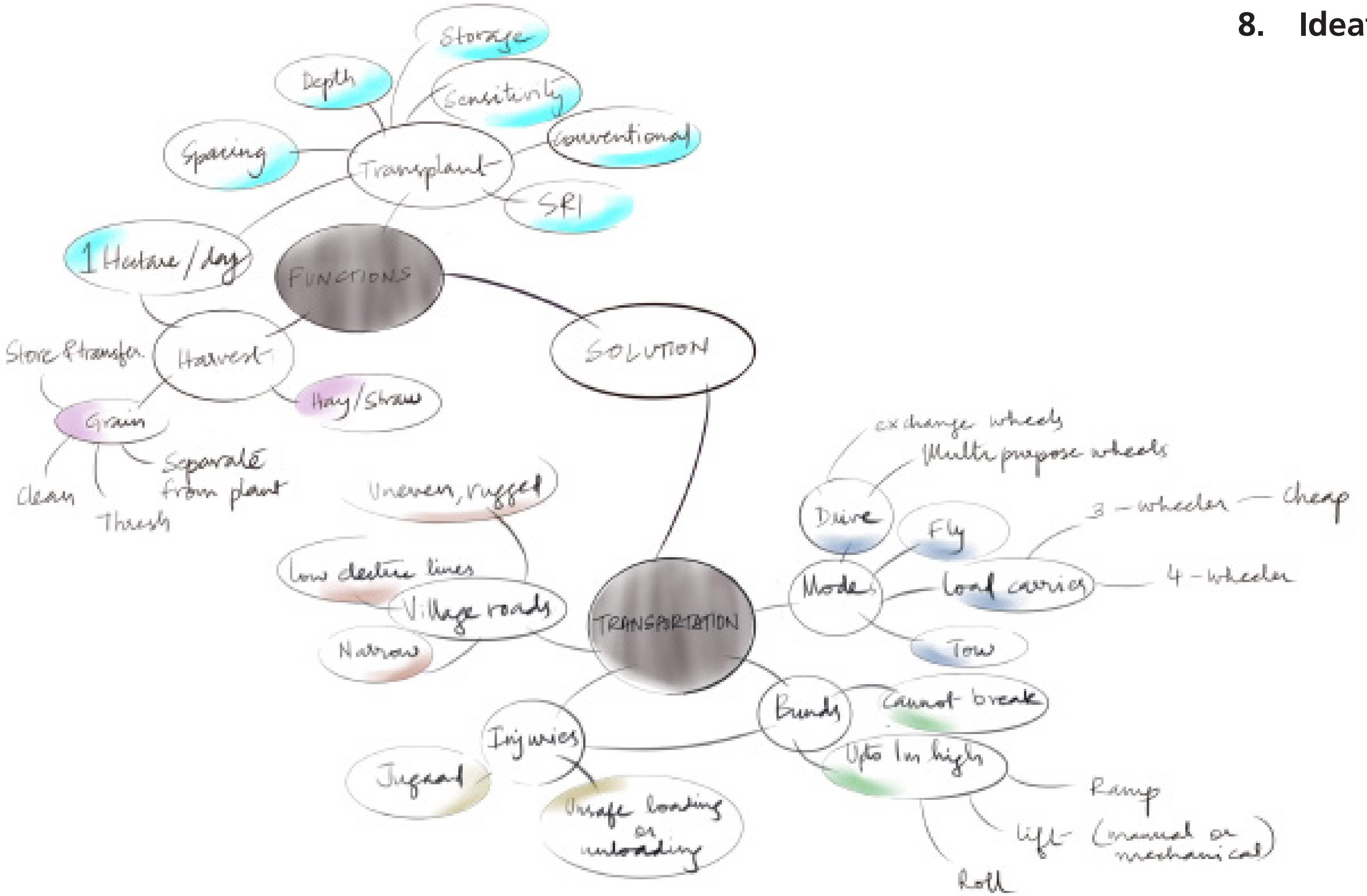
The device is to be used by inexperienced male and female users. The controls for operating the device should be minimal and self-explanatory based on the context.

With this detailed brief specifying the requirements (Table 7-1), the next chapter continues with ideation.

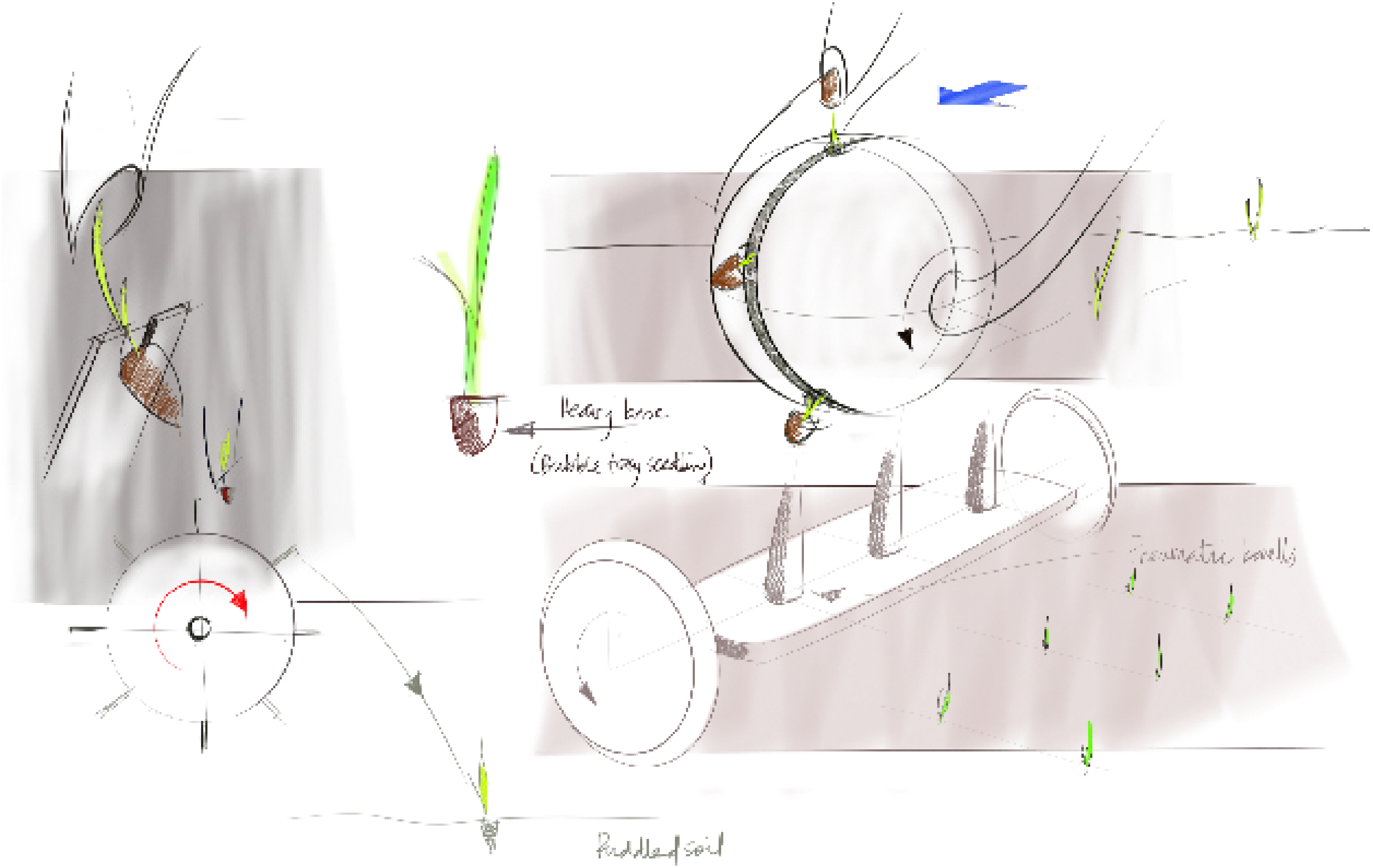
Fuctionality		Performance		Maintenance		Assistance	
Transplanting	Depth of planting upto 1.5cm	Maneuverability	Handle corners of field	Repair	Easily replaceable parts	Operation	By inexperienced users
	Adjustable spacing between rows		Muddy and dry terrains				
	Optimum storage of seedling		Cross bunds	Spare parts	Affordable	Controls	Contextual
							Minimal
Harvesting	Separate grain from plant	Transportation	Cheap to transport				Self explanatory
	Work on lodged crop as well		Narrow village roads				
	Store grain		Chances of unsafe loading and unloading practices				
	Thresh and clean the grain						
		Working capacity	1hectare/day				
Gather straw	Cut long hay						
	Make bundles						

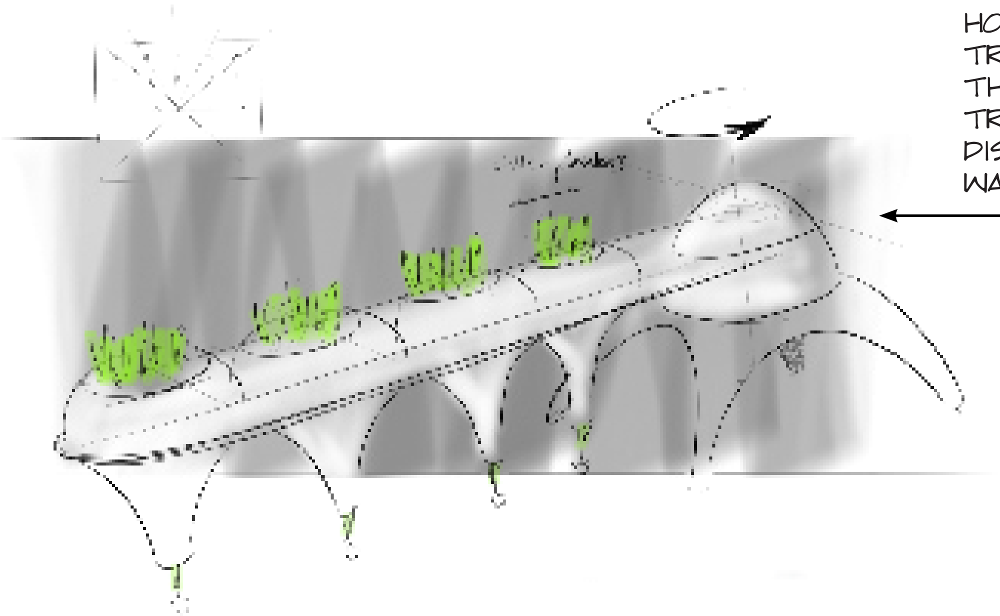
Table 7-1. The design brief

8. Ideations


Storage
Depth
Sensitivity
Spacing
Transplant
Conventional
SRI
1 Hectare / day
FUNCTIONS
SOLUTION
Store & transfer
Harvest
Hay/Straw
Grain
Separate from plant
Clean
Thresh
Uneven, rugged
Low electric lines
Village roads
Narrow
TRANSPORTATION
exchange wheels
Multi purpose wheels
Drive
Fly
3 - wheeler
Cheap
Mode
Load carrier
4 - wheeler
Tow
Bunds
Cannot break
Upto 1m high
Ramp
Lift (manual or mechanical)
Roll
Injuries
Jugaad
Unsafe loading or unloading

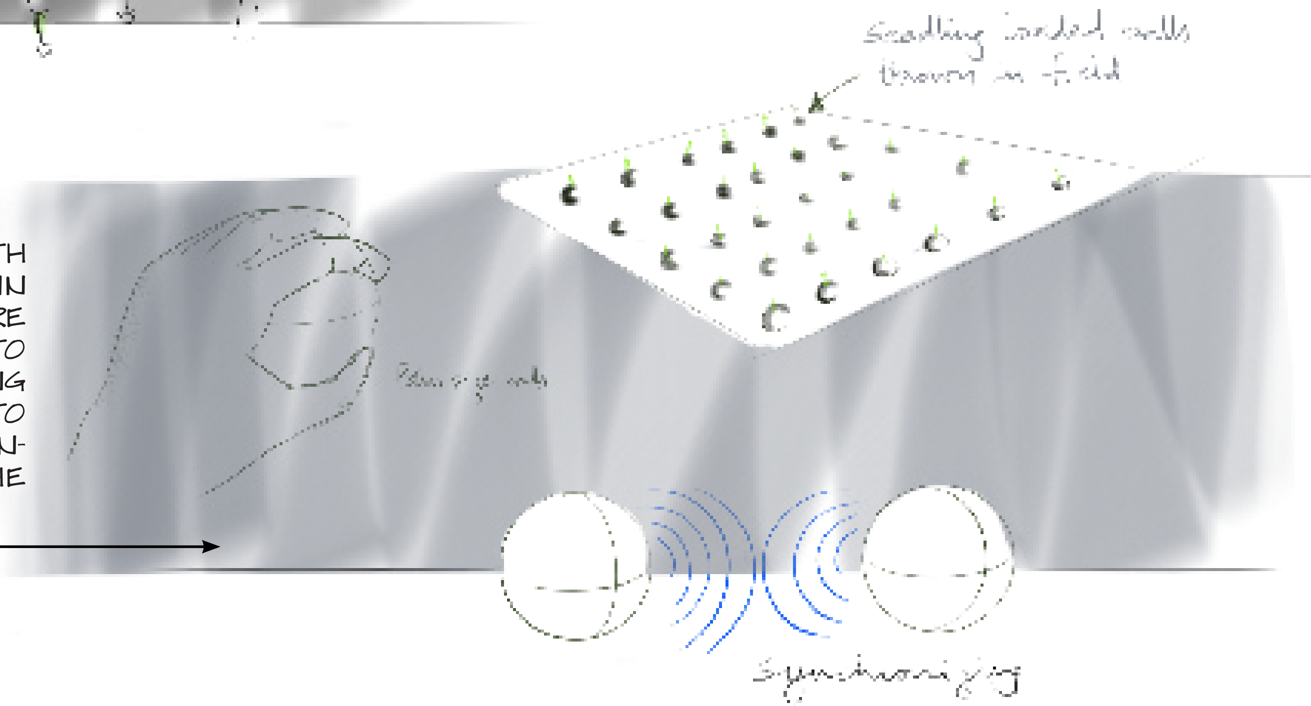
THESE IDEAS FOR TRANSPLANTING ARE BASED ON THE SEEDLINGS GROWN IN BUBBLE TRAYS WHERE THE ROOTS HAVE A LUMP OF MUD WHICH ALLOWS IT TO DROWN INTO THE PUDDLED SOIL IN THE RIGHT ORIENTATION



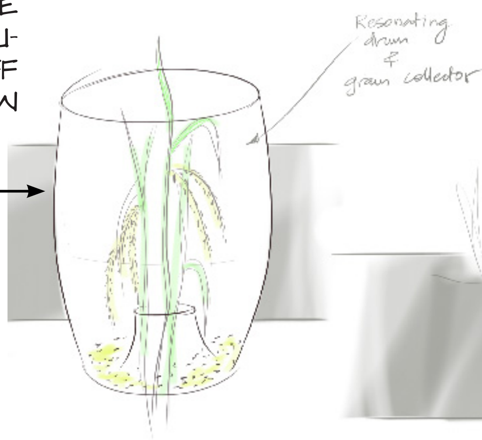


A CENTRE PIVOTED ROTATING ARM FIXED ON TO HOUSING IS LOADED WITH SEEDLINGS GROWN IN BUBBLE TRAY. THESE ARE THEN DROPPED ONE BY ONE THROUGH THE FUNNEL DISPENSER WHILE THE ARM ROTATES. THE TRANSPLANTED REGION WILL BE A SQUARE BLOCK AS THE DISPENSERS ALSO MOVES RADIALLY OUTWARD AND INWARD DURING THE PROCESS.

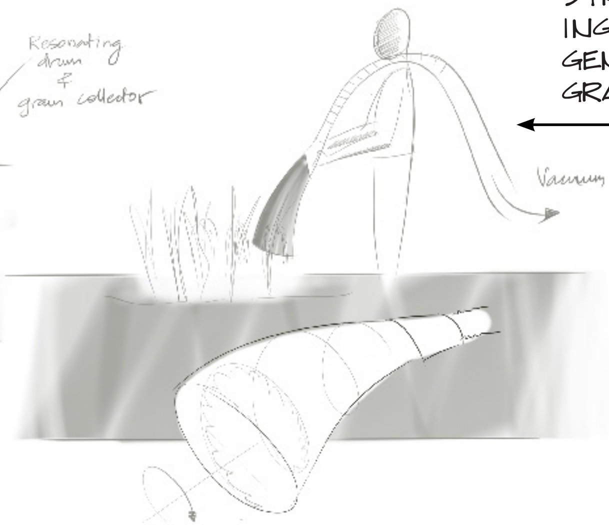
A SET OF BALLS LOADED WITH SMALL SEEDLINGS ARE THROWN INTO THE FIELD AND THE BALLS ARE SYNCHRONIZED TO EACH OTHER TO ACHIEVE OPTIMAL SPACING DURING TRANSPLANTING. THE IDEA WAS TO EXPLORE THE POSSIBILITIES IN INCREASING THE ACCURACY OF THE DISTANCE BETWEEN THE PLANTS.

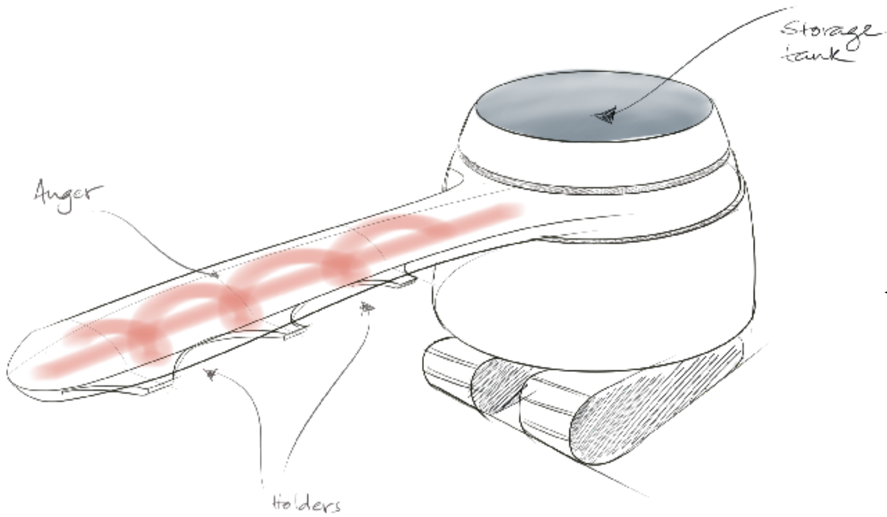


A RESONANCE CUP WHERE THE GRAIN IS EXCITED AT ITS NATURAL FREQUENCY TILL IT SHEDS OFF THE PLANT AND THE CUP BELOW COLLECTS IT.



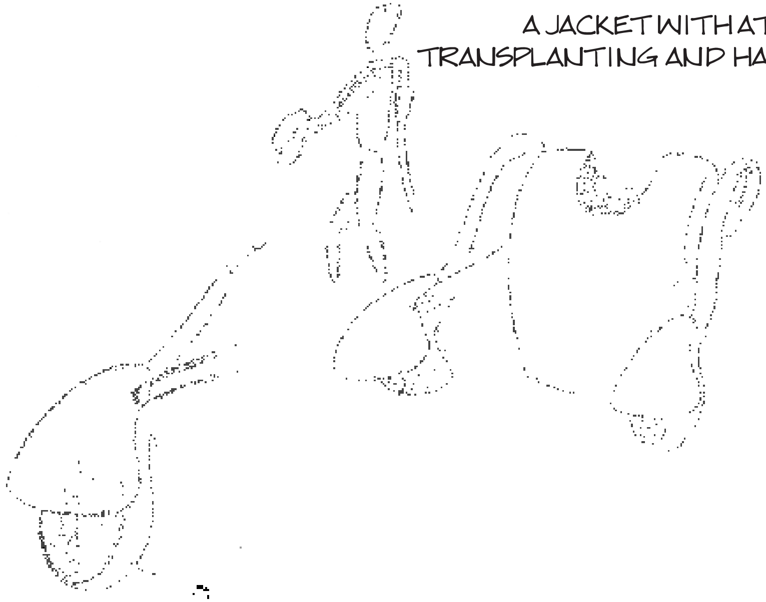
A VACUUM OPERATED GRAIN COLLECTOR WHERE THE GRAIN IS STRIPPED BY THE HELICAL ROTATING STRIPPERS AND THE VACUUM GENERATED WILL TRANSFER THE GRAIN TO A STORAGE UNIT.



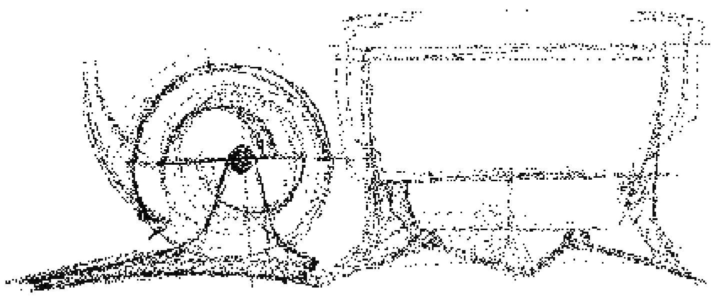


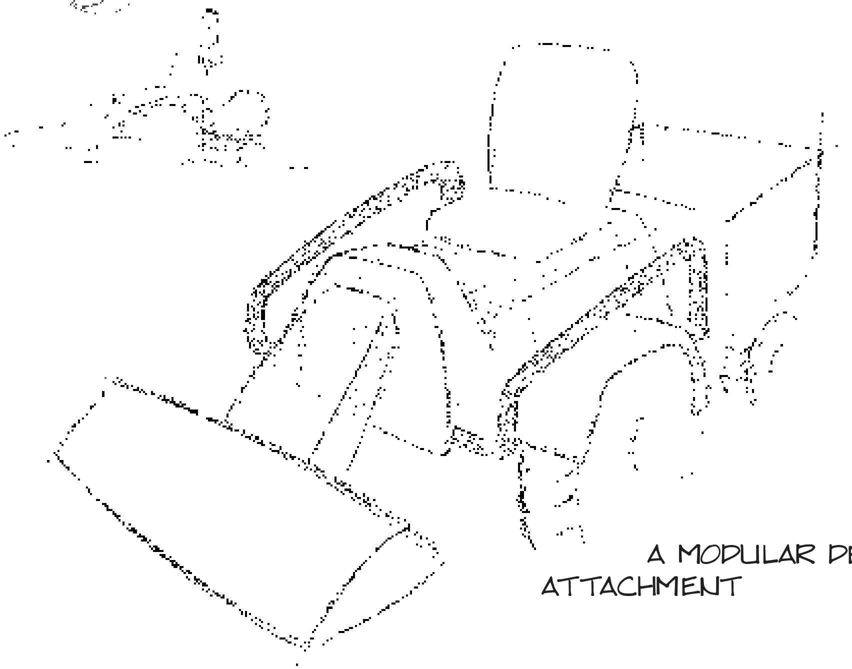
UTILIZING THE IDEA OF A CENTRE PIVOTED TRANSPLANTING DEVICE, THE ARM IS FIXED WITH AN AUGER AND HOLDERS WHICH CAN ACCOMODATE THE RESONANCE CUP AND THE SEEDLING DIFFUSER CONE TO CARRY OUT BOTH THE OPERATIONS WHEN REQURIED. THE CENTRAL HOUSING ACTS AS A STORAGE ASWELL.

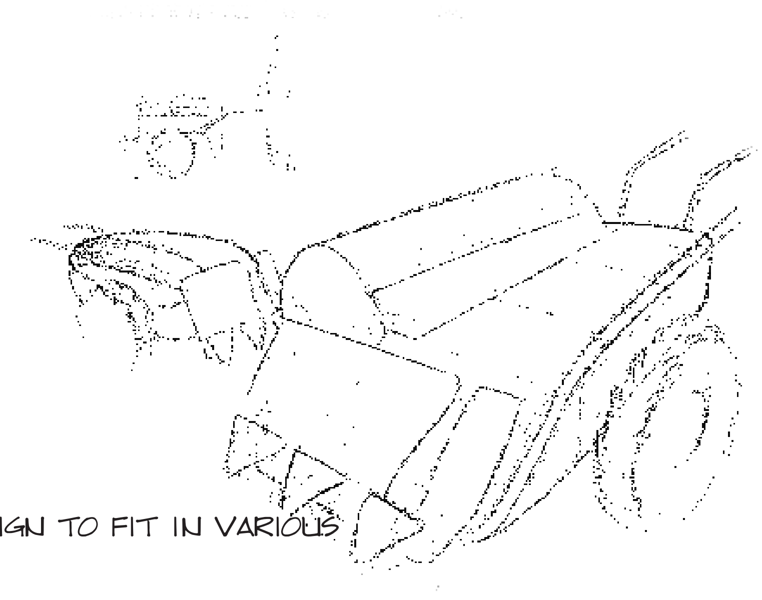
A JACKET WITH ATTACHMENTS FOR BOTH TRANSPLANTING AND HARVESTING



A TRANSFORMABLE MACHINE FOR TRANSPLANTING AND HARVESTING





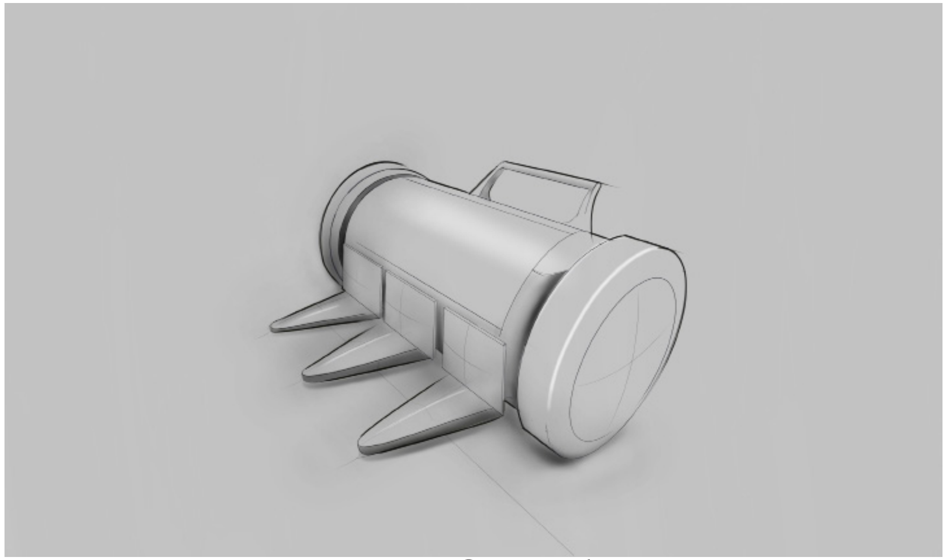


A MODULAR DESIGN TO FIT IN VARIOUS ATTACHMENT

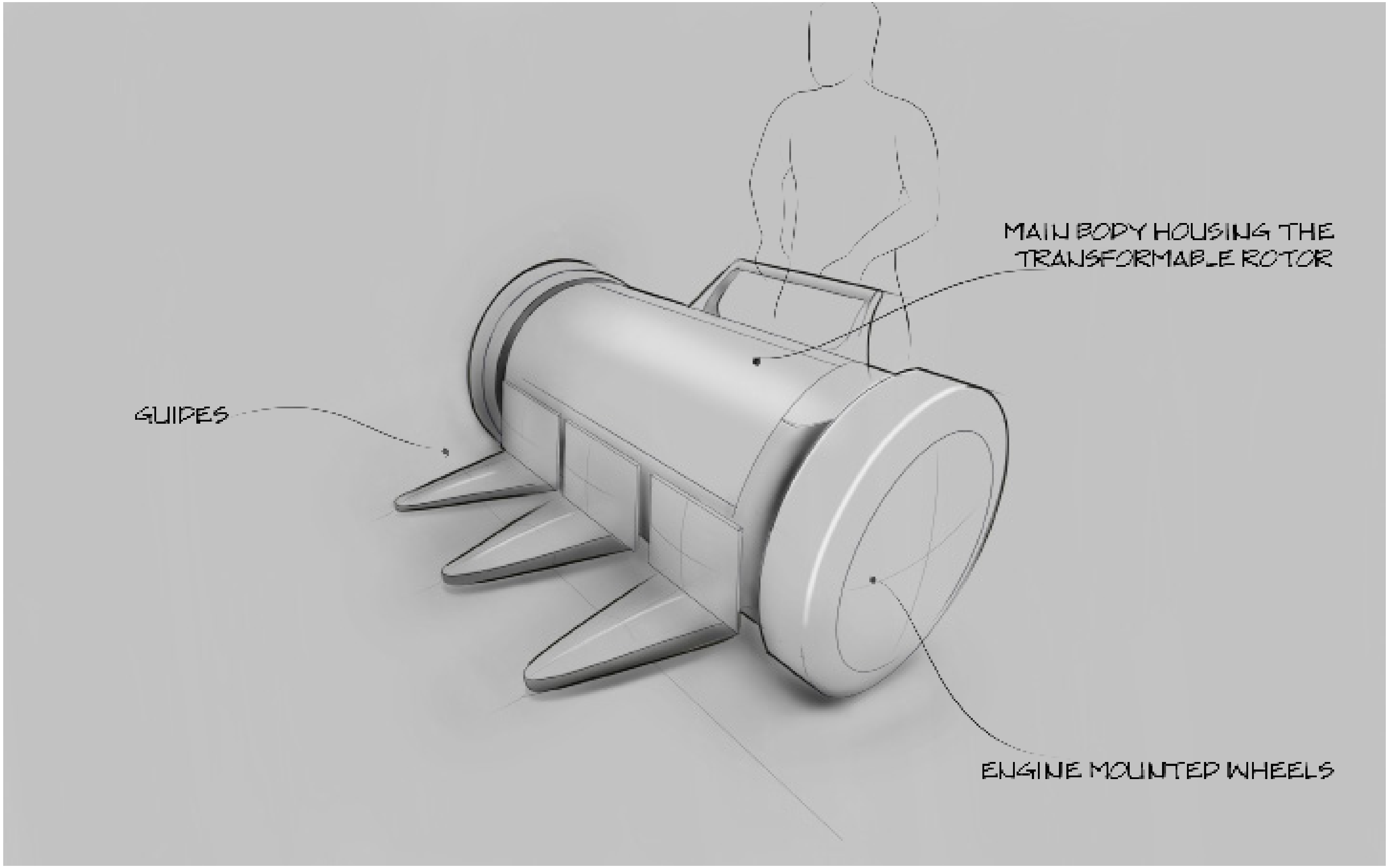
9. Concepts

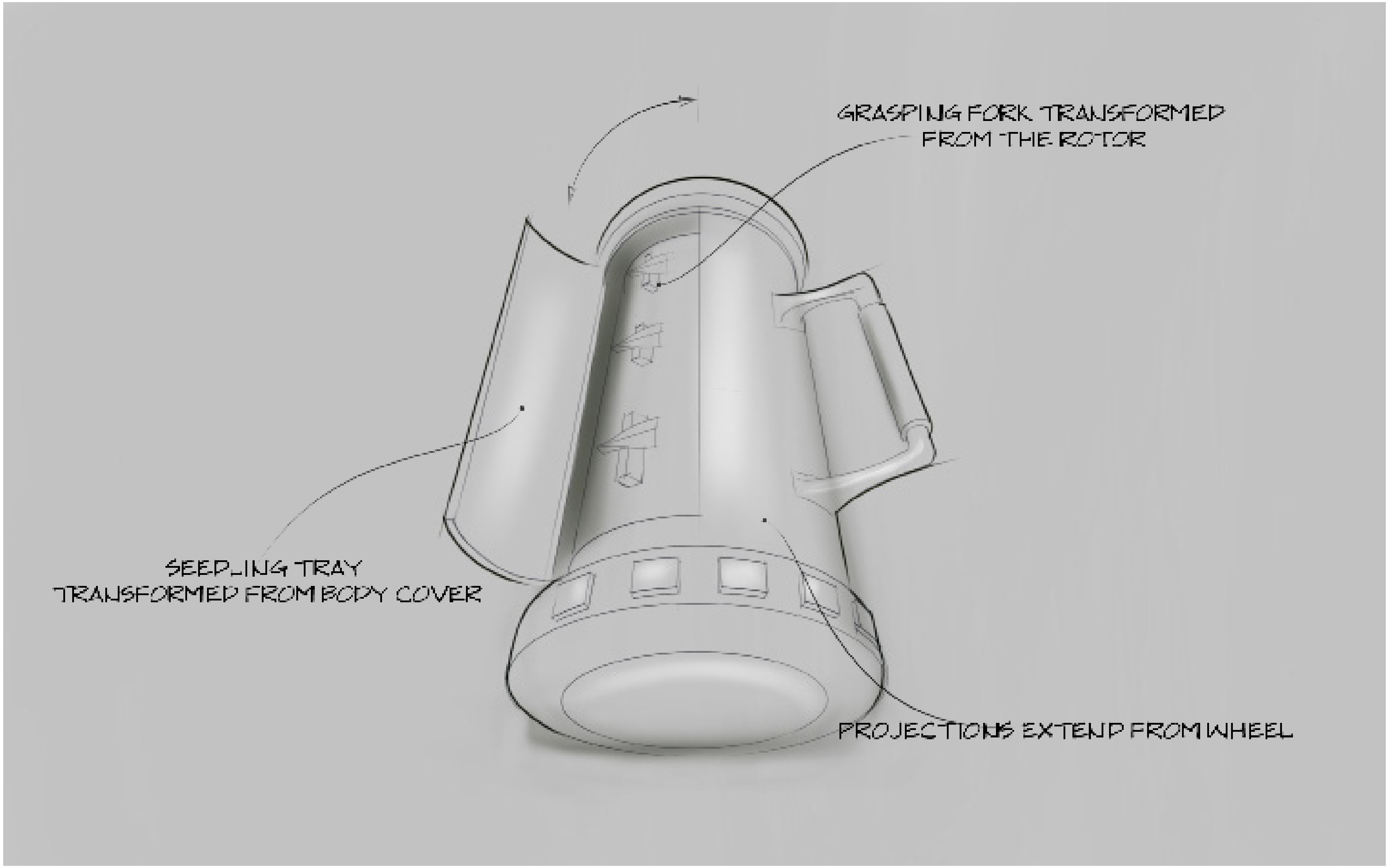
9.1 Concept 1

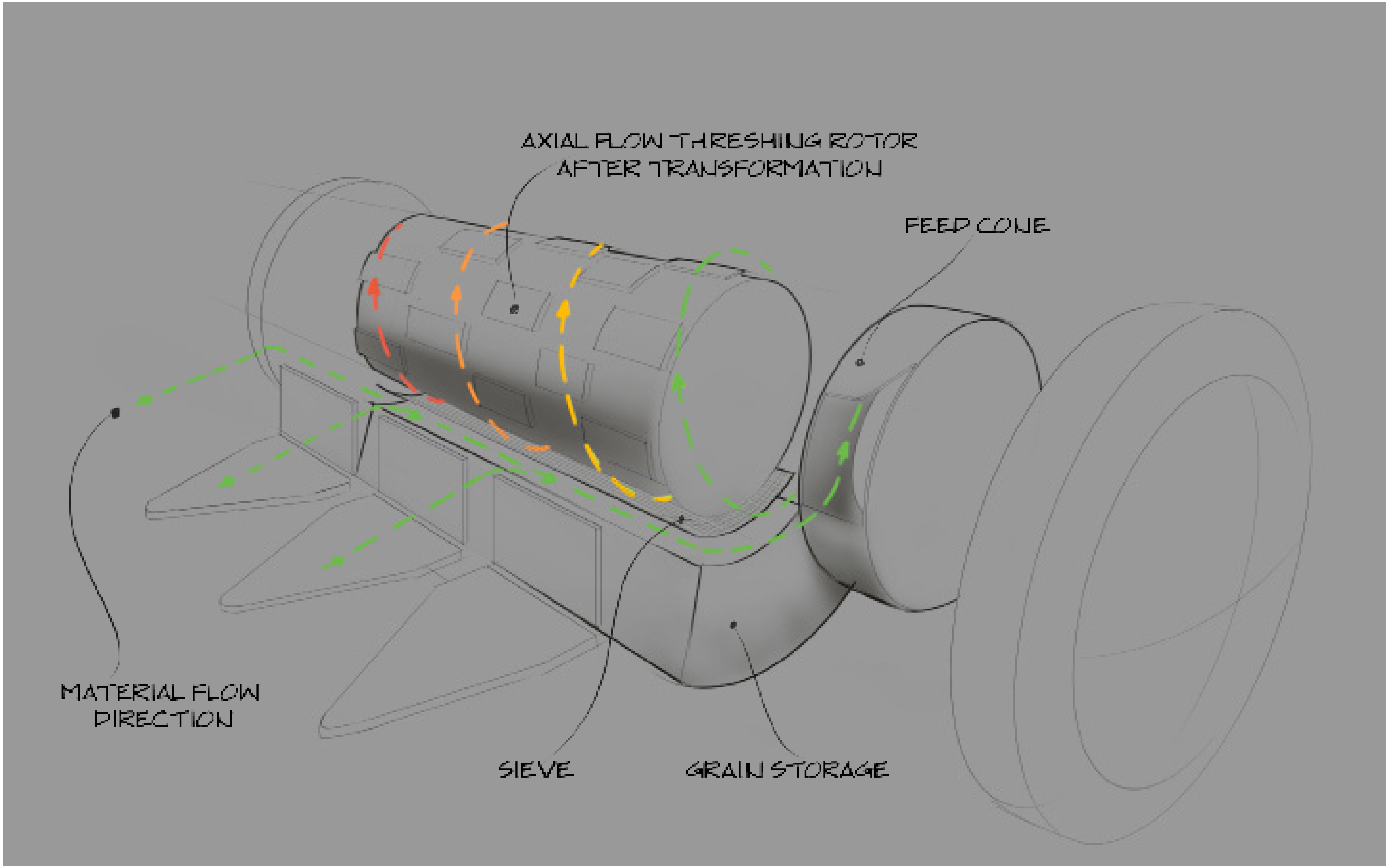
Concept 1 is inspired from the idea of transforming a device into multiple forms to carry out more than one activity. The common elements in harvesting and transplanting is identified and this is incorporated in a transformable rotor which acts as a threshing drum by projecting out pegs or tooths during harvesting. During transplanting the pegs transform into grasping fork. The outer body covering the transformable inner drum also transforms by acting as an enclosure during threshing and as a seedling tray during transplanting. The guides used during harvesting acts as floating board during transplanting. The details are explained in subsequent pages.

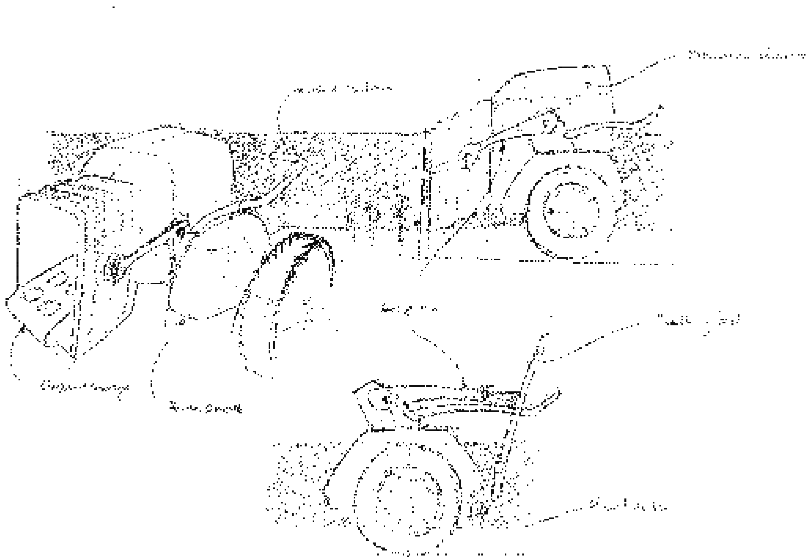


Concept 1


MAIN BODY HOUSING THE TRANSFORMABLE ROTOR
GUIDES
ENGINE MOUNTED WHEELS


GRASPING FORK TRANSFORMED FROM THE ROTOR
SEEDLING TRAY TRANSFORMED FROM BODY COVER
PROJECTIONS EXTEND FROM WHEEL


AXIAL FLOW THRESHING ROTOR
AFTER TRANSFORMATION
FEED CONE
MATERIAL FLOW
DIRECTION
SIEVE
GRAIN STORAGE

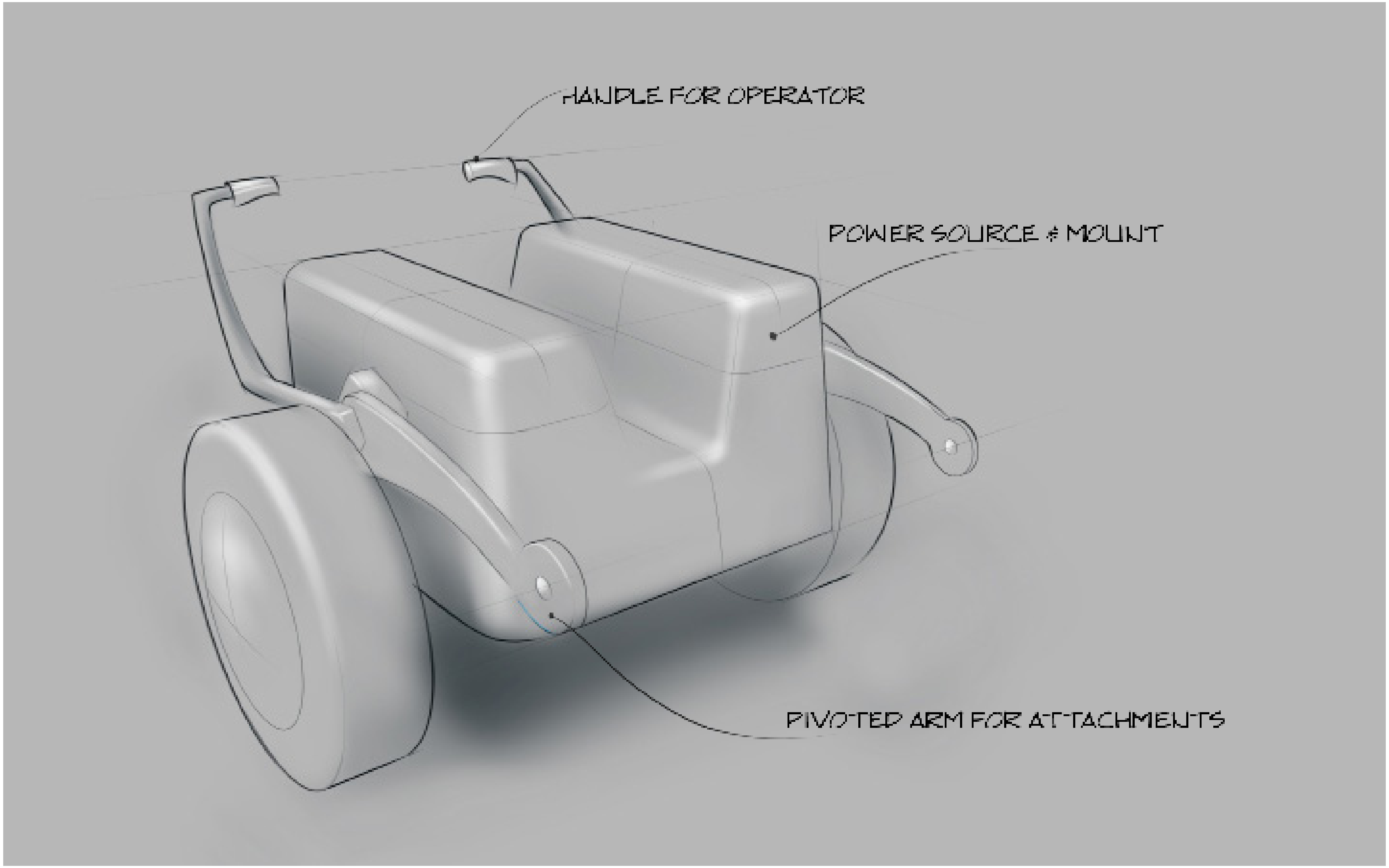


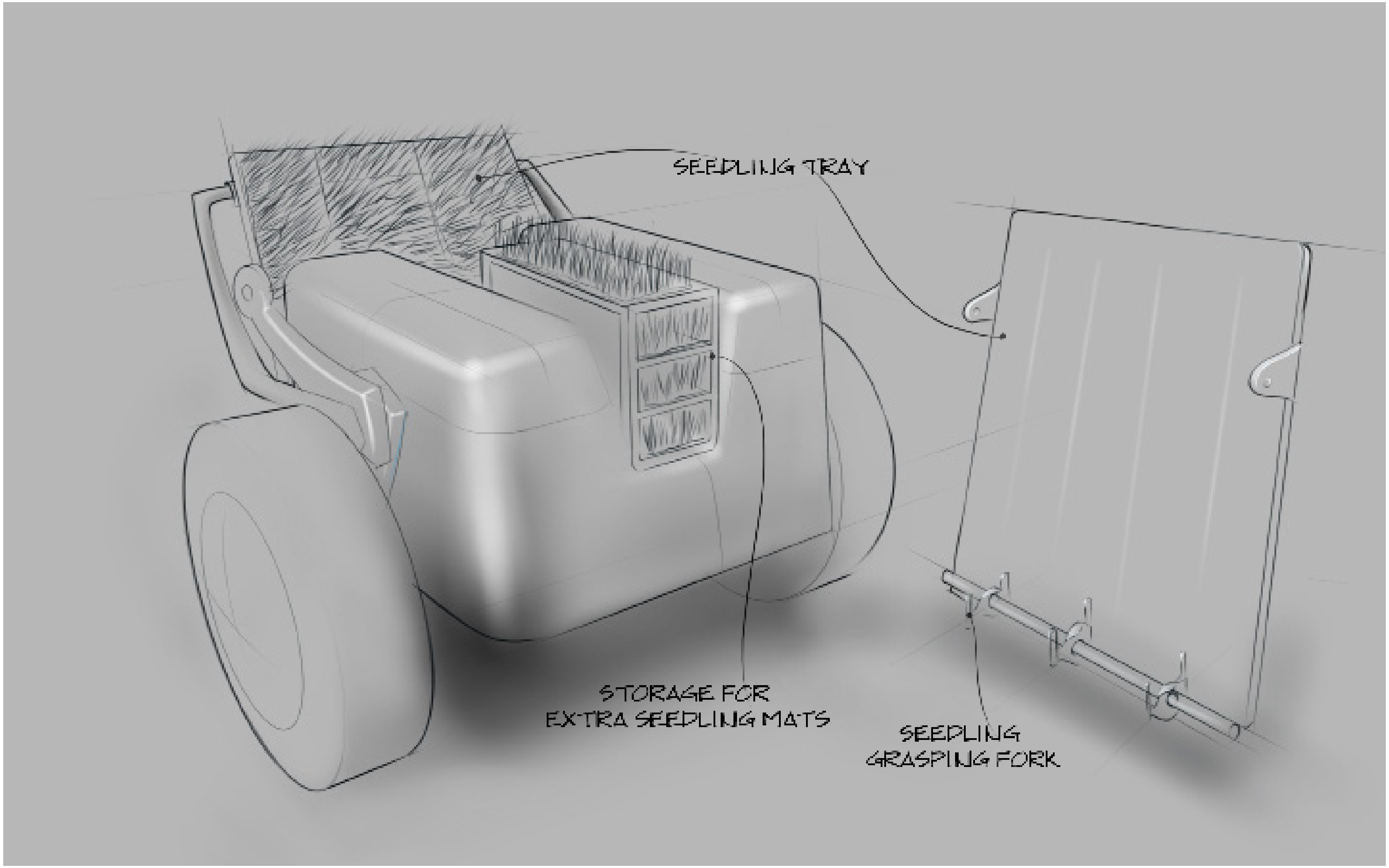
Concept 2

9.2 Concept 2

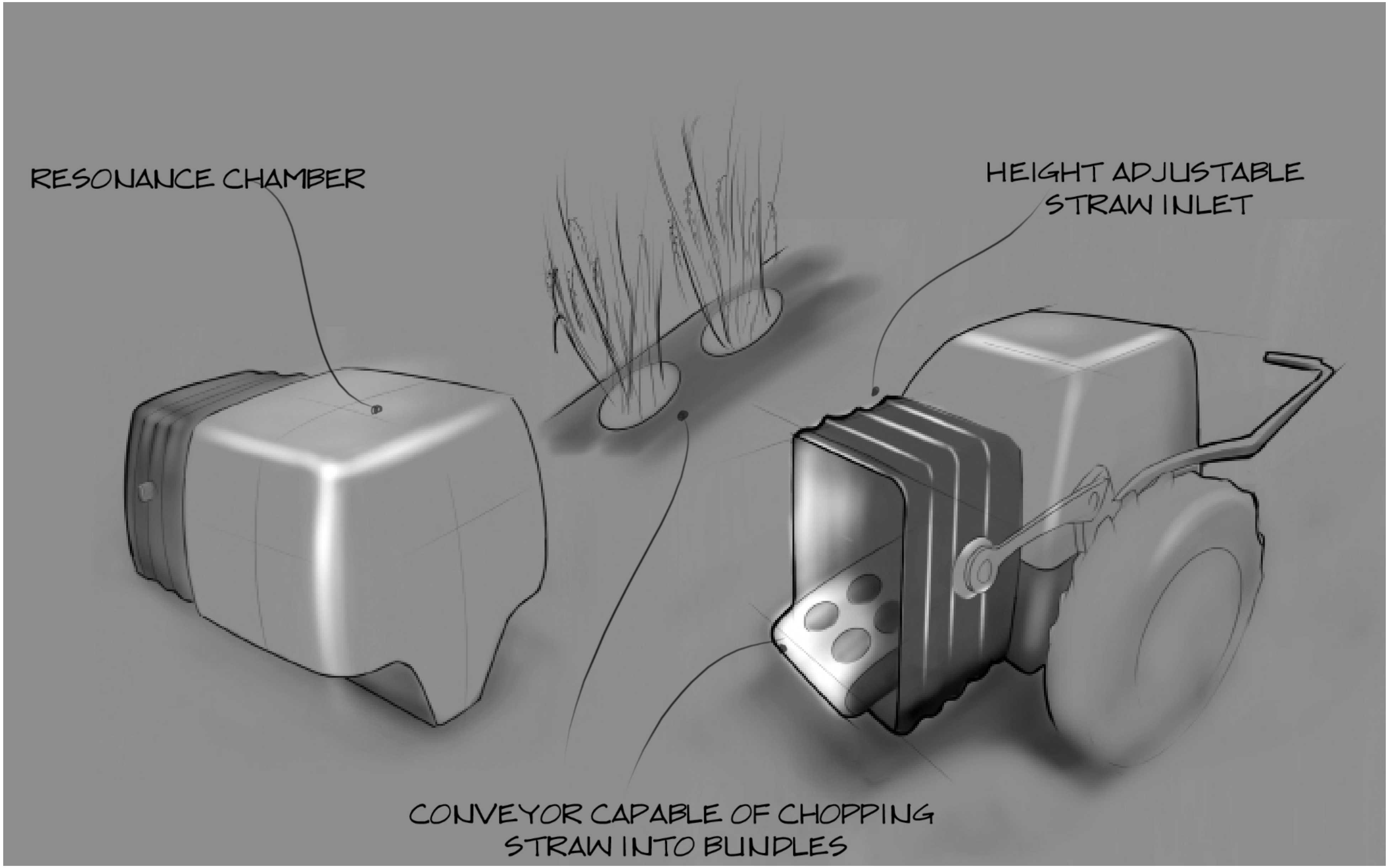
Concept 2 is a modular design where a power source is designed to accomodate transplanting and harvesting attachments. The transplanting is carried out by attaching the conventional transplanting tray and mechanism.

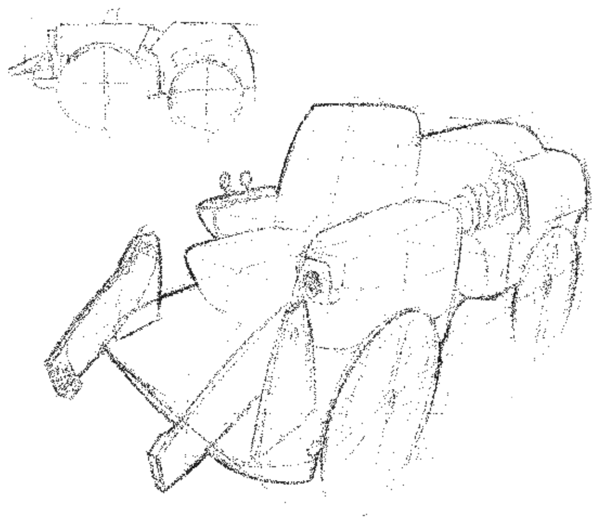
To carry out harvesting, a conveyor with chopping rings are proposed. These rings chop the plant from bottom and conveys it to a resonance chamber, where the bundle is excited with an external vibration equivalent to the natural frequency of the grain. This causes the falling of the grain from the plant to the storage box below due to the resonance phenomenon. The plant is then bundled and thrown out of the chamber. Further details are explained through sketches in subsequent pages.


HANDLE FOR OPERATOR
POWER SOURCE & MOUNT
PIVOTED ARM FOR ATTACHMENTS


SEEDLING TRAY
STORAGE FOR
EXTRA SEEDLING MATS
SEEDLING
GRASPING FORK

Concept -2


RESONANCE CHAMBER
HEIGHT ADJUSTABLE STRAW INLET
CONVEYOR CAPABLE OF CHOPPING STRAW INTO BUNDLES

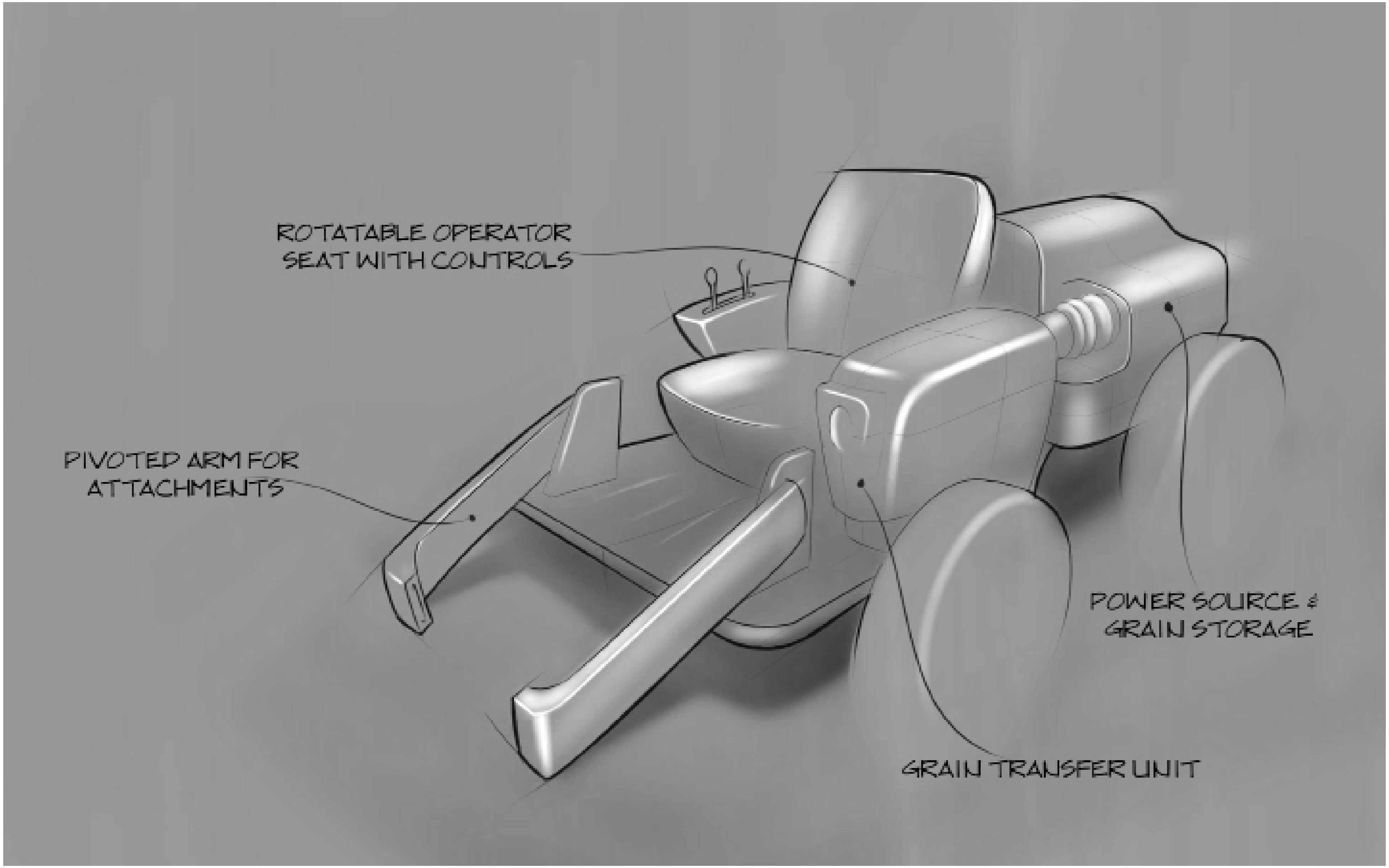


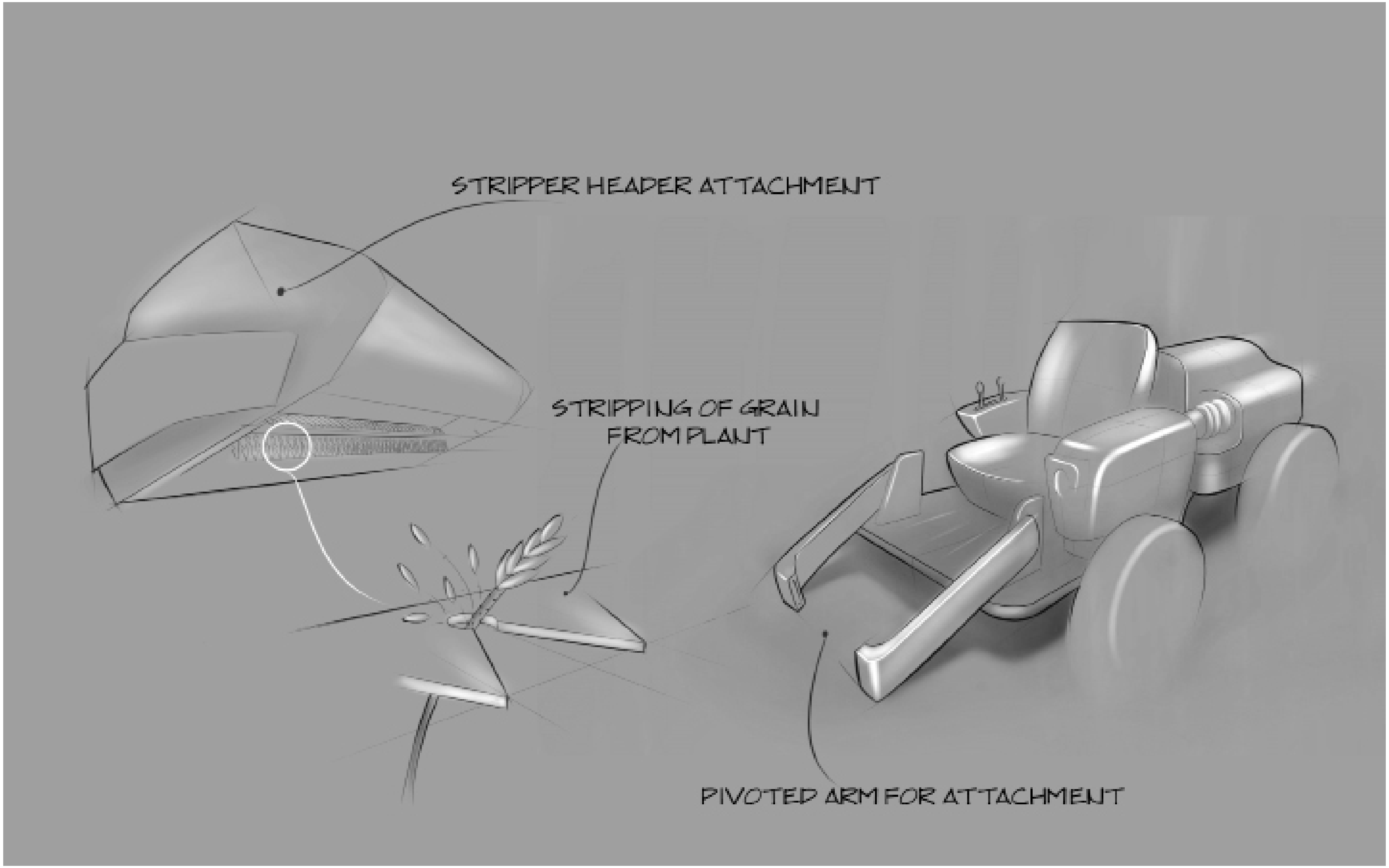
Concept 3

9.3 Concept 3

The concept 3 consists of two separate platform joined through an articulated steering mechanism. The idea is to isolate the operator from engine vibrations and also to achieve a lower turning radius.

The concept uses, stripper header to harvest the grain and the conventional mechanical transplanting attachment for transplanting. The attachments are fastened to the pivot arm during the required operation.


ROTATABLE OPERATOR
SEAT WITH CONTROLS
PIVOTED ARM FOR
ATTACHMENTS
POWER SOURCE &
GRAIN STORAGE
GRAIN TRANSFER UNIT


STRIPPER HEADER ATTACHMENT
STRIPPING OF GRAIN FROM PLANT
PIVOTED ARM FOR ATTACHMENT

10. Concept Evaluation

Criteria			Weightage (%)	Concept 1		Concept 2		Concept 3	
				Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score
Functionality (60%)	Transplanting (25%)	Flexible for planting parameters (spacing, depth)	15	1	0.15	2	0.3	2	0.3
		Reserve storage of seedling mat	10	0	0	2	0.2	2	0.2
	Harvesting (25%)	Separate and clean grain	15	2	0.3	2	0.3	1	0.15
		Storage space and ease of unloading	10	1	0.1	2	0.2	2	0.2
	Straw gathering (10%)	Cut long hay	6	1	0.06	2	0.12	0	0
		Make bundles	4	0	0	2	0.08	0	0
Performance (30%)		Work in muddy and dry field	6	2	0.12	2	0.12	2	0.12
		Handle corners	6	1	0.06	1	0.06	2	0.12
		Climb bunds upto 1m	3	2	0.06	0	0	1	0.03
		Traverse through narrow village roads (2m)	6	2	0.12	2	0.12	2	0.12
		Safety while handling during transportation	6	1	0.06	2	0.12	2	0.12
		Cheap mode of transport	3	1	0.03	2	0.06	2	0.06
					0		0		0
Maintenance (10%)		Easily replaceable parts	6	1	0.06	2	0.12	2	0.12
		Local resources for repair	4	1	0.04	1	0.04	2	0.08
			Total		1.16		1.84		1.62
			Rank	3		1		2	
Feasibility		Feasibility of deploying the technology immediately	50	1	0.5	0	0	2	1
		Affordability in realizing the technology	50	1	0.5	1	0.5	2	1
			Total		1		0.5		2
			Rank	3		2		1	

0-does not satisfy, 1- satisfies upto 50%, 2- satisfies above 50%

Table 10-1. Concept evaluation

11. Final Concept

The idea behind the final concept is to have a platform which can be attached with the harvesting or transplanting devices depending upon the seasons and thereby avoiding the need for specific purpose machines. Through this the problems arising from seasonal usage and smaller land size will be resolved as the solution maximizes the usage of the machine. This modular design also brings in the flexibility in the intial investment as there is scope for gradual upgradation based on functional requirements. The machine is also designed for the custom hiring centres making it affordable for the end users. This ultimately achieves the goal of maximizing the profit through mechanization. In addition to this the size of the machine is also accounted for to ensure the machine is compact enough to access and at the same time economically viable for marginal land holdings. During the process an effort is also made to balance the aspirations of the user and the feasibility of realizing the product in the near future. This journey of refining the basic concept to realize a product is carried out in different stages and the discussions on this continues below.

11.1 Stage-1

The process involves collecting information to visualize the components and how each of these individual sub systems will build up the whole. The refinement of the selected concept is also carried out during this phase.

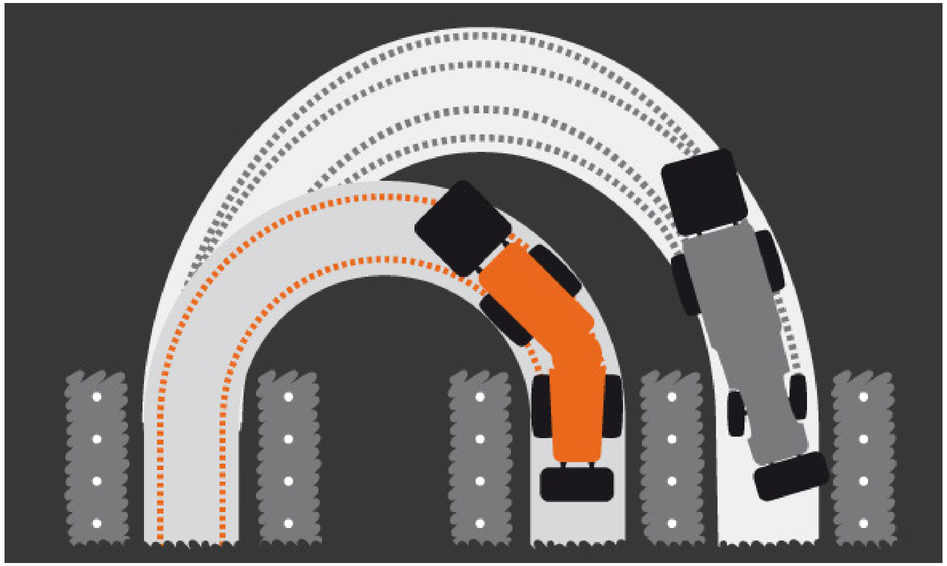


Figure 11-1: Schematic of lower turning radius achieved through articulated steering[20]

Figure 11-2: A stripper header attachment[21]

11.1.1. The Layout

The machine is split into two parts, the operator area and the power source area. The two parts are on separate platforms and are connected at a pivoted joint housing the articulated steering. This approach is taken by considering the advantages of isolating the operator from the engine vibrations and the temperature and also to take the advantage of the lower turning radius of articulated steering mechanism (Figure 12-1) which is crucial while transplanting and harvesting operations.

11.1.2. Attachments

The machine consists majorly three attachments, i.e., the stripper header, the threshing and grain storage unit and the transplanting mechanism. The choice of attachments such as a stripper header (Figure 12-2 and Figure 12-3) is to ensure there is minimum material handling as only grain with minimal chaff is stripped from the head of the plant and brings in ease of threshing which ultimately results into a compact and less complex system. The threshing unit comprises of an axial flow threshing drum and a vacuum pump with airlock mechanism to transfer the material from stripper header to threshing chamber. The axial flow thresher also ensures maximum separation of grain as the contact time between material and thresher is more when compared to tangential flow threshers. The transplanting is carried out by attaching the currently available transplanting mechanism which is widely used in the existing rice transplanters. The current model proposes a 6 row transplanting mechanism which makes the machine equally useful for smaller and bigger land holdings and thereby maximizing the usage of machine during the season. A detailed description of the attachments and the technology is carried out in chapter 5.

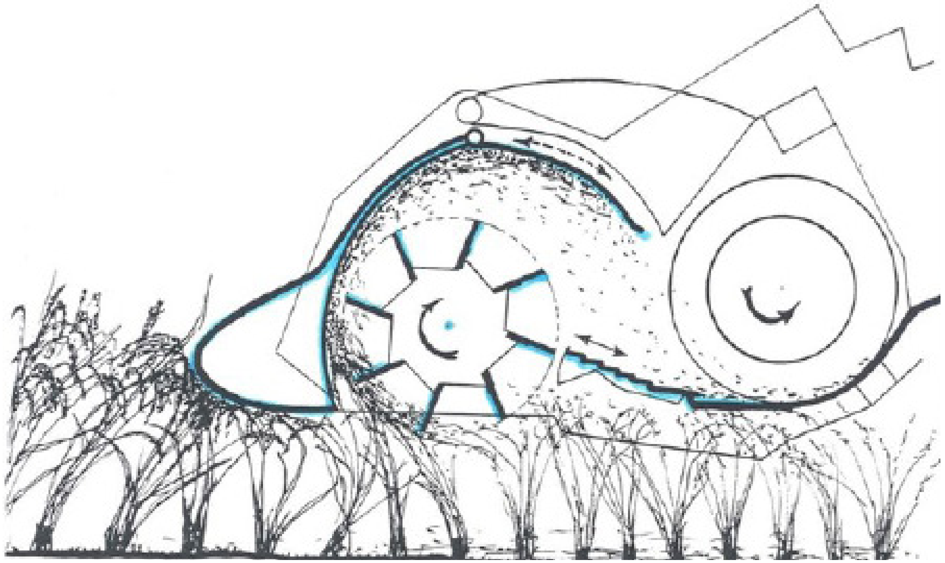


Figure 11-3: A schematic of stripper header working mechanism[14]

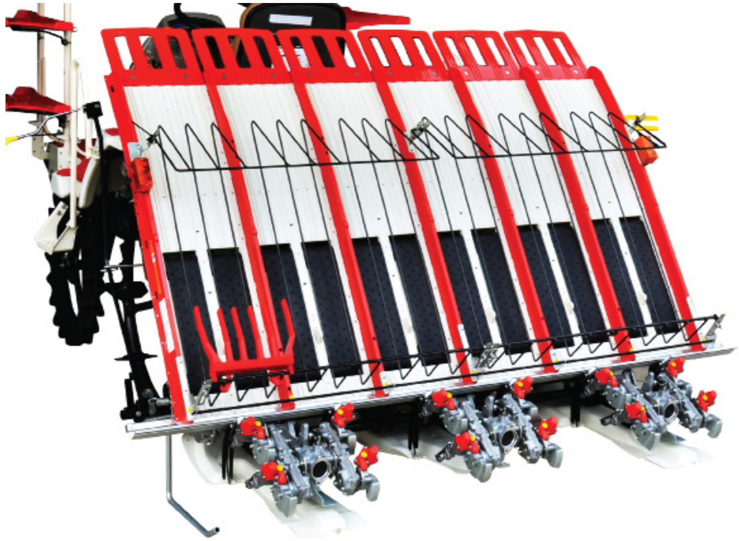


Figure 11-4: A rice transplanter seedling tray[22]

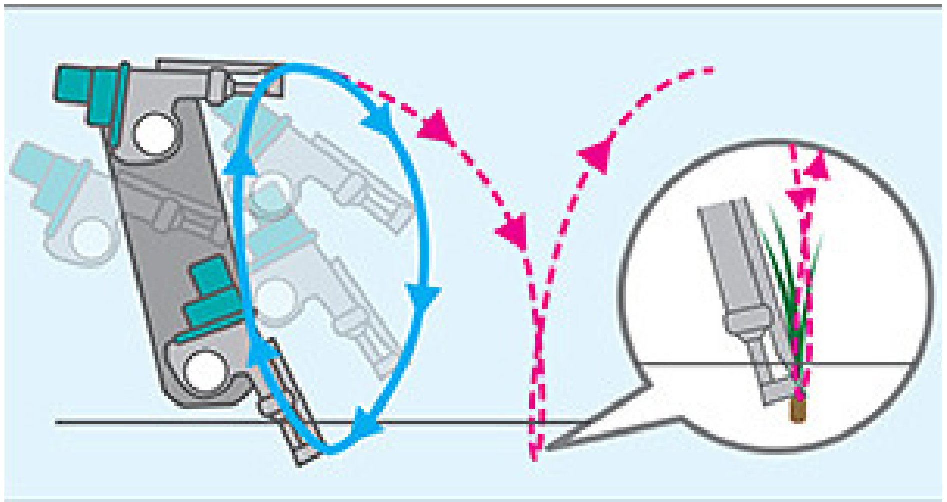


Figure 11-5 Kubota rice transplanting mechanism [28]

11.1.3. Technology

A brief description on the thoughts of choice of technology is discussed here. Starting with the power source, the potential of fuel cell was found quite exciting, also the changing trends like diesel-electric drives in tractors, hydrostatic transmissions etc. were studied. The current project proposes a diesel engine to drive the hydraulic system to carry out the various operations. The studies also reveals that the hydraulic systems are less compact and cost effective compared to electric drives and is widely used in most of the agricultural machines. Based on the potential of hydraulic system and the current trend, the machine uses hydrostatic drive (Figure 12-5) for motion and the articulated steering mechanism (Figure

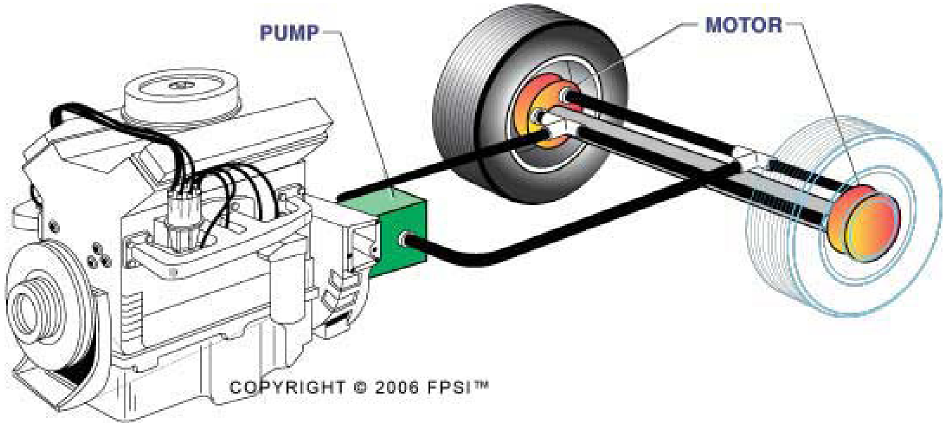


Figure 11-6 Hydrostatic drive system[23]

Figure 11-7: Articulated steering mechanism[24]

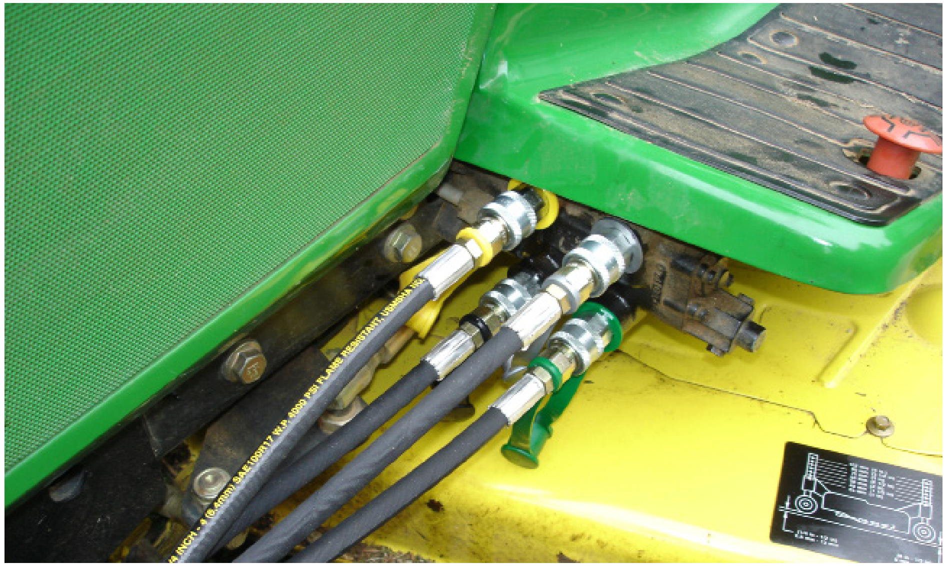


Figure 11-8: Plug in valve[25]

Figure 11-9: Honda internal combustion engine[26]

Figure 11-10 Existing wheel dimensions used in machines operating in mud[27]

12-6) is also hydraulics driven. The power transmission to the attachments are carried out through the plug in valves (Figure 12-7) commonly used in many of the agricultural machines.

11.1.4. Dimensions

To understand the overall dimensions of the machine the dimensions of various elements such as the power source, the minimum operator space as per the Indian standards (IS 11115 1999, IS 12343 1998) and the ground clearance available in other machines operating in muddy fields are considered. Similarly the dimension of other components such as threshing drum, hydraulic actuators, impellers etc. are also considered for the process. The data used from Indian standards are provided in Appendix 2.

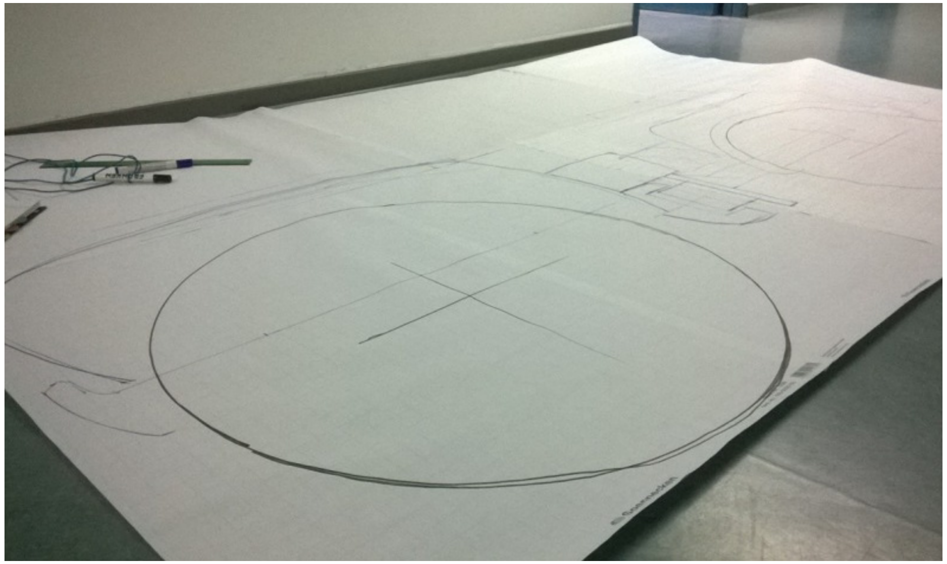


Figure 11-11: 1:1 sketch developed to visualize the size of the machine

11.2 Stage-2

The data collected in stage-1 is the foundation for the realization of the product for the targets set in terms of requirements, aspirations and the context. This data collected is taken forward to make a basic structure of the machine starting from the chassis, the position of seat and operator space, the power source, the tyres and the threshing unit. This developed a basic layout of the machine in terms of position of various parts and the volume occupied by each. And the process continues further to refine and optimize the space and components by incorporating various changes while exploring the available technologies for various systems.

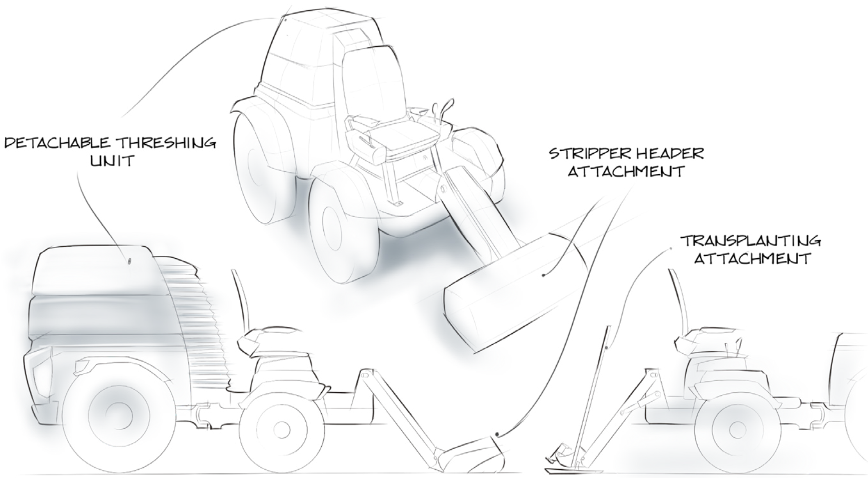


Figure 11-12: Refinements in the concept

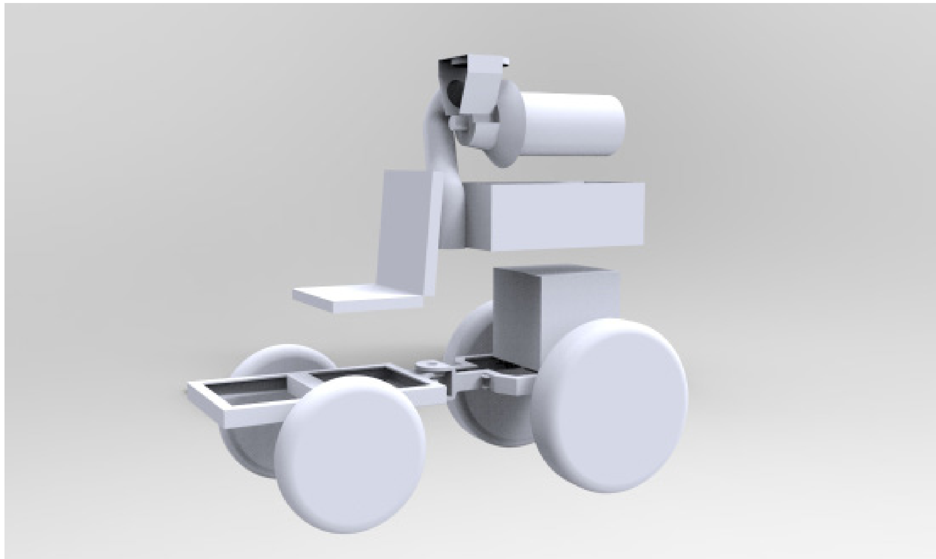


Figure 11-13: CAD model to understand the volume and layout

11.3 Stage-3

During this stage the process was to package the various functional systems to bring in the desired aesthetics and safety features. The operator needs, the ease of handling the components, human machine interaction were addressed during this stage. The explorations are depicted in the following pages. And the discussions on the final output will proceed thereafter.

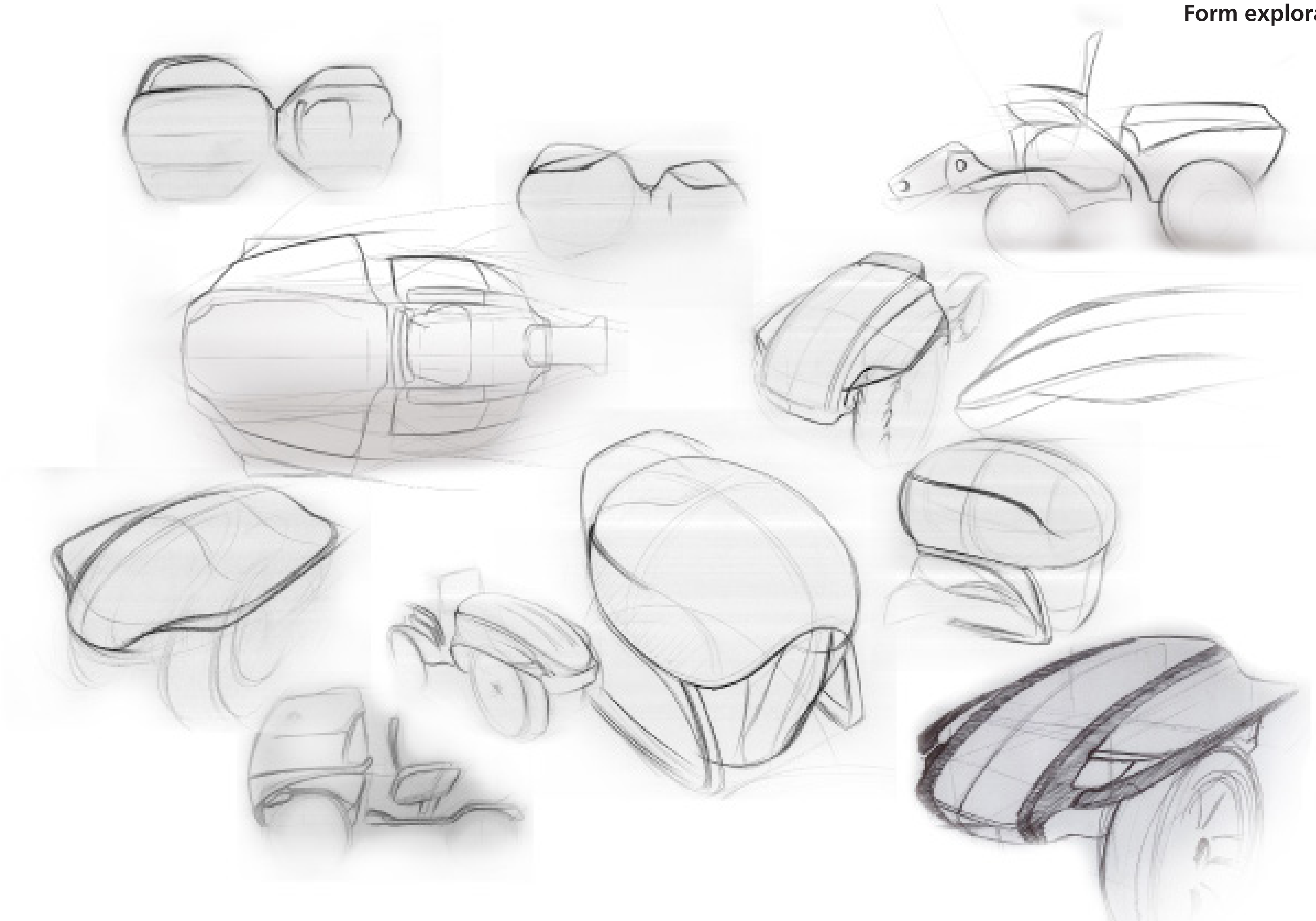
Keyword : Strong

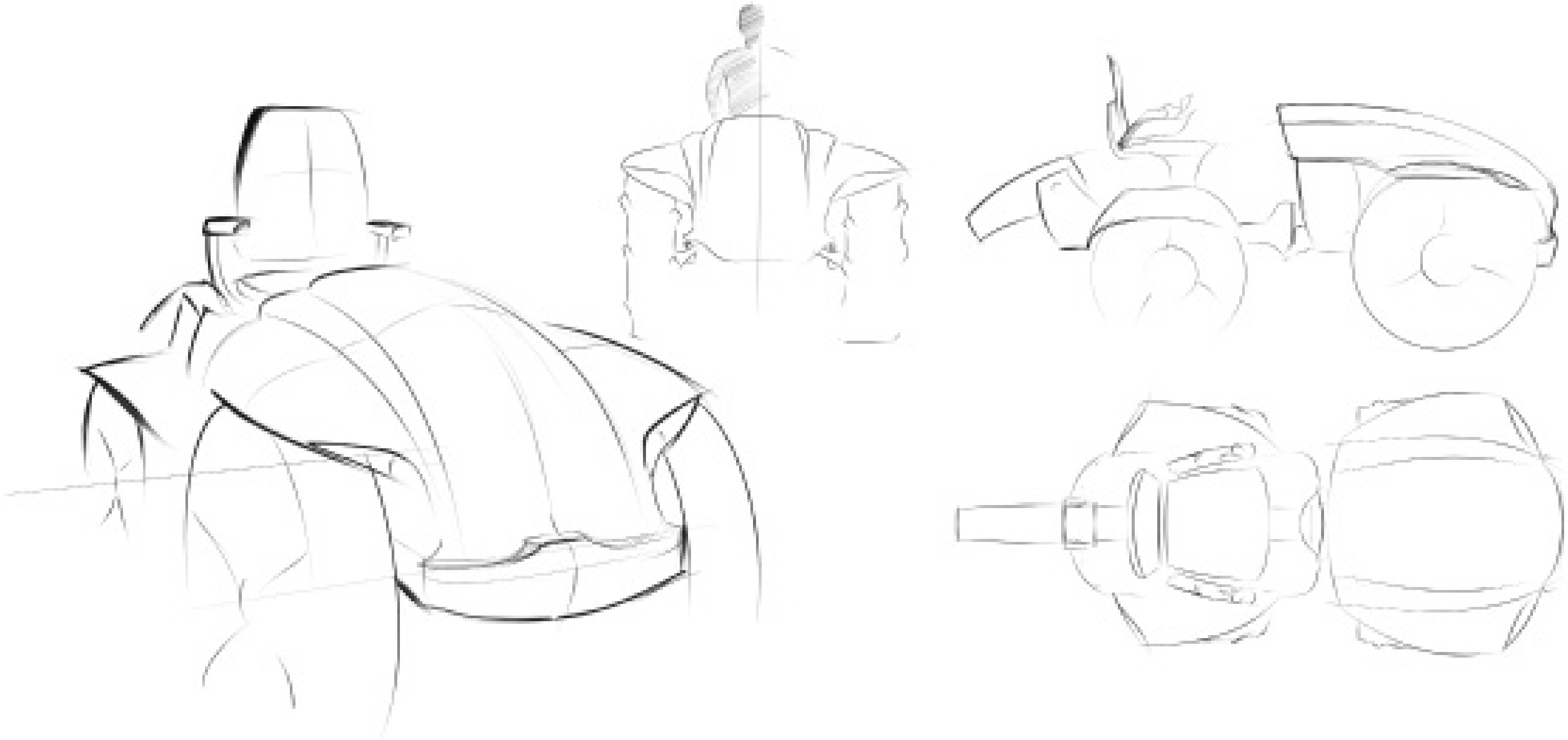


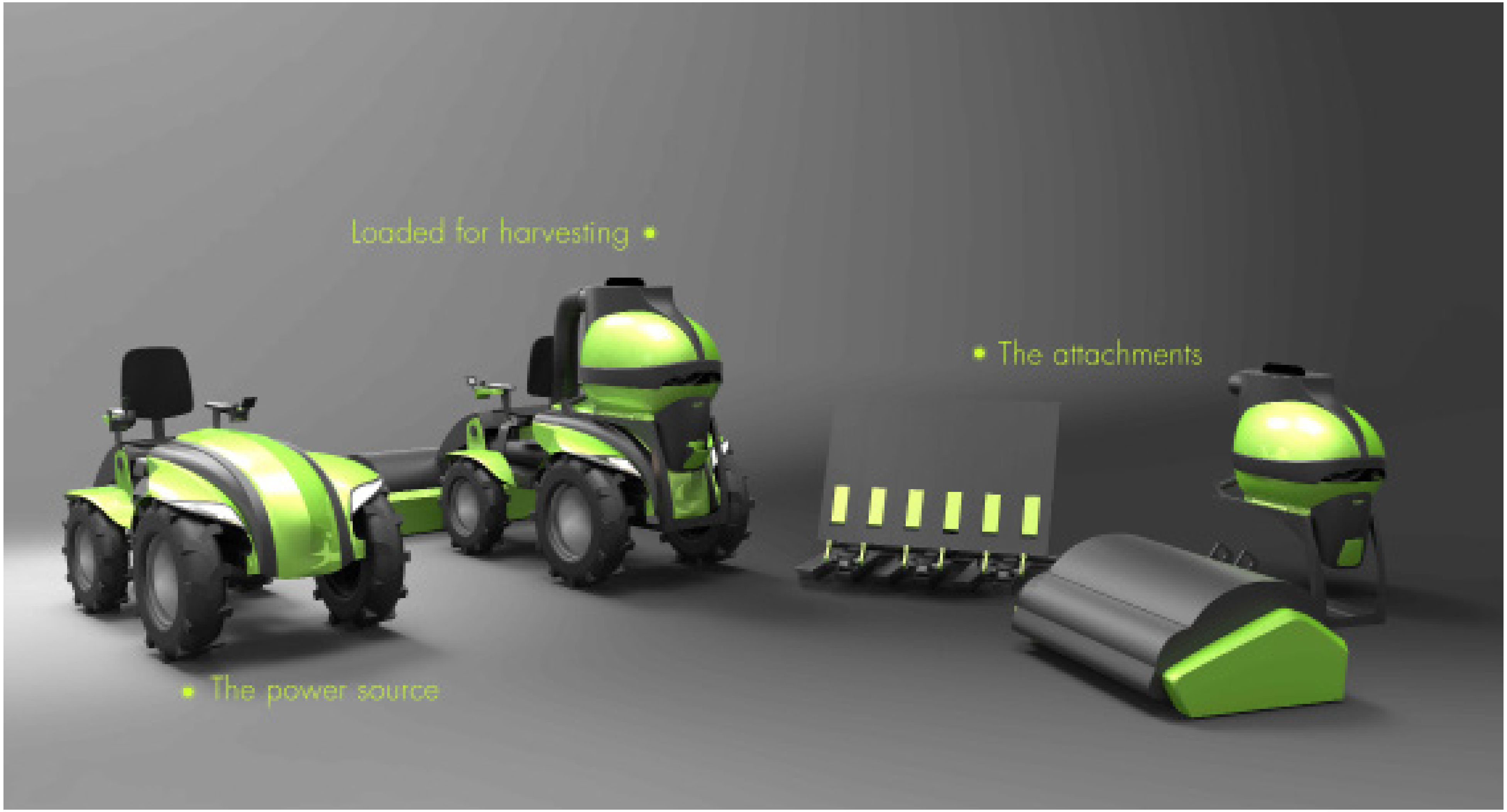


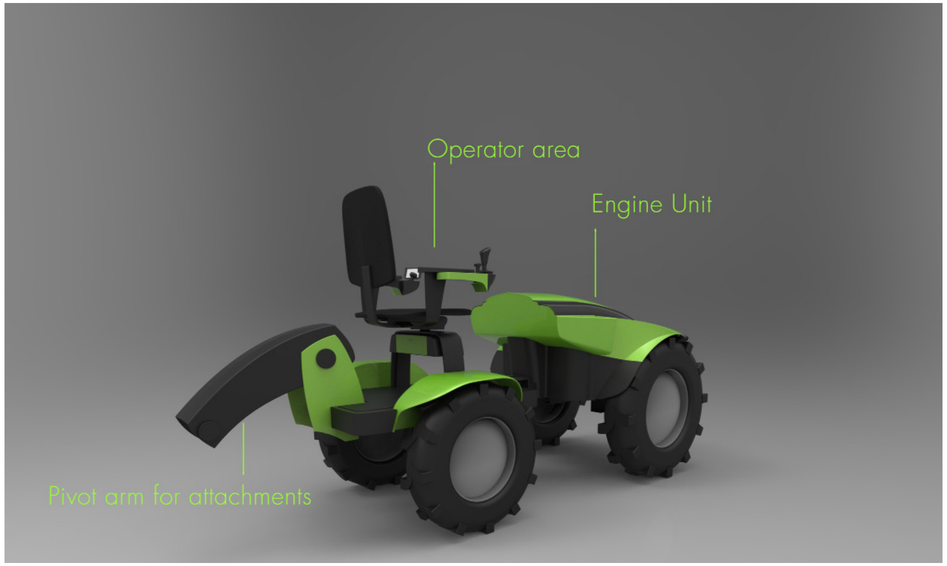



Form exploration



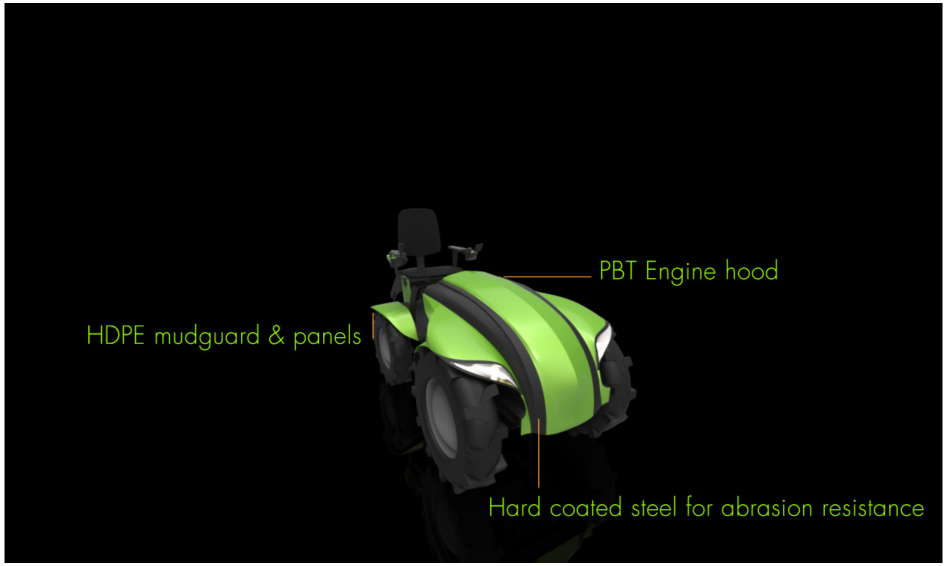



Loaded for harvesting
The attachments
The power source



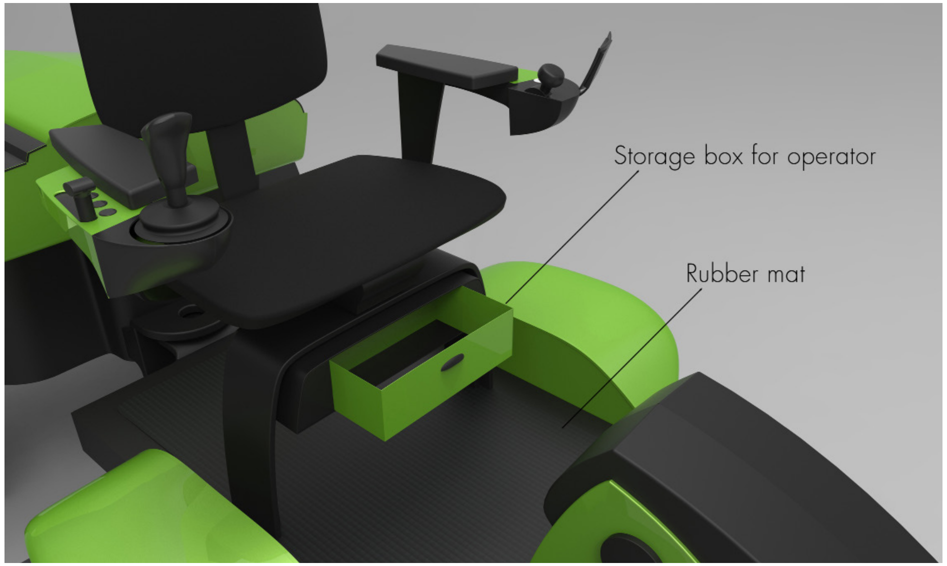
The power source

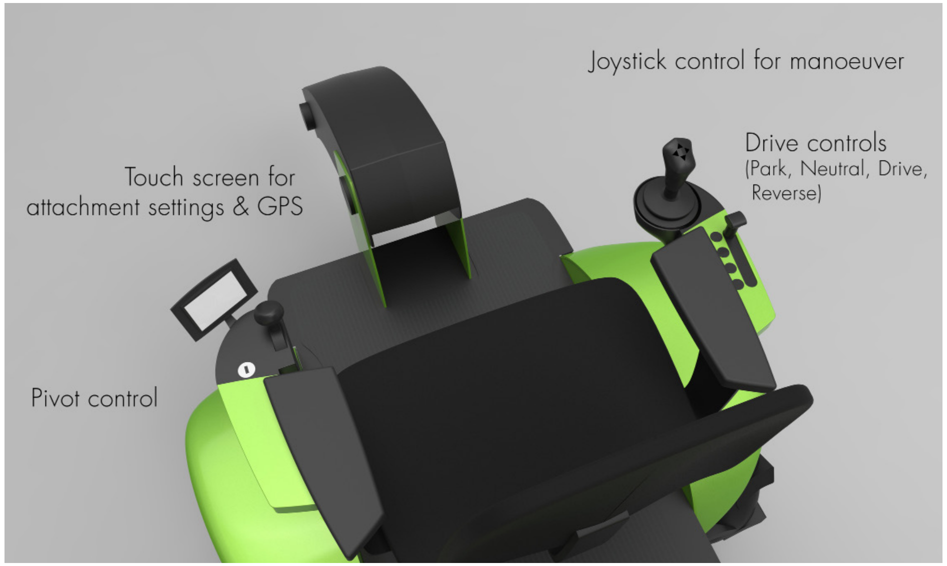
This is the core of the machine where the power is generated and transferred to various attachments. The operator platform, the engine and power delivery unit and the pivot arm for attachments are the major components.



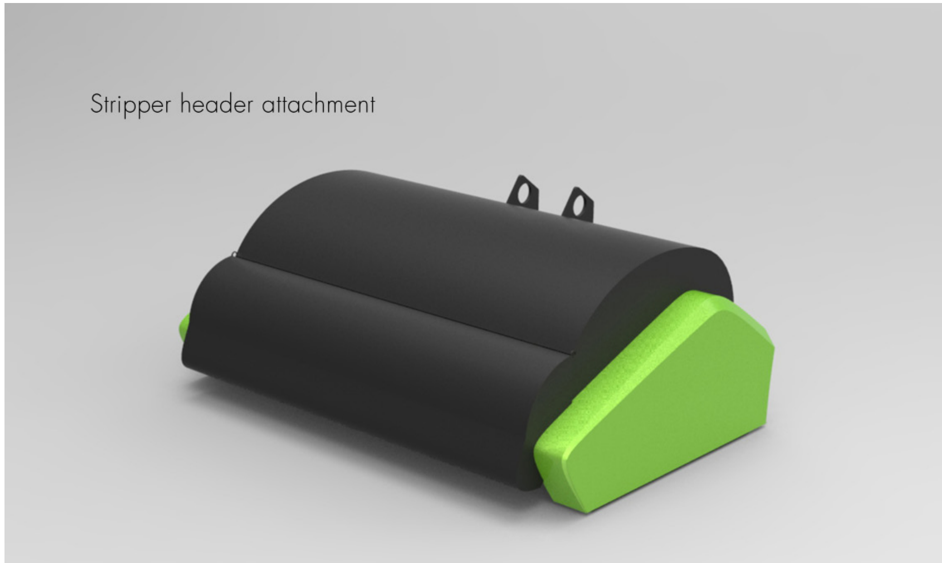

1400mm
1060mm
2800mm

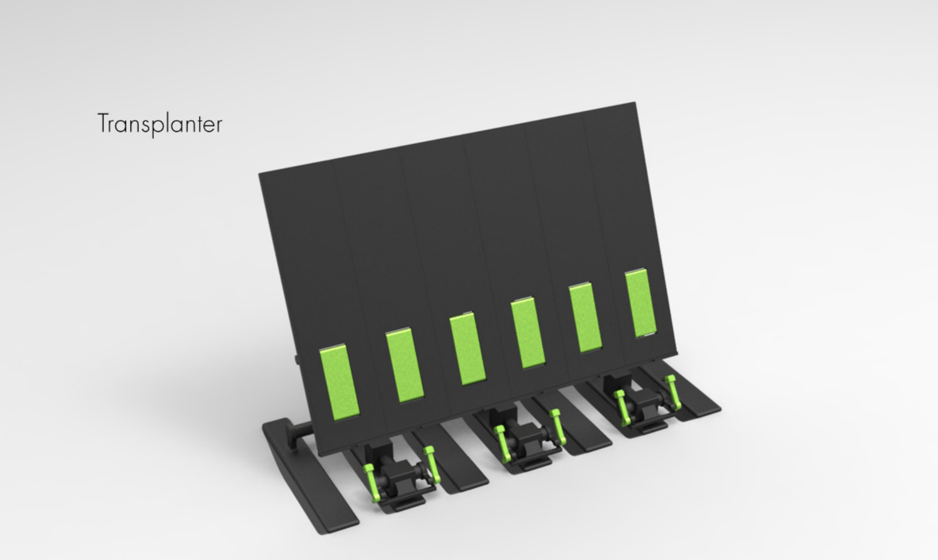
The operator space

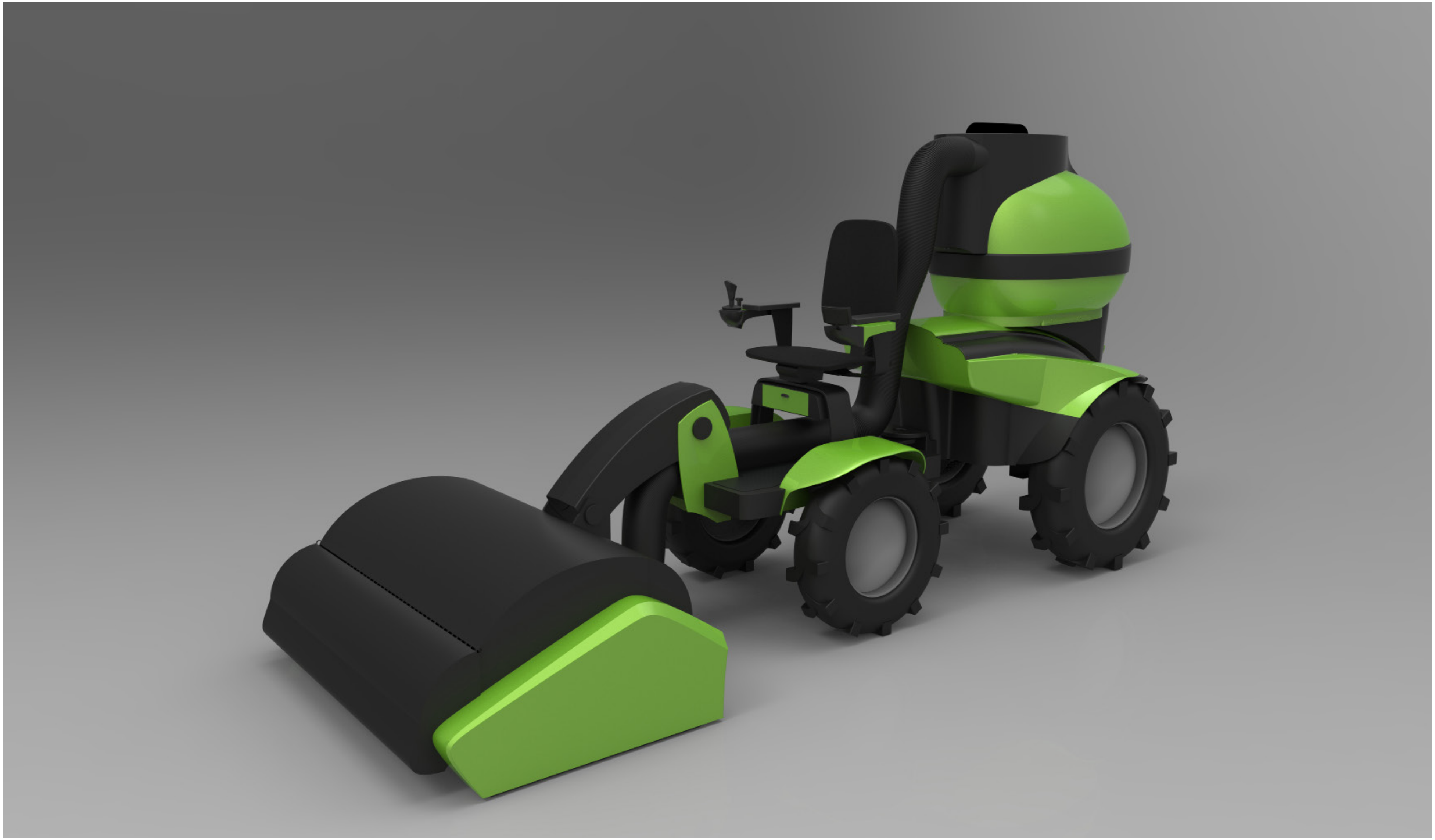


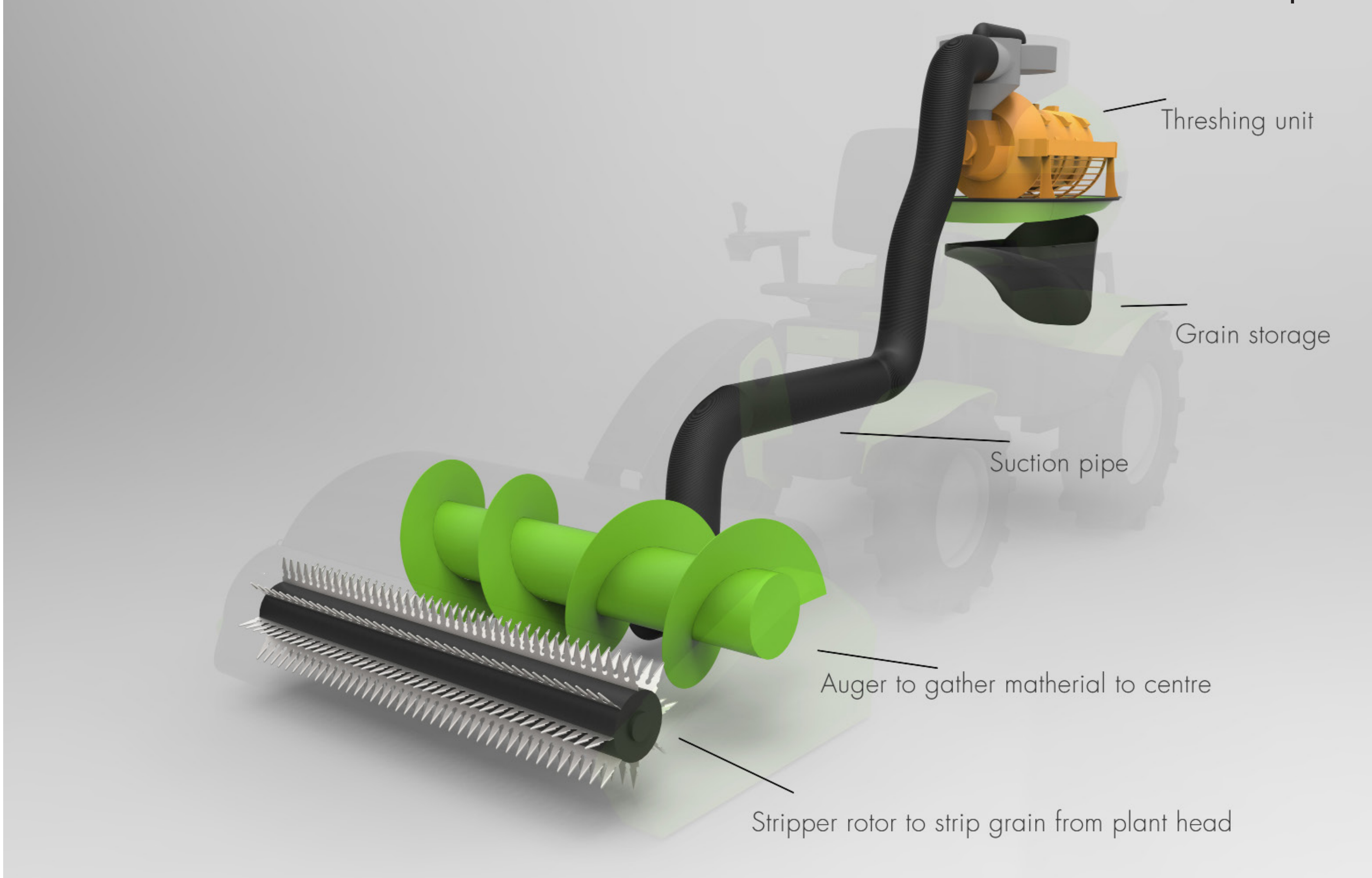


The attachments

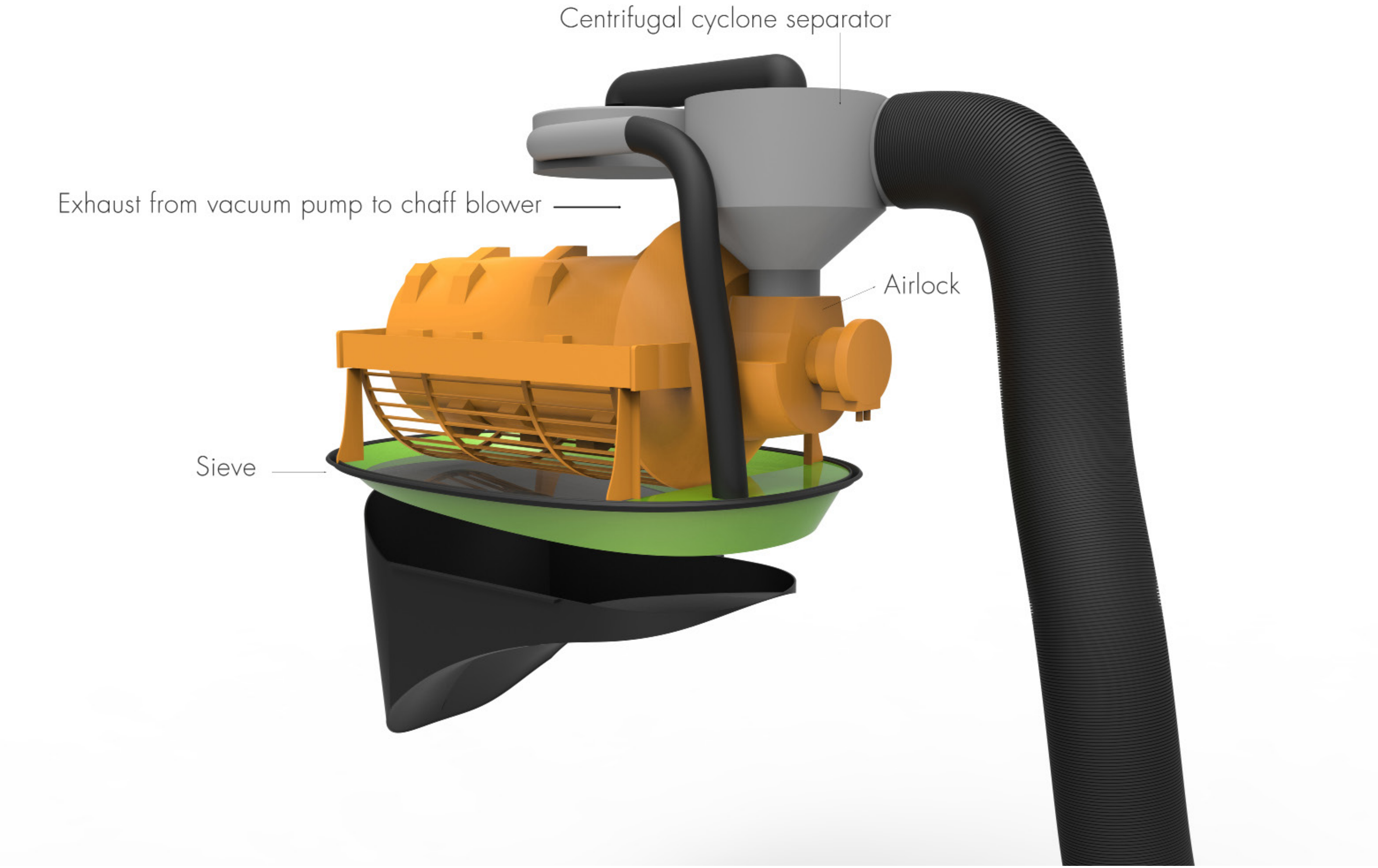




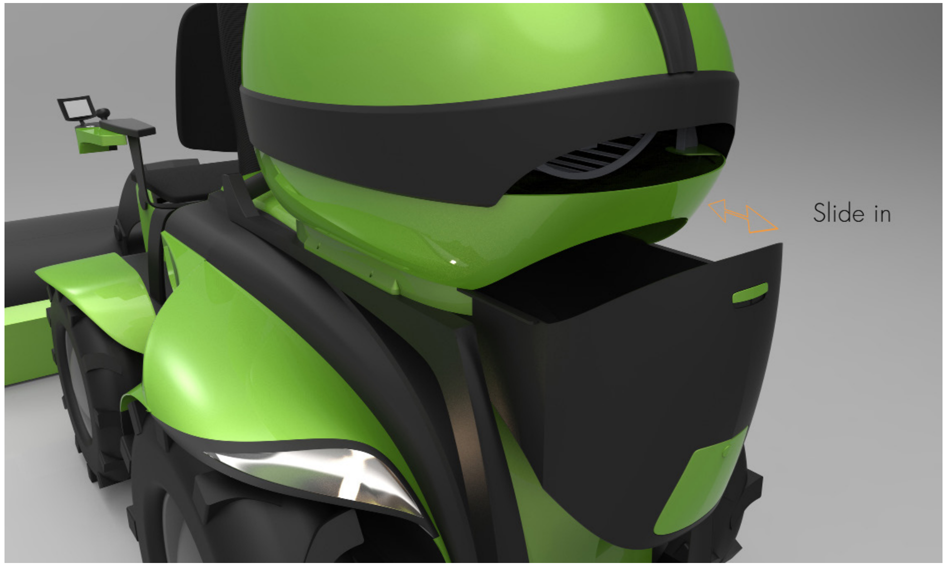



Threshing unit
Grain storage
Suction pipe
Auger to gather matherial to centre
Stripper rotor to strip grain from plant head

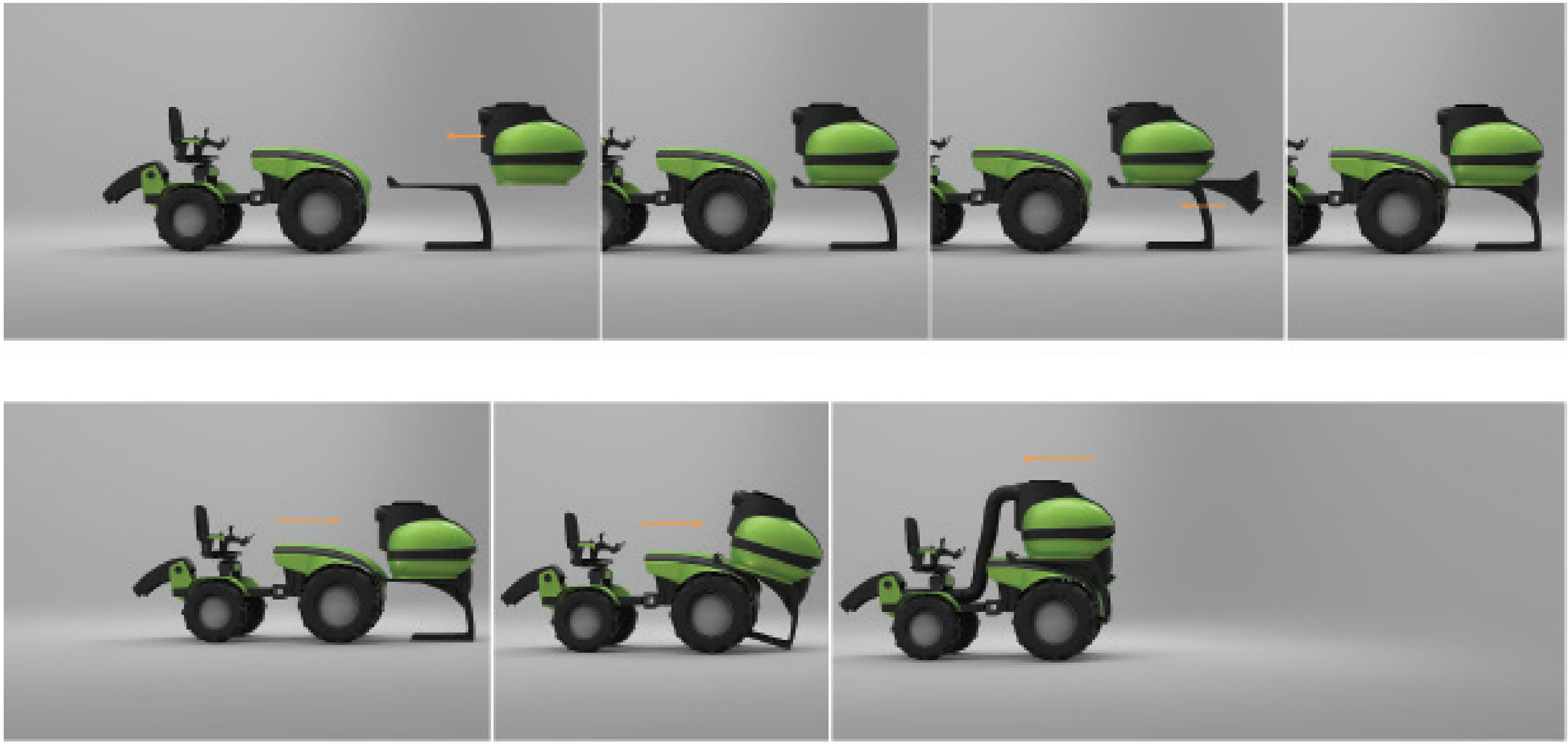
A close view of threshing unit



The grain storage box

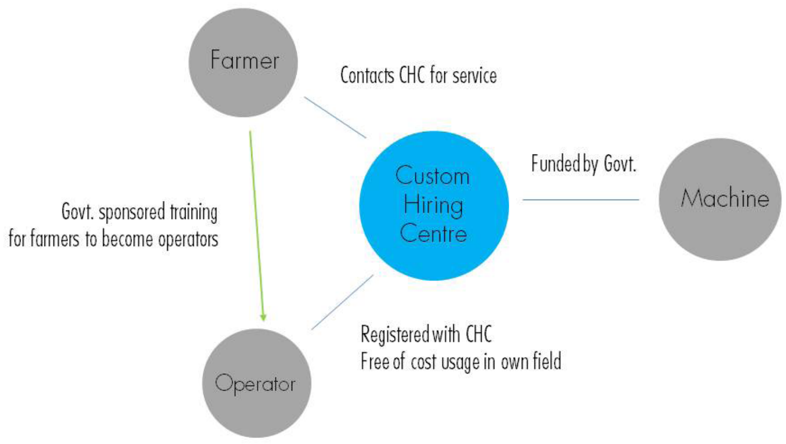


Loading of threshing unit



The transplanting mode

Scheme of operation



The machine is designed for custom hiring centres (CHC) by central government or for the entrepreneurs interested in setting up own business to cater to the needs of the farmers. In case of the government funded CHC, the farmers are encouraged to undergo training in the usage of machine. This ensures a pool of operators during any time and also helps in the fast pace of mechanization.

Apart from the farmers, interested individuals are taken in for training. The training programme is sponsored by the government and the operators have the benefit of using the machine for free in their land. The machine is funded and by the CHC and the income raised from the services are used for the maintenance of the machine and operators.

It is also proposed for a farmer and CHC networking among the nearby localities where the proximity of the machine and the tracking of availability is made possible through utilizing the upcoming schemes of central government such as ‘Digital india’. This ensures an efficient and maximum usage of the machine.

Conclusion

The project concludes with the design of a conceptual machine which is economically viable to operate in marginal sized land holdings to carry out transplanting and harvesting of rice, which are the most intensive activities in rice farming. The solution also focuses on the various factors such as safety, comfort and efficiency for improving the productivity of the farm activities while addressing the need to sustain marginal rice farming.

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Appendix 1

16-1/2015-M&T(I&P)Vol.IV
Department of Agriculture & Cooperation
(Mechanization & Technology Division)
Room No. 298, Krishi Bhawan, New Delhi.
Dated 24th February, 2015

To

Shri Midhun KM
Kalathuvapavalappil (H)
P.O. Thaikkattusserry,
Ollur-680306
Thrissur

Subject: Information under RTI Act 2005

In so far M&T Division is concerned the information as sought by you vide your RTI application of dated 23.1.2015 are furnished as under:

Sl. No.	Query	Reply
1	Kindly provide me the currently available method used to calculate the subsidies provided for marginal farmers to buy transplanter, reaper and combine harvester.	The high value and high productive machineries & equipments are normally popularized through farm machinery Banks for Custom Hiring services so as to have an easy accesses of small and marginal farmers to such machinery without any significant capital investment. Under Sub Mission on Agricultural Mechanization (SMAM), the small and marginal farmers/SC & ST/women and NE States beneficiaries are admissible for additional 10% of subsidy than other/general category of beneficiaries under the component no 3 of SMAM guidelines for individual ownership of farm machinery. Based on the market-survey, the rates of agricultural machinery are decided and the quantum of subsidy is decided on the basis of approved pattern of assistance.
2	How is the percentage or subsidy amount is decided for the machineries used by marginal rice farmers.	There is no separate criteria to determine financial assistance for the marginal rice farmers. However, based on the market survey, the rates of agricultural machinery are decided and the quantum of subsidy is decided on the basis of approved pattern of assistance for various category of machinery.
3	What are the factors which decides whether the percentage or fixed amount is considered.	Based on the market survey, the rates of agricultural machinery are decided and the quantum of subsidy is decided on the basis of approved pattern of assistance.

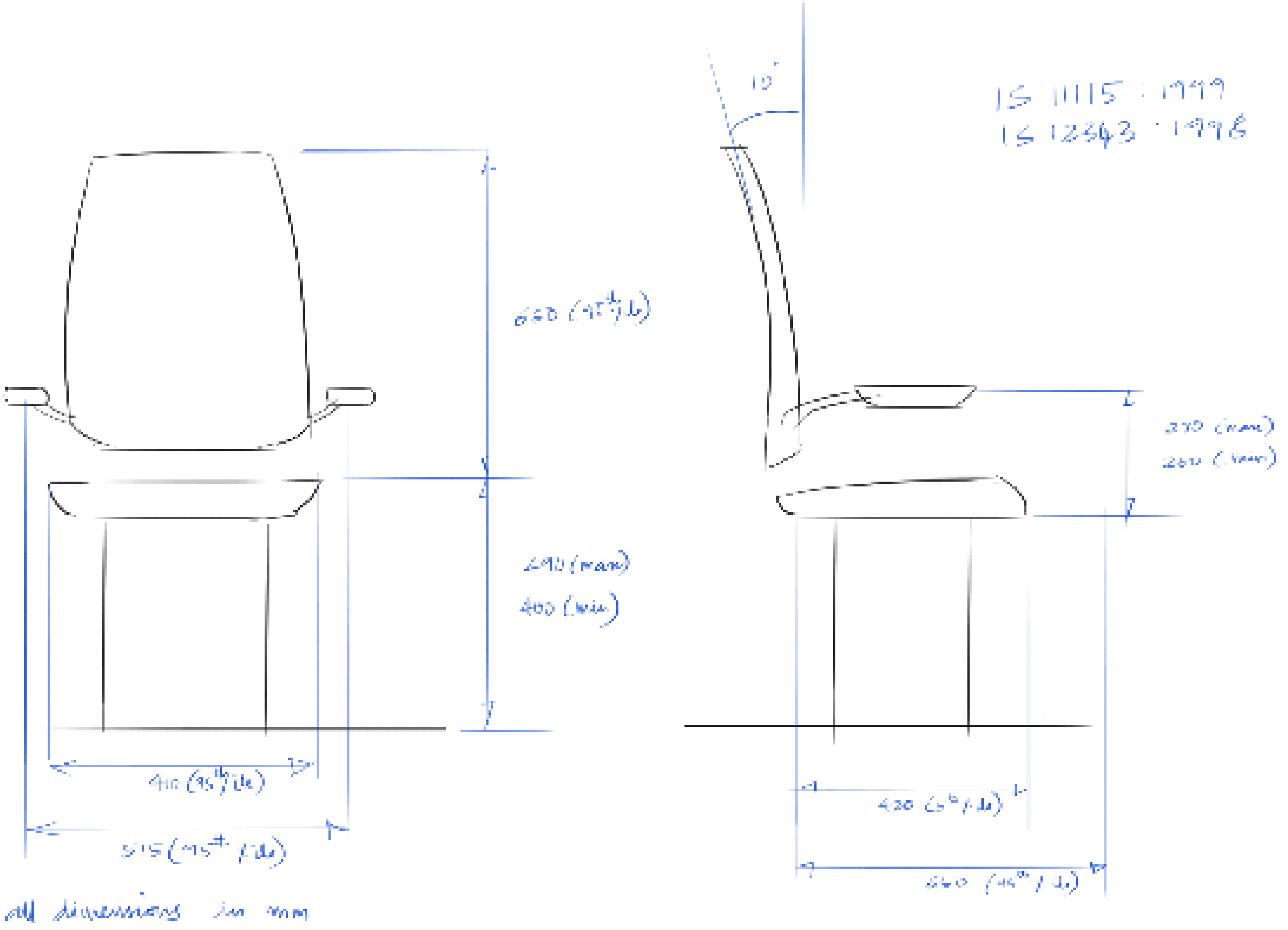
If you are not satisfied with the above information, you may appeal **to Smt. I. Rani Kumudini, Joint Secretary (M&T) & appellate authority, Room No. 237, Krishi Bhawan, New Delhi** for redressal of your grievances.

Yours faithfully,

(V.N. Kale)
Additional Commissioner (M&T) & CPIO

Copy to:
CPIO, Department of Agriculture and Cooperation w.r.t. RTI Cell Registration No. DOA&C/R/2015/60033 dated 23.1.2015

Appendix 2



10°
IS 11115 : 1999
IS 12843 : 1998
650 (95th %ile)
490 (max)
400 (min)
270 (max)
260 (min)
410 (95th %ile)
515 (95th %ile)
420 (5th %ile)
660 (95th %ile)
all dimensions in mm